January 2024

Assessment of Impact on the Maritime Usage Report – Volume 3

Navigation Maintenance Dredging 2026-2033

On behalf of

Port of Waterford

MALONE O'REGAN ENVIRONMENTAL

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Assessment of Impact on the Maritime Usage Report – Volume 3

Navigation Maintenance Dredging 2026-2033

Port of Waterford

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In Waterford Harbour.

7th August, 1996.

AQUA-FACT INTERNATIONAL SERVICES LTD.

Photographic And Visual Survey Of The Seabed In The Areas Of And Around The Proposed Dumpsite In Waterford Harbour.

7th August, 1996.

Aqua-Fact International Services Ltd.,
[redacted]

Report Title: Photographic And Visual Survey Of The Seabed In The Areas Of And Around The Proposed Dumpsite In Waterford Harbour. 7th August, 1996.

Job Number: JN 153

Date: 8/8/96

Author: [redacted]

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1. INTRODUCTION

Aqua-Fact International Services Ltd., were commissioned by the Department of the Marine to carry out a dive photographic survey prior to a dumping of fine materials in Waterford Harbour. It is envisaged that a similar survey will be subsequently carried out following the completion of the dumping operation. In the first instance the specific objectives of the pre survey were to determine the seabed conditions in the areas of and around the proposed dumpsite. Photographs were to be taken of the sediment surface of a number of transects within the dumpsite and at the edge of the dumpsite and visual observations were to be made of the biological characteristics of these locations. The co-ordinates of the proposed dumpsite as outlined by the Department of the Marine are as follows (see Figure 1):

52° 07,45'N	06° 58,80'W
52° 07,45'N	06° 58,10'W
52° 07,10'N	06° 58,10'W
52° 07,10'N	06° 58,80'W

2. MATERIALS AND METHODS

Dive surveys were carried out at a proposed dumpsite in Waterford Harbour on the 7th of August, 1996. Diving was carried out at slack water during a neap tide period. Prior to the survey strong north/north-east winds force 5-6 were blowing and the rivers running into the harbour area were in full spate. At the time of diving winds had backed to a south/south-west direction and had moderated to a light force 3-4.

Six dive transects were undertaken, two in the centre of the dumpsite, two towards the southern end of the dumpsite, one at the northern end of the dumpsite and a further transect at the northern end of the dumpsite heading into the harbour. (see Figure 1.)

Photographs and general observations were made along each of these transects. Photographs were taken with a Nikonos V fitted with a 15mm lens and Isotecknic Flash System. Images were recorded on 100 ASA print film.

3. RESULTS

Photographs 1-10 record bottom conditions along the transects taken by the diver in the middle of the proposed dumpsite (see Figure 1). In general, the bottom in this area consisted of gravel of various diameters. The gravel was coarse with numerous large stones (approximate diameter of 10cm) observed on the first transect (Photo's 1-6). The bottom was flat with no obvious dunes. There were few macrofaunal species recorded, the most prominent being the common starfish, *Asteries rubens* (Photo's 1, 4 & 6). Most of these large stones were covered with white egg spirals, presumably from nudibranchs (Photos 1-4). The red algae, *Delesseria sanguinea*, was the most common macrophyte observed (Photo's 1-4). The nature of the bottom on the second transect in the middle of the box was more diverse with the surface composition varying from a coarse sand (Photo 8) to a coarse gravel (Photo 10), a mixture of both (Photo7) and a fine gravel (Photo 9). The fine gravel formed small waves indicating some movement during strong bottom currents. Macrofauna and macrophytes were sparce with *A. rubens* again being the most prominent species recorded (Photo 9). An edible crab, *Cancer pagurus*, was imaged in Photo 10 and a hermit crab, *Pagurus bernhardus*, and a small goby in Photo 8. These occurred in low numbers throughout the area. A number of large oyster shells were also observed scattered around the bottom (Photo 7).

Photographs 11-25 record bottom conditions along the transects taken by the diver on the southern end of the proposed dumpsite (see Figure 1). The bottom composition was more uniform in this area. It consisted of a mixture of gravel sizes which formed dunes or waves of approximately 0.5m in height (Photo's 11 & 16), the small diameter gravel forming the crests (Photo's 11, 12 &16) and the large diameter gravel filling the troughs (Photo's 18, 13, 15 & 20). This is indicative of a high energy site with an amount of sediment transport during periods of strong currents. This movement allows little attachment of algae and epifauna and the gravel is very clean. Few macrofauna can live in this environment, those that were observed included the starfish, *A. rubens* (Photo 22), hermit crabs, *P.bernhardus* (Photo18) and a small red gurnard, *Aspitrigla cuculus* (Photo's23-25) The remains of an edible crab are seen in Photo 15.

Photographs 26-43 record bottom conditions along the transects on the northern end of the proposed dumpsite (see Figure 1). The bottom was more variable in nature at this end compared to the other transects. It varied from a flat corse bottom at the most northerly point (Photo's 39-43) to a coarse clean gravel (Photo 33) with a mixture of these in between. In some places there was a fine sediment mixed with the gravel (Photo 31). Macrofauna were again mostly absent, the only species recorded being *A. rubens* (Photo 28 & 34), *P.bernhardus* (Photo 34,40 and 42) and a small masked crab, *Corystes cassivelaunus* (Photo 39).

4. OVERVIEW

For the most part the proposed dump site lies in an area experiencing strong tidal currents. The bottom is highly mobile with little or no fine material present in the area. In this type of environment there is generally a paucity of fauna with mobile species dominating. With the exception of a small number of edible crabs there was little in the way of commercial species observed. Fine material deposited in these type of locations are generally resuspended and relocated elsewhere.

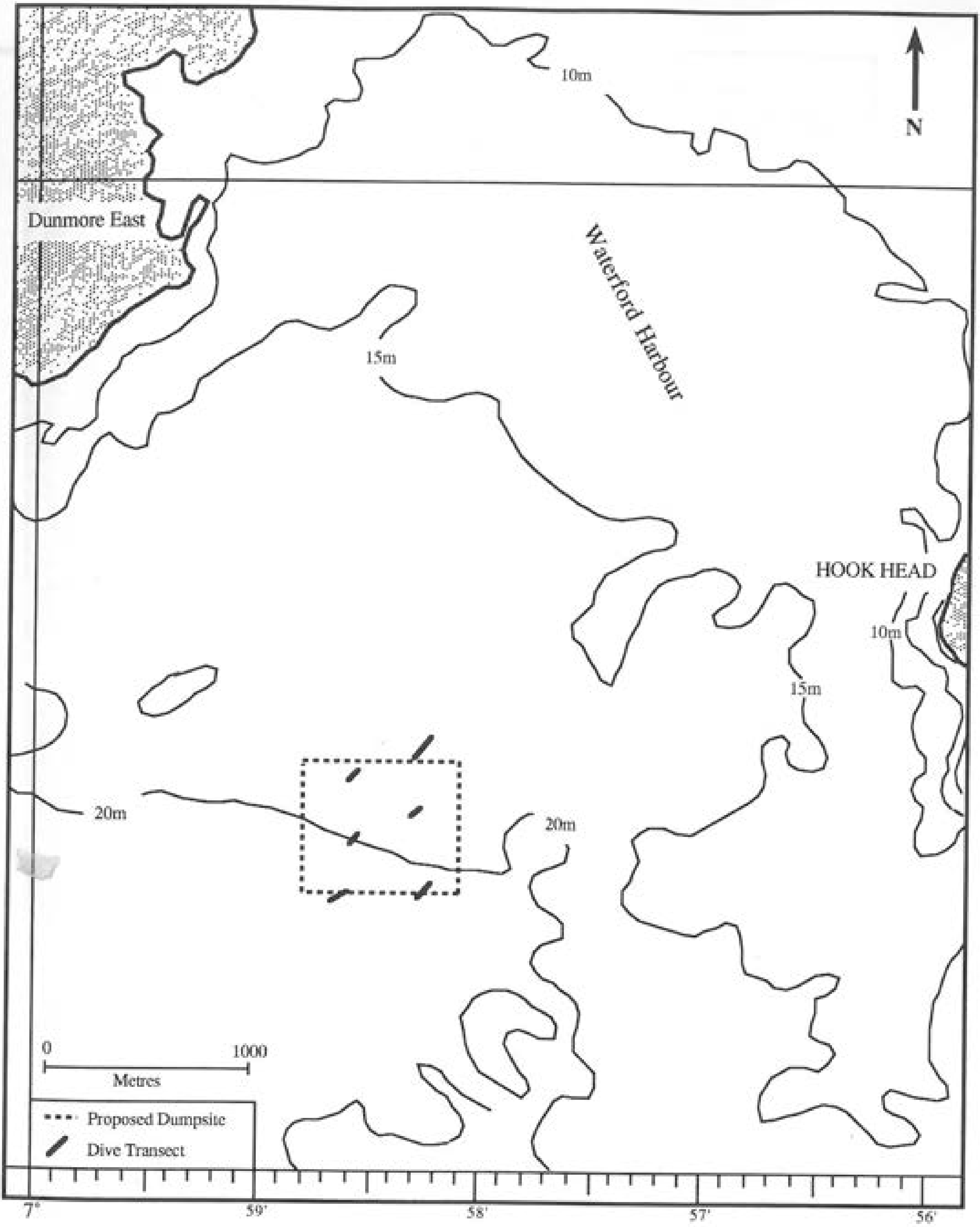

Figure 1. Location of the dive transects in the vicinity of the proposed dumpsite in Waterford Harbour, 7th August 1996.

Photo No.:— 1

Photo No.:— 2

Photo No.:— 3

Photo No.:— 4

Photo No.:— 5

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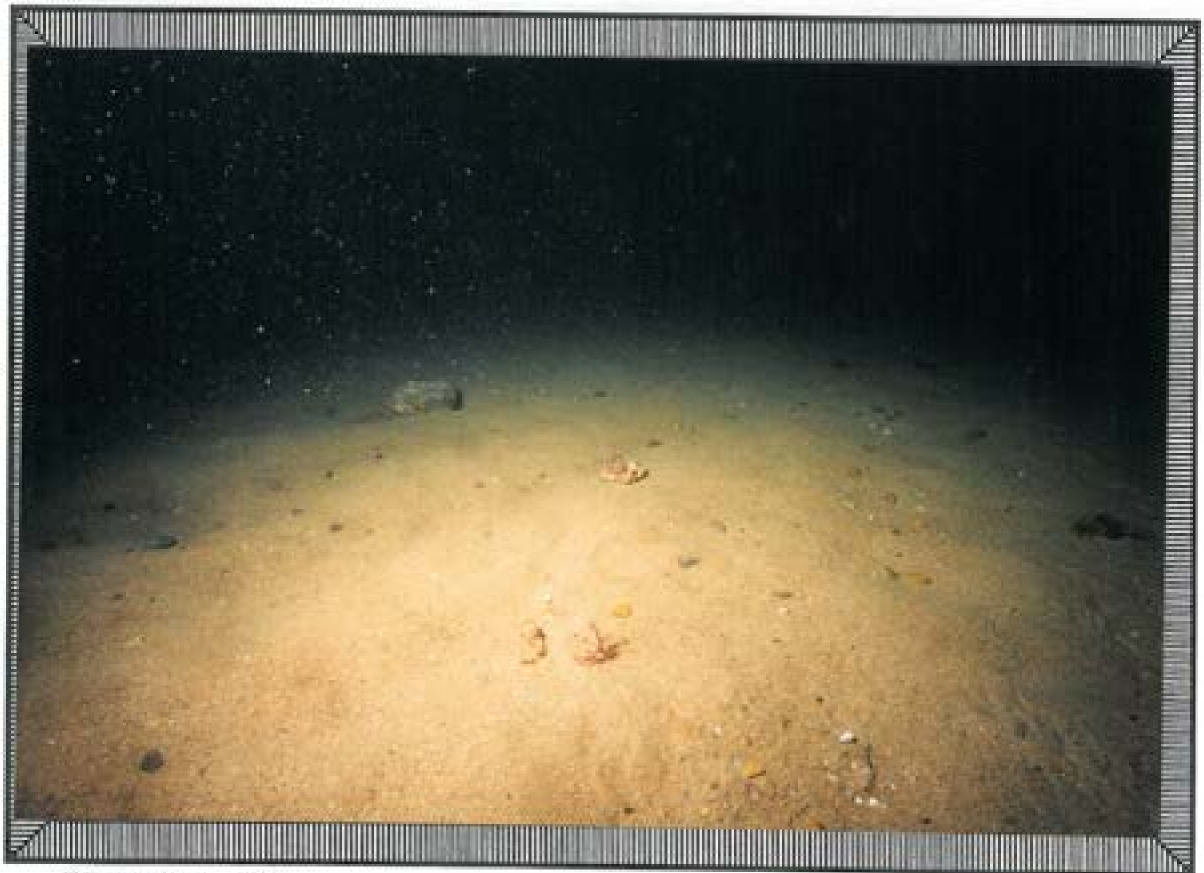

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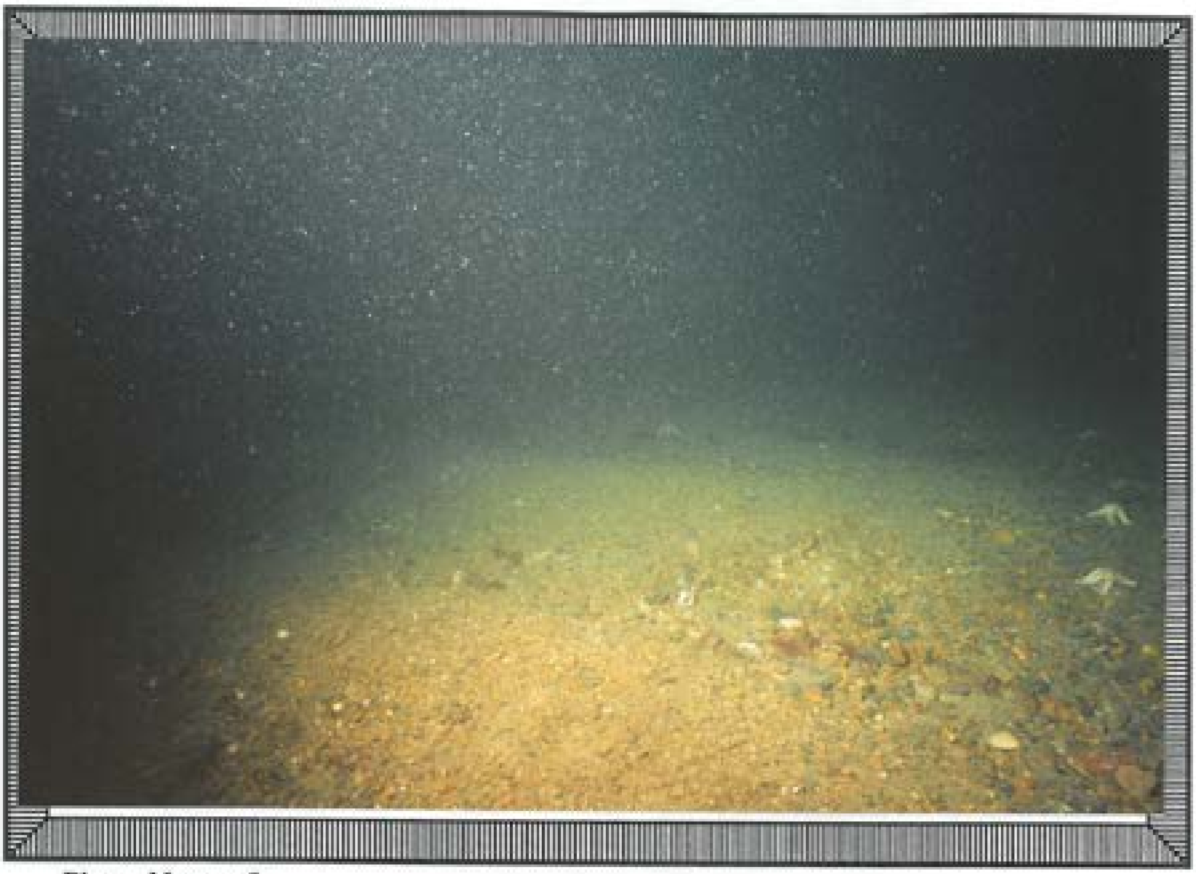

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Photo No.:— 10


Photo No.:— 13


Photo No.:— 14

Photo No.:— 11

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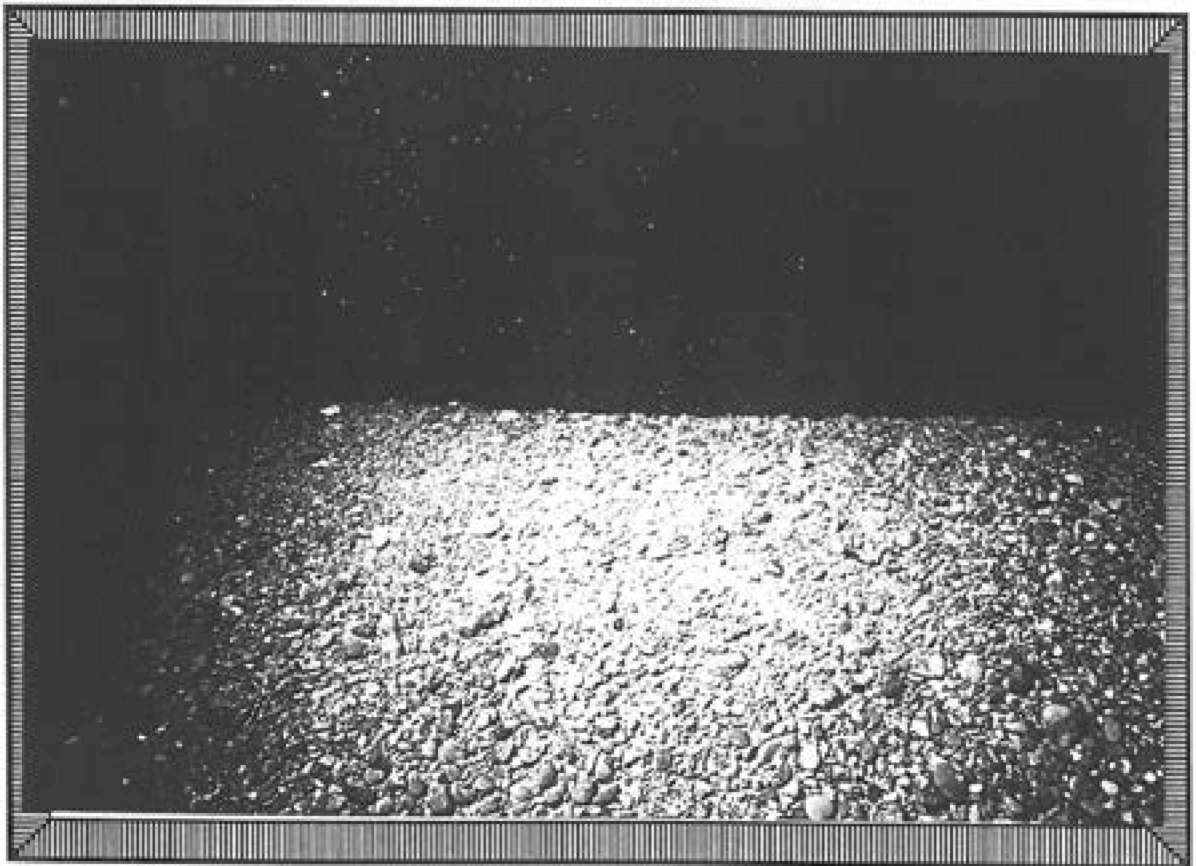

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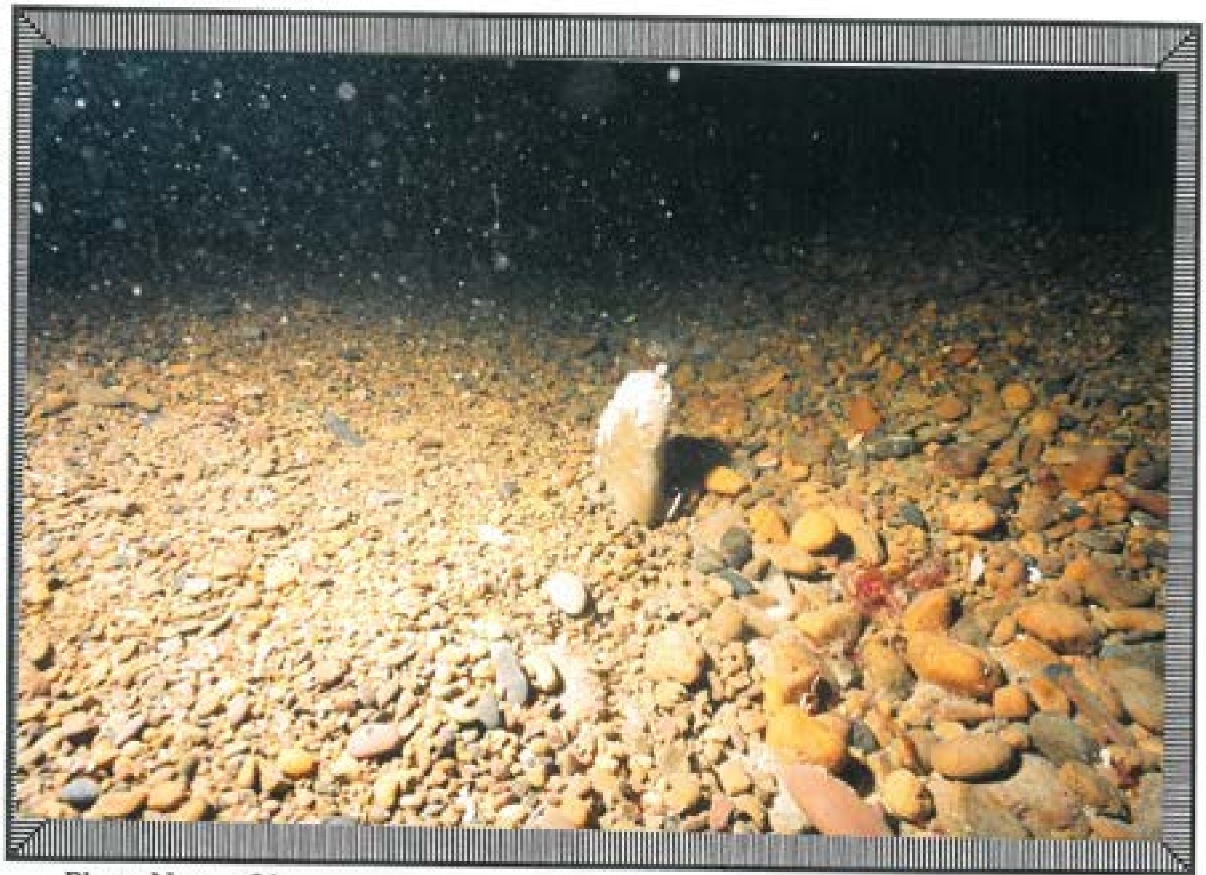

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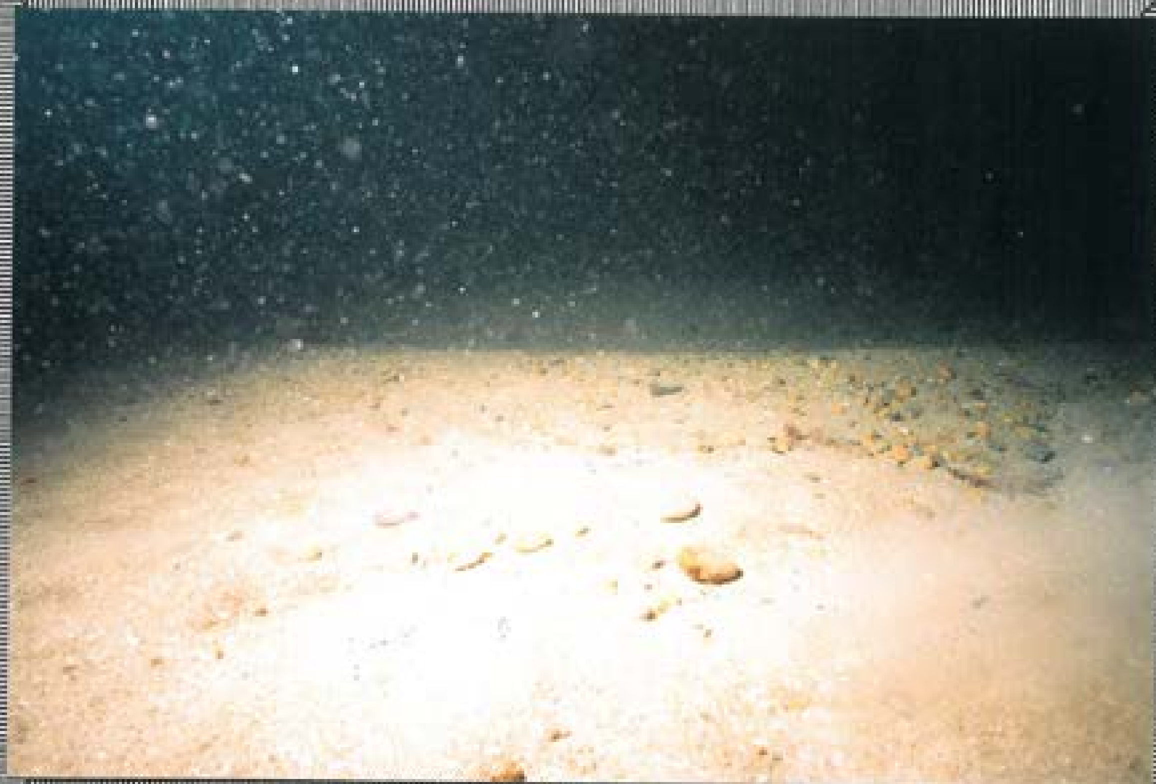

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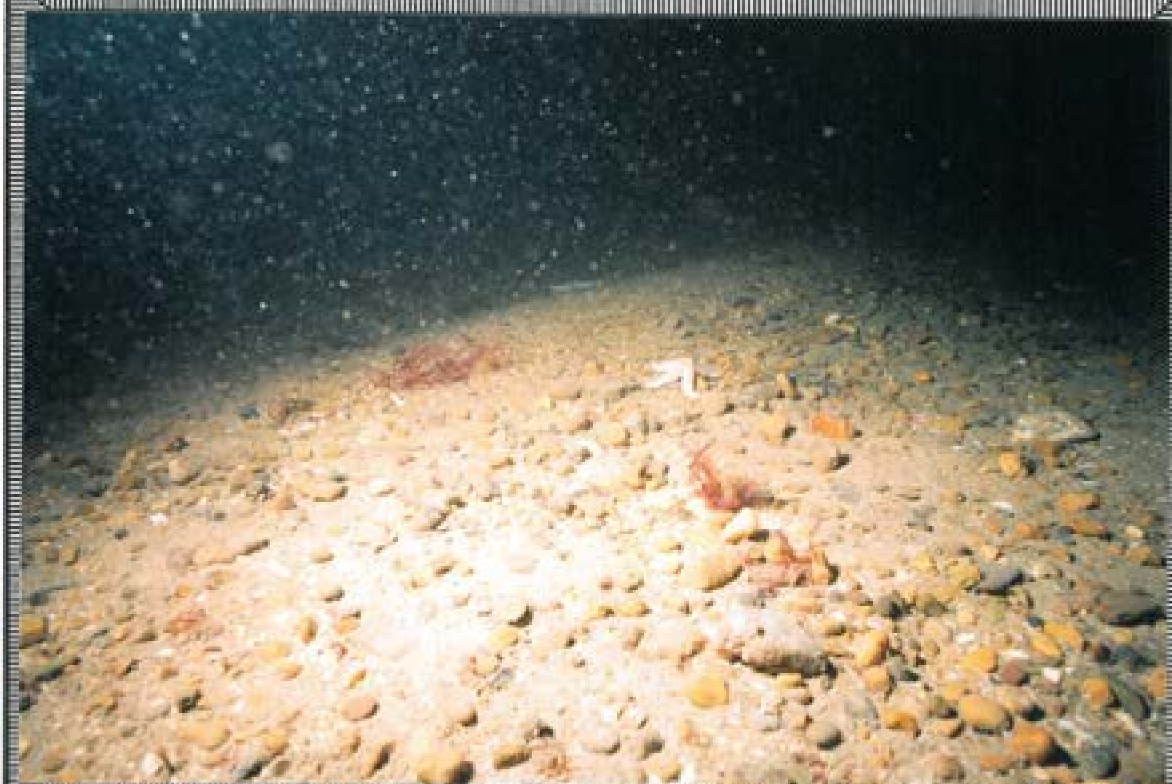

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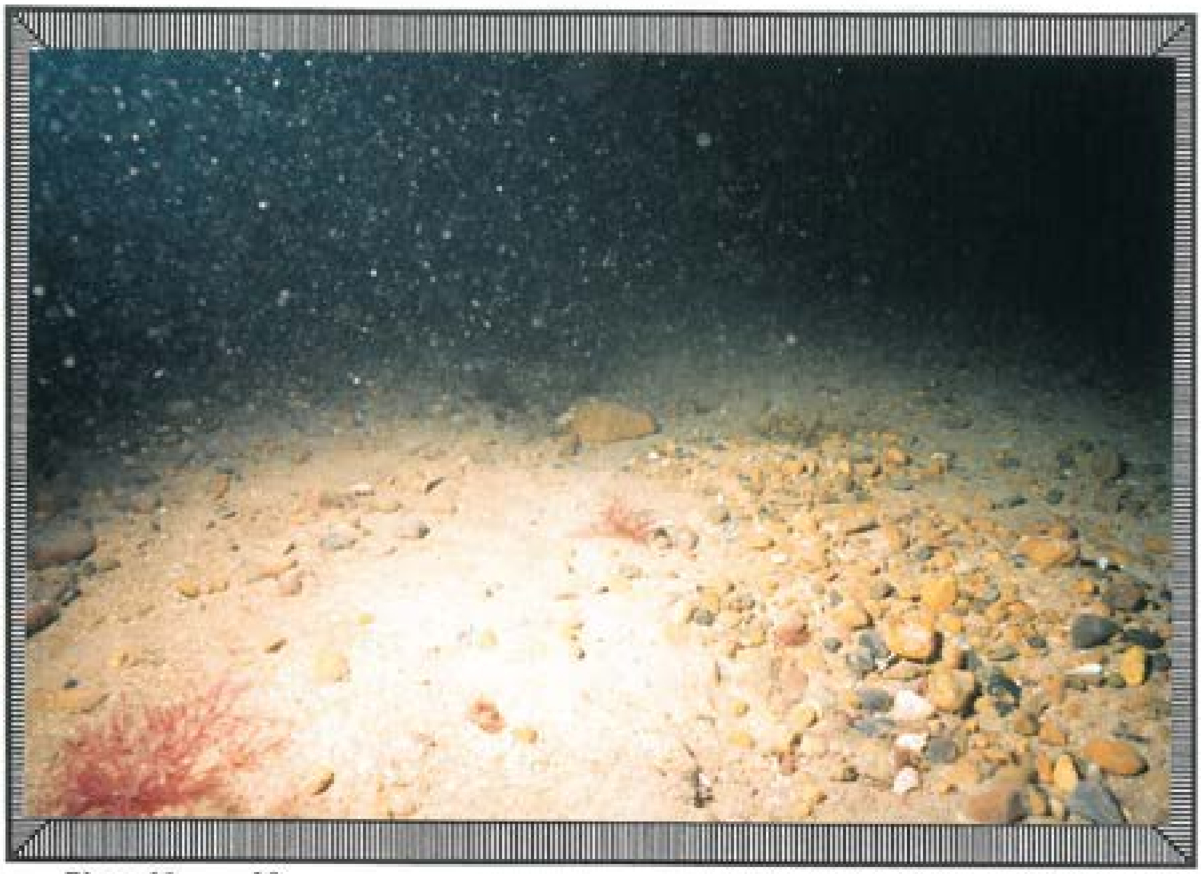


Photo No.:— 29

Photo No.:—30

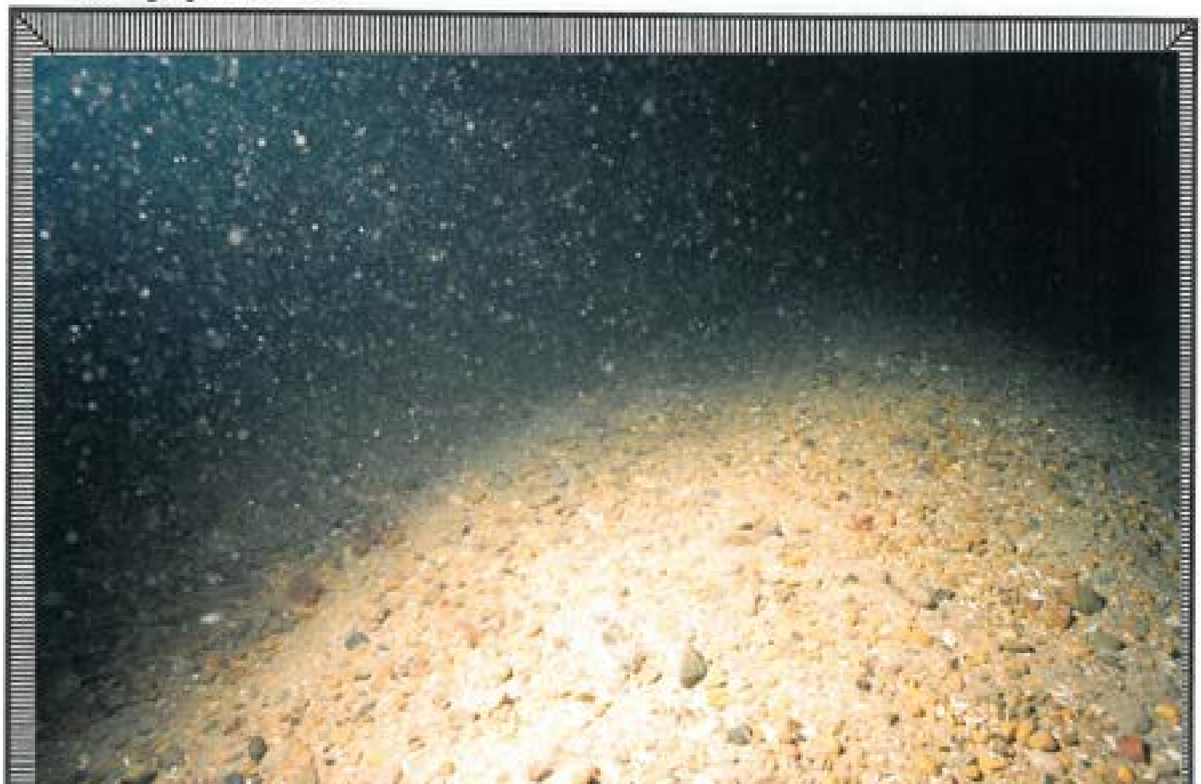
Photo No.:— 31

Photo No.:—32

Photo No.:— 33

Photo No.:—34

Photograph No.:- 35



Photograph No.:- 36

Photograph No.:- 37

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Photograph No.:- 39

Photograph No.:- 40

Photograph No.:- 41

Photograph No.:- 42

Photo:- 43

INTRODUCTION.

Historical

Waterford Harbour has been the focus of a considerable tonnage of shipping over the years and to allow this activity, a certain amount of channel dredging has been required. This dredging activity is carried out at two locations, one at Cheek Point and the other at the Duncannon Bar. The spoil is dumped at two locations within the Harbour, one at Buttermilk Point and the other at Doornoge Point.

Proposal

Current developments at Waterford harbour necessitate the dumping of further dredge material in the outer region of the harbour. Because of the particular type of dredging operation proposed, the spoil material must be deposited at some location inside the line between Hook Head and Swines Head. A diving survey, incorporating both still and video photography was carried out at two proposed locations to document the bottom type, the fauna and the general suitability for the dumping of dredge spoil material.
Site 1 (Position 1, 52° 8' 14" Lat., 7° 56' 3" Long) lies within the existing dumping area off Doornoge Point and site 2 (Position 2, 52° 8' 4" Lat, 7° 58' 40" Long) lies just southwest from site 1.

Site 1.

This site is characterised by rocky ledges, running in a NW- SE direction. These ledges vary in height from 0.5 to 3 m and support a variety of red algae (see photos A - D). Along with this weed cover, a wide variety of encrusting and/or epifaunal species were seen which include a variety of sponge species, the ascidians Dendroa grossularia, Ascidiella, Botyrilloides, the saddle oyster Anoimia, the tube worms Pomatoceros sp. and Bispira volutacornis, the sea mats Cellopora pumicosa and Electra pilosa, the barnacle Balanus spp., and the echinoderms Ophiothrix fragilis, Echinus esculentus, Asterias rubens ,Marthasterias . Other than these epifaunal species, more mobile forms such as swimming crabs and a variety of fish life (gobies, pollock, wrasse, etc) were seen. The depth at this site varied from 8 to 13 meters, with the depth increasing in steps of approximately 0.5 meter intervals when rocky ledges were encountered. At the deeper sections, the bottom is comprised of large, flat boulders with abundant epifaunal assemblages. Most of the fauna observed are sessile and suspension feeders and as such would be smothered and/or suffer

INTRODUCTION.

Revisit to the dump site in Waterford Harbour

Historical

Waterford Harbour has been the focus of a considerable tonnage of shipping over the years and to allow this activity, a certain amount of channel dredging has been required. This dredging activity is carried out at two locations, one at Cheek Point and the other at the Duncannon Bar. The spoil is dumped at two locations within the Harbour, one at Buttermilk Point and the other at Doornoge Point. Following a survey and report by Aqua Fact International Services Ltd. in September 1989 a new dump site(see map 1), close to the Doornoge Point site, was identified for dumping

Dump site description form September 1989

The site identified for dumping is broadly described as follows:
This site lies in a large patch of medium sand and shell debris. Animals are for the most part hidden in the sand with such
features as the holes left by retracting Ensis sp. being common. Other species seen on the surface were Eupagurus , Asterias and an echinoid, probably Echinocardium cordatum . Some flat fish are present in the area. Infaunal species were relatively rare in this location as revealed by the dredge with, in addition to the species listed above, the worm Nephtys hombergii being common. Depth at this site was in the region of 18m.

Revisit to the dump site March 1990

Following the qualitative dredge survey and semi-synoptic hydrographic investigation in September 1989, a revisit to the dumpsite (see map 1) was carried out on the 20th of March 1990. A number of dives were taken over the dive site to look for change subsequent to the dumping activity carried out by the Waterford Harbour Board.
The location, as previously described, is characterised by medium sand and coarse shell gravel. During the revisit dives this sandy shelly bottom was found to have a small number of intermittent boulder outcrops to the south covered by epifauna. These outcrops and associated epifaunal communities were previously described during the

initial survey and are dominated by Asterias, Dendrodoa, Ascidiella , Botrylloides, Cellepora, Electra, Obelia, Anomia and Echinus.

No obvious effect of dumping was observed during the course of the revisit dives. Although visibility was poor (<0.5m) making photography impossible, no physical evidence of deposited material or abrasion/smothering effects on the animal communities could be detected.

This is not surprising, however, as the location is located in the channel area experiencing strong currents and the previous 3 months experienced continuous strong gales. The presence of 6-10cm ripple marks on the bottom indicates that the bottom at this site experiences strong current/swell activity abraision if dredge spoil was dumped in large quantities over this area. In general this location has a wide and varied marine life.

Site 2.

This site lies in a large patch of medium sand and shell debris (photos E - L). Animals are for the most part hidden in the sand with such features as the holes left by retracting Ensis sp. being common (see photo H). Other species seen on the surface were Eupagurus (photo I), Asterias (photo J) and an echinoid, probably Echinocardium cordatum (photo K). Some flat fish are present in the area as shown on the video. Infaunal species were relatively rare in this location as revealed by the dredge with, in addition to the species listed above, the worm Nephtys hombergii being common. Depth at this site was in the region of 18m.

The above described assemblages of animals at site 1 & 2 can be seen on the video which was taken at the same locations as the stills.

APPENDIX F-2

'hotographic And Visual Survey Of The Seabed
In The Areas Of And Around A Dumpsite
In Waterford Harbour.

15th November, 1996.

AQUA-FACT INTERNATIONAL SERVICES LTD.

Photographic And Visual Survey Of The Seabed
In The Areas Of And Around A Dumpsite
In Waterford Harbour.

15th November, 1996.

Aqua-Fact International Services Ltd.,
[redacted]

Report Title: Photographic And Visual Survey Of The Seabed In The Areas Of And Around A Dumpsite In Waterford Harbour. 15th November, 1996.

Job Number: JN 170

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Author: [redacted]

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1. INTRODUCTION

Aqua-Fact International Services Ltd., were commissioned by the Department of the Marine to carry out a dive photographic survey prior to, and after the dumping of fine materials in Waterford Harbour. The initial survey was carried out on the 7th of August, 1996 to determine the seabed conditions prior to dumping and the results can be found in the report "Photographic and visual survey of the seabed in the areas of and around the proposed dumpsite in Waterford Harbour. &th August, 1996."

Results from this survey indicated that, for the most part the dumpsite lies in an area experiencing strong tidal currents. The bottom was highly mobile with little or no fine material present. There was a paucity of fauna with mobile species (e.g. crabs) dominating.

The following report records seabed conditions after the dumping operation. Photographs were taken of the sediment surface during a number of transects within and outside the dumpsite and visual observations were made of the biological characteristics of these locations. The co-ordinates of the proposed dumpsite as outlined by the Department of the Marine are as follows (see Figure 1):

52º 07,45'N	06º 58,80'W
52º 07,45'N	06º 58,10'W
52º 07,10'N	06º 58,10'W
52º 07,10'N	06º 58,80'W

2. MATERIALS AND METHODS

Dive surveys were carried out at the dumpsite in Waterford Harbour on the 15th of November, 1996. At the time of diving sea conditions were calm with a light northly wind blowing.

Seven dive transects were undertaken, two towards the southern end of the dumpsite, one in the centre of the dumpsite, three at the northern end of the dumpsite and a further transect north of the dumpsite heading into the harbour (see Figure 1.). Position fixes were taken with a GPS system.

Photographs and general observations were made along each of these transects although visibility on the bottom was bad. Photographs were taken with a Nikonos V fitted with a 15mm lens and Isotecknic Flash System. Images were recorded on 100 ASA print film.

3. RESULTS

Photographs 1&2 record bottom conditions along the transects taken by the diver inside the north-eastern corner of the dumpsite (see Figure 1). The bottom is covered by a fine muddy sediment with no elements of the original seafloor apparent. No fauna were seen. Photo's 3-10 record conditions along the transect to the north-east of the site. The original coarse sand bottom was observed with a light layer of fine material covering it. Occasional blocks of dredged material were located (Photo's 4, 5, 8 & 10). Hermit crabs, *Pagurus bernhardus*, were common (Photo 3).

Photo's 11-14 show the depth of material deposited in the southern part of the site. The diver dug down approximately two feet to uncover rocks from the original bottom. The covering material is similar in composition as that recorded in the first transects. Again no fauna were observed.

Photo's 15-18 record conditions seen during the transects in the western side of the site. There was a light covering of fine material covering the coarse gravel bottom. Starfish, *Asteries rubens* (Photo's 17 & 18), were common.

Bottom conditions prevailing to the extreme north of the dumpsite are seen in photo's 19-22. There was a extremely light, flocculent layer of fine material covering a coarse gravel bottom. This fine material was easily displaced and in places was moving with the bottom current. No fauna were observed.

4. OVERVIEW

The bottom in and around the dumpsite has clearly been impacted, the bulk of the dumped material being deposited on the eastern side of the site. This material is seen to consist primarily of a fine muddy sediment which overlays the original gravel/sand bottom. Any fauna covered by this material would presumably have died. Given that this area is a high energy site, this sediment is continually being sorted by the action of tidal currents and is being dispersed over a large area, the finer element being dispersed the furthest as observed in the northern transect located away from the site. It is probable that the bottom will eventually return to its original composition with the fine material being either dispersed in the open sea or settle in a depositional area near the shore.

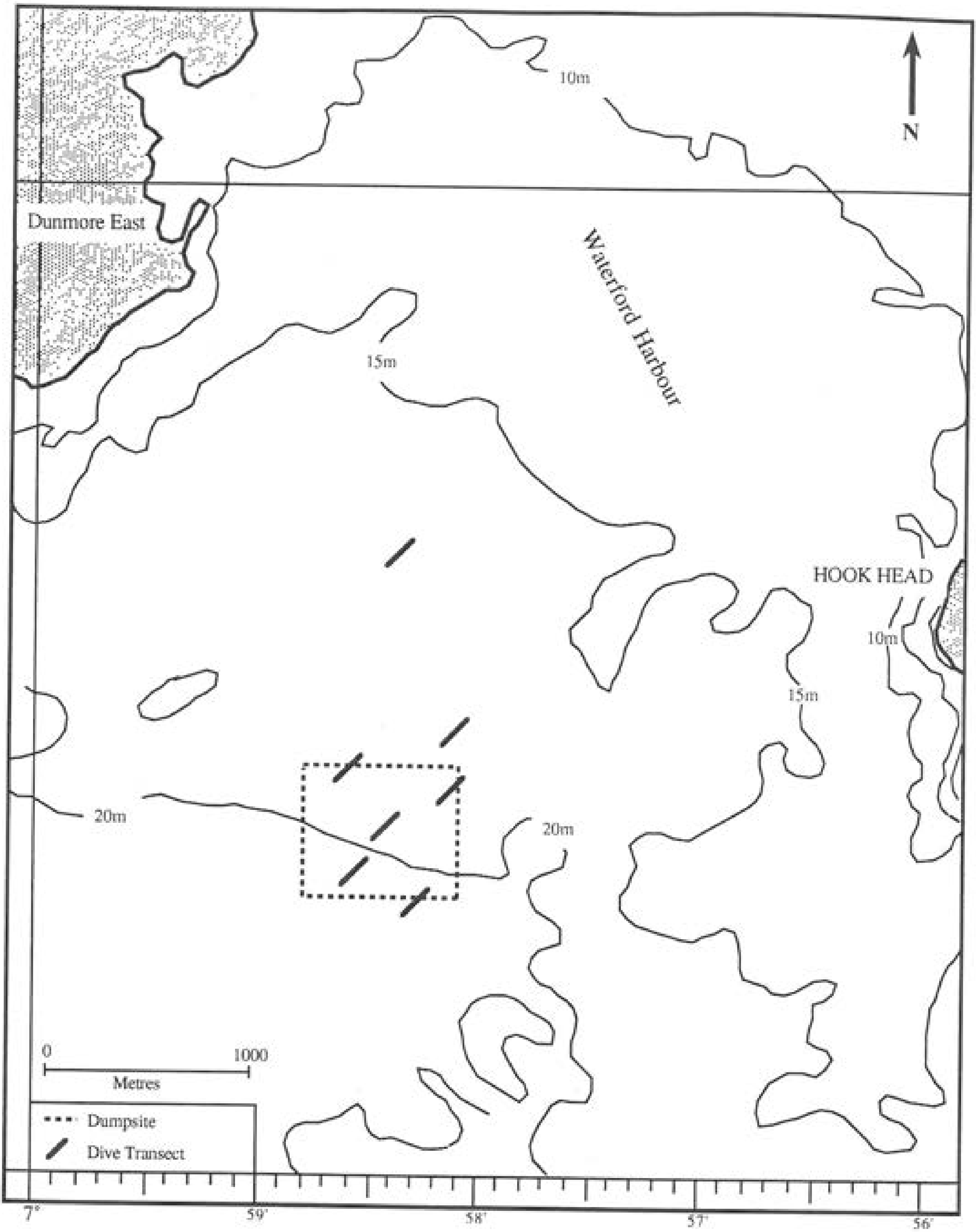
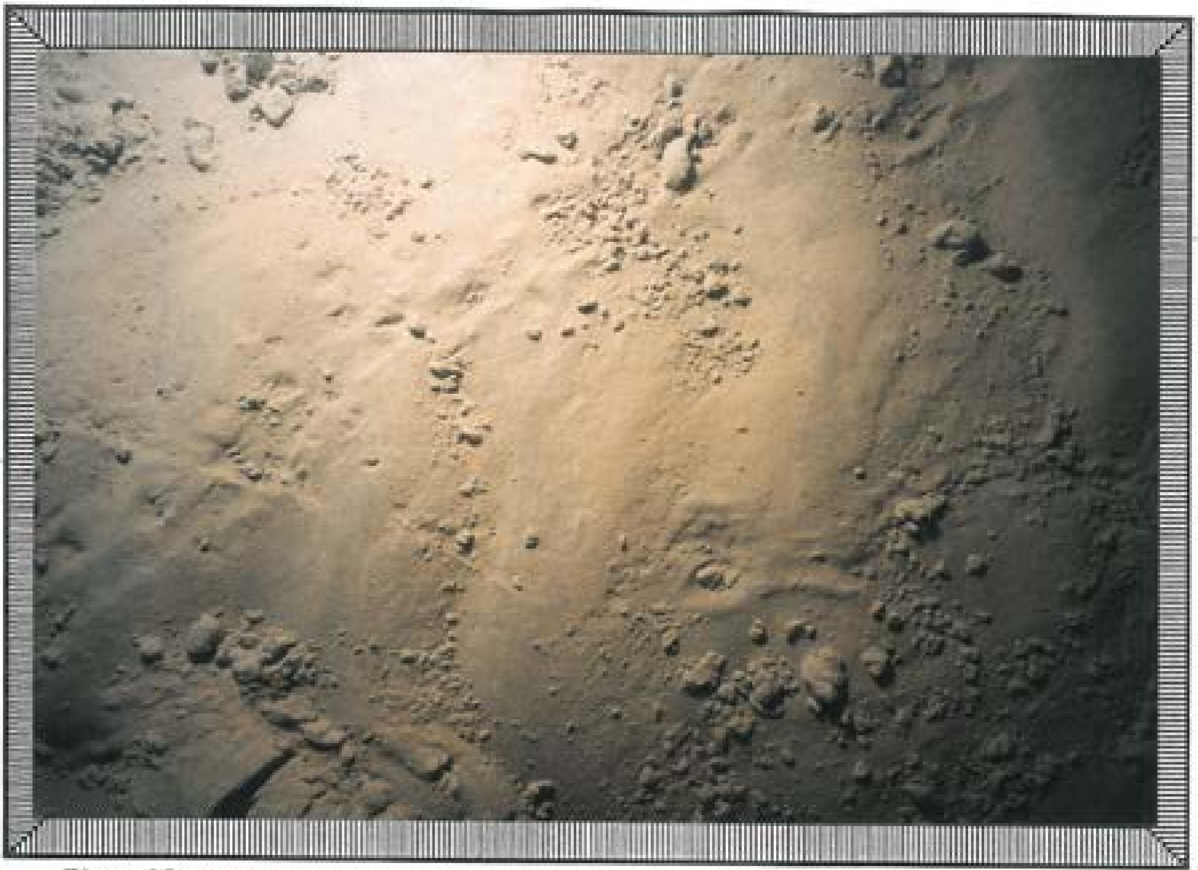


Figure 1. Location of the dive transects in the vicinity of the dumpsite in Waterford Harbour, 15th November 1996.



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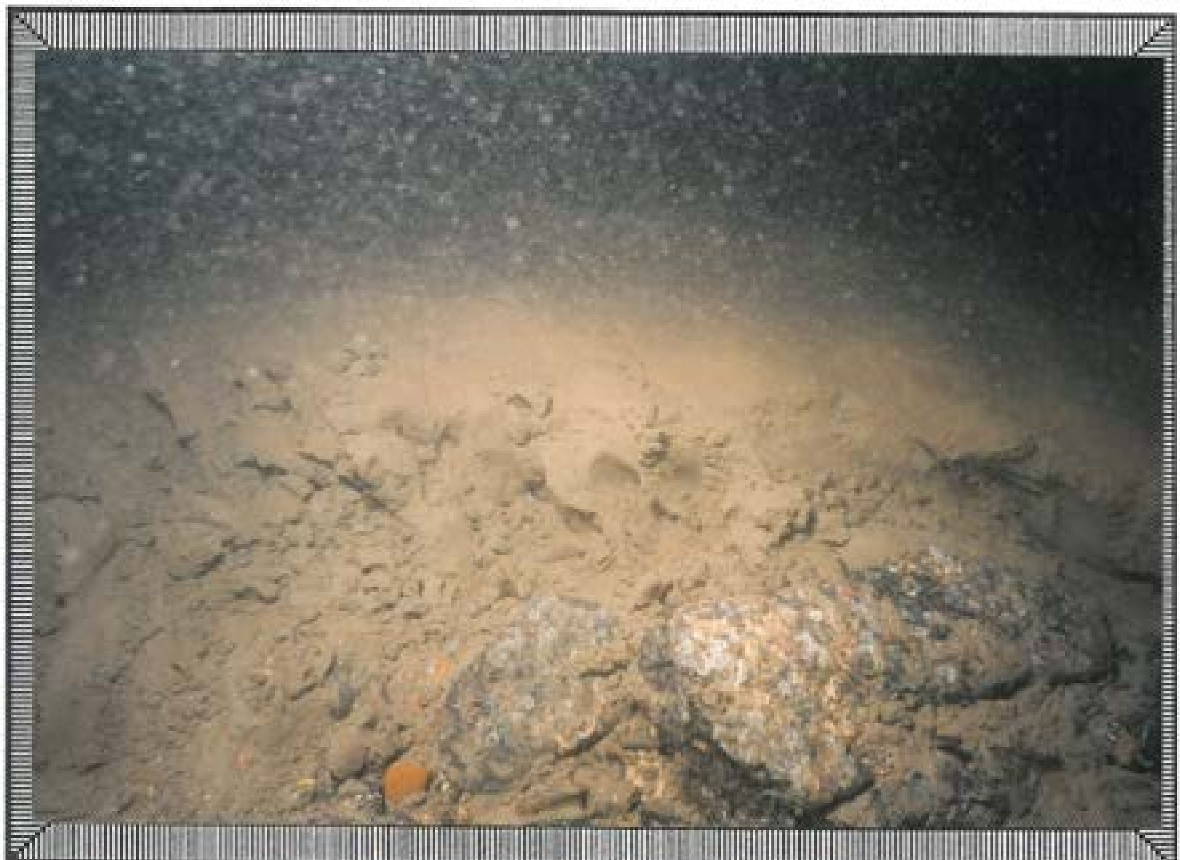

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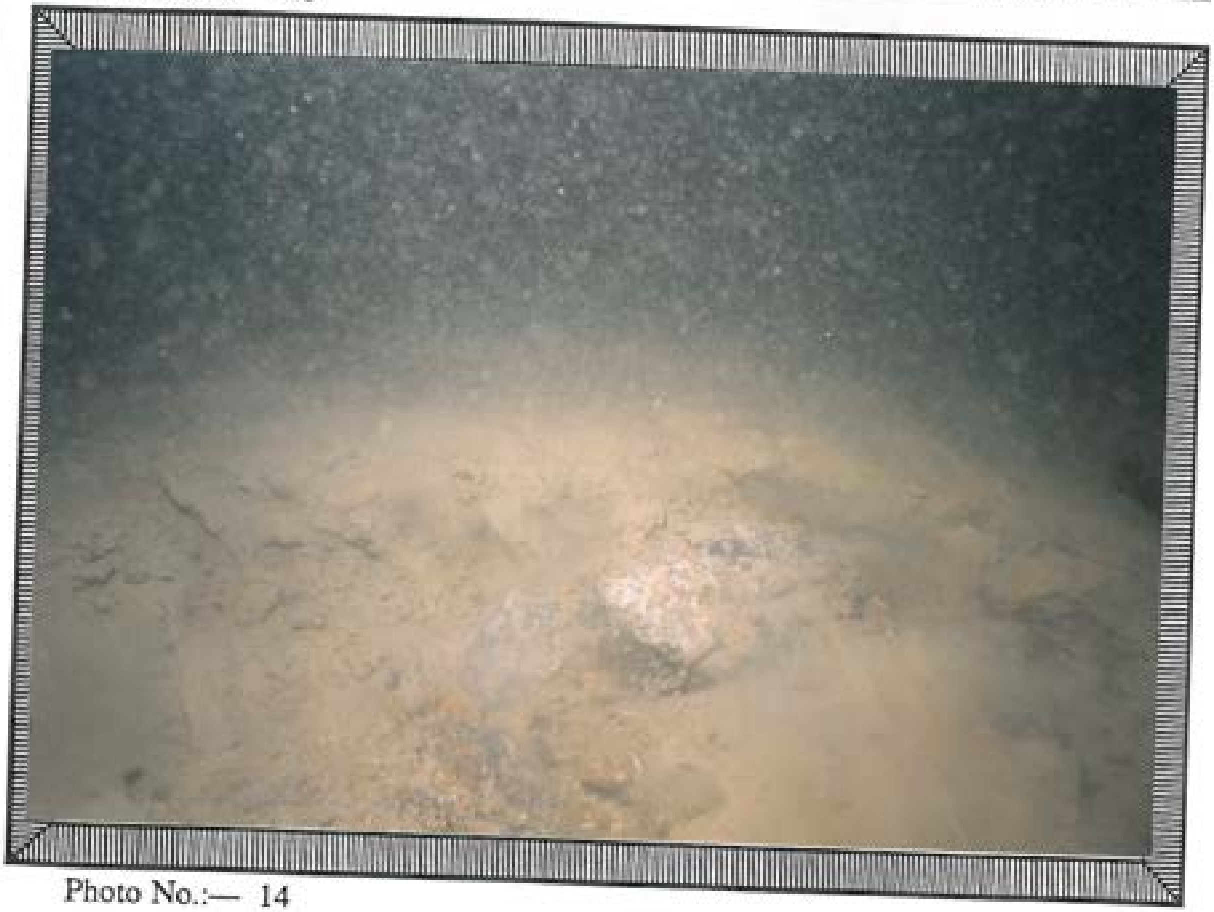

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Photo No.:— 15

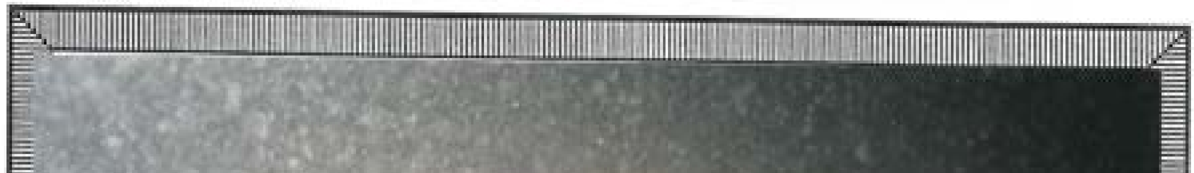

Photo No.:— 16

Photo No.:— 17

Photo No.:— 18

Photo No.:— 19

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Photo No.:— 21

Photo No.:— 22

APPENDIX F-3

AQUA-FACT

Photographic Survey of a Dredge Spoil Dumpsite Waterford Harbour.

30th January, 1999.

Photographic Survey of a
Dredge Spoil Dumpsite
Waterford Harbour.

30th January, 1999.

Aqua-Fact International Services Ltd.,
[redacted]

Report Title: Photographic survey of a dredge spoil dump site, Waterford Harbour, 30th January, 1999.

Job Number: JN273

Date of Issue: 10-2-99

Author: [redacted]

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TABLE OF CONTENTS

1. INTRODUCTION

Aqua-Fact International Services Ltd., was commissioned to carry out a quantative and qualitative photographic survey of a licensed dump site in Waterford Harbour prior to the resumption of dumping of fine materials. This site had previously being used in 1996 and observations following this event revealed significant amounts of fine material overlaying the natural sand/gravel bottom (see Aqua-Fact reports 1996 a&b). This report documents the environmental conditions of the seabed in and around the dumpsite at the time of sampling on 30th January, 1999. The main objectives were to document the current environmental conditions prior to an imminent dumping operation and assess residual effects, if present, from the previous disturbance. Both surface photography and Sediment Profile Imagery (SPI) were employed in order to get an accurate account of conditions.

A dive survey, carried out by scientific divers, involves direct observation of bottom conditions covering as extensive an area as possible. Equipped with a camera, the diver photographs representative shots of the bottom and fauna. Visual observations recorded during the dive include the appearance of the bottom *i.e.* colour and texture, noting the species of animals observed. Observations are recorded immediately on surfacing and a map of the dive track drawn up. Combined with photography, the visual observations are compiled into a written report describing the bottom conditions. The diver survey can be compared with the Sediment Profile Images and together they give a clear picture of environmental conditions.

Sediment Profile Imagery incorporates the use of an underwater camera that takes *in situ* photographs of vertical sections of the sediment, from which important ecological parameters can be ascertained. It reveals many aspects of the processes within a sediment that other conventional tools fail to reveal or destroy in the process of sampling. Its use in marine benthic studies has revolutionised our knowledge of the physical, chemical and biological relationships on the sea floor. It is non-destructive and therefore, comparisons can be made directly to baseline and previous SPI studies. As the data return is relatively very rapid, this allows the implementation of management decisions which are based on current information rather than the 'after the fact' remedial actions imposed by the more traditional surveying/monitoring methods. A description of the SPI apparatus and its applications is included as Appendix 3.

Twelve SPI stations were sampled in the vicinity of the existing dump site as outlined in Figure 1 and defined by the co-ordinates :

52° 07.45 N, 06° 58.80 W;	52° 07.45 N, 06° 58.10 W;
52° 07.10 N, 06° 58.10 W;	52° 07.10 N, 06° 58.80 W.

Concurrent with the SPI sampling, surface photographs were taken in and around each of the SPI stations. It is envisaged that a similar survey will be carried out following the completion of the upcoming dumping operation.

2. MATERIALS AND METHODS

Dive surveys were carried out at a proposed dumpsite in Waterford Harbour on the 30th of January, 1999. Diving was carried out on the flooding tide in order to maximise underwater visibility.

In order to examine the nature of the seafloor extensively, Sediment Profile Imagery (SPI) was employed at twelve stations as outlined in Figure 1. Using SPI, one can deduce the dynamics of biological and physical seafloor processes from imaged structures. The SPI camera differs from other underwater cameras in that it effects a vertical profile of the sediment water interface and obtains a photographic image of that profile (see Appendix 3). Since the SPI camera obtains images of the undisturbed sediment *in situ*, it delivers information on benthic processes which is not readily available using many conventional sampling tools. Furthermore, as the object being photographed is directly against the face plate of the camera assembly, water turbidity is never a limiting factor.

Sediment Profile Imaging (SPI) can remotely identify the successional status of the seafloor and also has the potential to document its maintenance, development and/or destruction over time. With experience, both the physical and biological forces responsible for maintaining or driving a succession (*e.g.* bottom erosion or deposition, changes in substratum type, relative changes in levels of dissolved oxygen, organic decomposition processes *etc.*) can also be detected with confidence. This also applies to chemical driving forces where sensing probes are used in conjunction with the SPI instrument. A great deal of information about benthic processes is available from sediment profile images and while certain features (*e.g.* deep-living infaunal forms) may escape direct observation on the SPI images, their presence can typically be inferred from their impacts on the sediment structure.

SPI is particularly useful in the analysis of dump sites. The extent and dispersion patterns of material can be quickly assessed and recovery rates of the bottom visually estimated. Dredge spoil material is normally of a different texture/grain size to a dump sites natural sea floor and a visual record can be made of the layering of this material over the bottom. Follow up surveys give an accurate account of recovery rates. An extensive survey over a wider area will give an accurate account of the area of dispersion.

The images were developed as diapositives (slides) and each of these were analysed using a dedicated image analyses system. The SPI parameters measured from each image include:

1) – **sediment type** measured from the upper 5 cm sediment layer.

2) – **prism penetration depth** which gives an indication of relative sediment compaction.

3) – **sediment boundary roughness** which indicates the degree of physical disturbance or biotic activity at the sediment water boundary.

4) - **depth of dredge material**, assesses the depth of dredge material covering the natural bottom.

5) – **sediment apparent redox potential discontinuity depth (ARPD)**, assesses the depth of oxygenated sediment on the bottom

6) – **infaunal successional status** which qualifies the type of animals living in the bottom.

7) – **additional parameters** such as the presence of mud clasts, epifauna (surface living animals), infaunal burrows and tubes, outgassing of sediments (due to production of hydrogen sulphide and ammonia as by-products of anaerobic metabolism) *etc.* were also assessed.

8) – calculation of **a mean sediment organism index** (OSI value) which integrates the information gained from the other parameters measured into a single index which is indicative of the health status of the location under investigation (see Appendix 3).

Surface photographs and general observations were made in the vicinity of each of the SPI stations. Photographs were taken with a Nikonos V fitted with a 15mm lens and Isotecknic Flash System. Images were recorded on 100 ASA slide film.

3. RESULTS

3.1 Dive Survey

Representative photographs from the dive survey are presented in Appendix 1.

Photographs 1-3 record bottom conditions in the middle to northern part of the dumpsite (stations 5, 6 and 7, Figure 1). The bottom in this area consisted of a relatively flat, coarse to medium sand which is formed into small (< 10 cm) sand waves. This type of bottom was also recorded during the original baseline survey in 1996 (Aqua-Fact, 1996a). Some fine dredge material was observed between the sand waves (light sediment in Photo 3). A number of hermit crabs were recorded in this area, one photographed feeding on a dead fish (Photo 1).

Photos 4-9 were taken in the vicinity of stations 8-12. The bottom consisted of a mixture of sediment types with large rock/stone areas intermingled with coarse sand waves. Patches of fine sediment, originating from the dredge spoil, were present around the larger stones. This fine material was less evident on moving in a south east direction (Photo 9, station 11). Although a whelk was observed laying eggs on a large rock (Photo 9), macrofauna were generally scarce or non existent.

Bottom conditions at stations 1-4 are imaged in Photos 10-15. The natural bottom consists of gravel of various diameters formed into waves or banks (Aqua-Fact, 1996a). However, a covering of silt (seen as a light coloured sediment) of various thickness ranging from 0.5 to 5 cm blankets the bottom. Patches of gravel, were observed through this silt. These patches were more extensive on moving to the north-west (e.g. station 1). Throughout this area, large empty oyster shells were recorded on the bottom surface, these presumably having winnowed out of the dredge material from the harbour.

3.2 Sediment Profile Imagery

Representative SPI photographs taken at the twelve stations are presented in Appendix II.

Sediment Type

The distribution of the original sediment types in and around the dredge spoil dump site as assessed from the SPI images is presented in Figure 2.

Generally, the bottom type ranges from a coarse sand gravel in the western part of the site to a coarse gravel/ rocky area to the east with a flat medium sand area in-between. This is particularly evident from the SPI images taken from each of these areas e.g. stations 1, 12 and 6, respectively.

Fine sediment (≤0.063 mm), of dredge spoil origin), was recorded at a number of stations. The distribution of this dredged material is predominantly to the west-nortwest of the site. SPI images from stations 1, 2 and 3 clearly shows the fine material covering and mixing with the natural gravel bottom. The image from station 4 was taken through a bank of this material and the uniformity in size particles e.g. ≤ 0.063 mm of this material is evident. SPI images from the remaining stations show little or no silt material present on the surface or incorporated into the bottom.

Mean Prism Penetration Depth

The mean prism penetration depth reflects both the grain size composition and compactness of the bottom deposits. Prism penetration was relatively shallow (ranging from 1.0- 4.49 cm) at stations with a coarse compact bottom e.g. 1-5, 8 and 10-12. There was no penetration into the original bottom type at station 4 with only dredged material being imaged. Penetration was relatively good (ranging from 10.89-13.24 cm) at stations 6, 7 and 9, reflecting the finer nature of the bottom type.

Surface Boundary Roughness

Surface boundary roughness is an indication of the unevenness of the sediment surface resulting from either bioturbation (animals in the sediment) or physical disturbance. This value varied considerably from station to station and this was a reflection of the uneven nature of the sediment surface which was attributed to the grain size of the sediment surface and physical disturbance caused by water movement.

Apparent Redox Potential Discontinuity (ARPD).

The apparent redox potential discontinuity (ARPD) depths (depth of aerated sediment) at each of the stations were all below the depth of penetration of the camera. Stations with deep penetration and diver observations on the remaining stations indicate that redox values are well below 10 cm and reflect a well oxygenated bottom with little organic material present.

Infaunal Successional Stage

No infauna were observed in any of the images and consequently stages could not be assigned for this parameter on biological evidence. However, tentative stages were assigned on the basis of physical disturbance and recovery from the previous dumping event. Using this format, stations 1-3 were seen as stage II over III or near recovery from a disturbance while stations 5-12 were allocated stage III status, indicating either full recovery (i.e. the bottom has reverted back to its original state) or there was no impact from the dumping disturbance.

Organism Sediment Index

Organism Sediment Index (OSI) is the sum of a series of weighted values allocated to the various physical/chemical and biological SPI parameters measured. The OSI values have a potential range of -6 to +11.

Habitat quality is defined relative to the two end-member standards of OSI values. The lowest value is given to bottom types which have (low or no dissolved oxygen in the overlying bottom water), no apparent macrofaunal life and methane gas present in the sediment. The SPI OSI value for such a condition is -6. At the other end of the scale, an aerobic bottom with a deeply depressed ARPD, evidence of a mature macrofaunal assemblage and no apparent methane gas bubbles at depth will have an SPI OSI value of +11. From experience of mapping with this parameter values of +7 to +11 are indicative of high quality habitats. In dealing with areas which are subject to organic enrichment OSI values in the range +6 to +1 generally indicate an increased input of organic material. Index values which fall in the range +1 to - 6 identify varying degrees of habitat degradation.

Apart from stations 1-4, mean organism sediment index (OSI) values were all +11 indicating healthy habitats. Stations 1-4 were allocated OSI values of 9, indicative of some degree of impaction given the high quality of the surrounding area...

4. OVERVIEW

Although silt and shell from the previous dumping event remains in the vicinity of the dumpsite (particularly to the north-west) the evidence from both surface images and sediment profile imagery indicate that the vast majority of the material deposited at this site (see Aqua-Fact, 1996b) has been dispersed. It is evident from this and previous surveys that the bottom is highly mobile with fine material being resuspended and sand and gravel waves being formed during storm events. Fine material has being incorporated into the bottom at some of the stations although, generally, this material has been dispersed from the site. The final distribution of the dredged material is unknown as a sediment distribution and resuspension model and/or an extensive photographic survey would need to be carried out to determine this with accuracy. The pattern of distribution within and around the site would suggest it has travelled in a westerly direction and although this would be in agreement with current patterns in the area, the extent and impact can not be ascertained at this time.

Few macrofaunal species were observed during the survey. However, in this type of environment, conditions are far from optimum for a stable community and a natural paucity of fauna is the norm as was recorded in the original baseline survey (Aqua-Fact, 1996a).

5. POTENTIAL IMPACT OF PROPOSED DUMPING

The results of this survey and comparisons with previous surveys would suggest that the current proposal to dump up to 490,000 m^3 of dredge spoil would have little long term impact on the general environment within the dump site. This can be inferred from the coarse nature of the bottom sediments, the mobile nature of the sediment as indicated by sediment troughs and peaks and the removal of previously deposited fine sediments and the paucity of species recorded during the present study . In addition, the species which were recorded from the dump site are mobile and are common from coastal areas allowing them to move in and out of the site freely. Although there will be a physical change of the bottom sediment immediately after dumping as recorded during the previous survey (Aqua-Fact, 1996b), the bottom composition, following an adequate recovery period, will return to a similar composition as recorded during this survey due to the strong currents and resuspension and removal of the deposited fine material.

6. FUTURE ENVIRONMENTAL SURVEYS

Following the completion of the current proposed dumping operation a further environmental survey will be undertaken at the disposal site. Similarly, prior to any further consideration of additional disposal operations at this dump site environmental surveys will be carried out prior to their authorization.

References

Aqua-Fact International Services Ltd., 1996a. Photographic and visual survey of the seabed in the areas of and around the proposed dumpsite in Waterford Harbour, 7th August, 1996.

Aqua-Fact International Services Ltd., 1996b. Photographic and visual survey of the seabed in the areas of and around the proposed dumpsite in Waterford Harbour, 15th November, 1996.

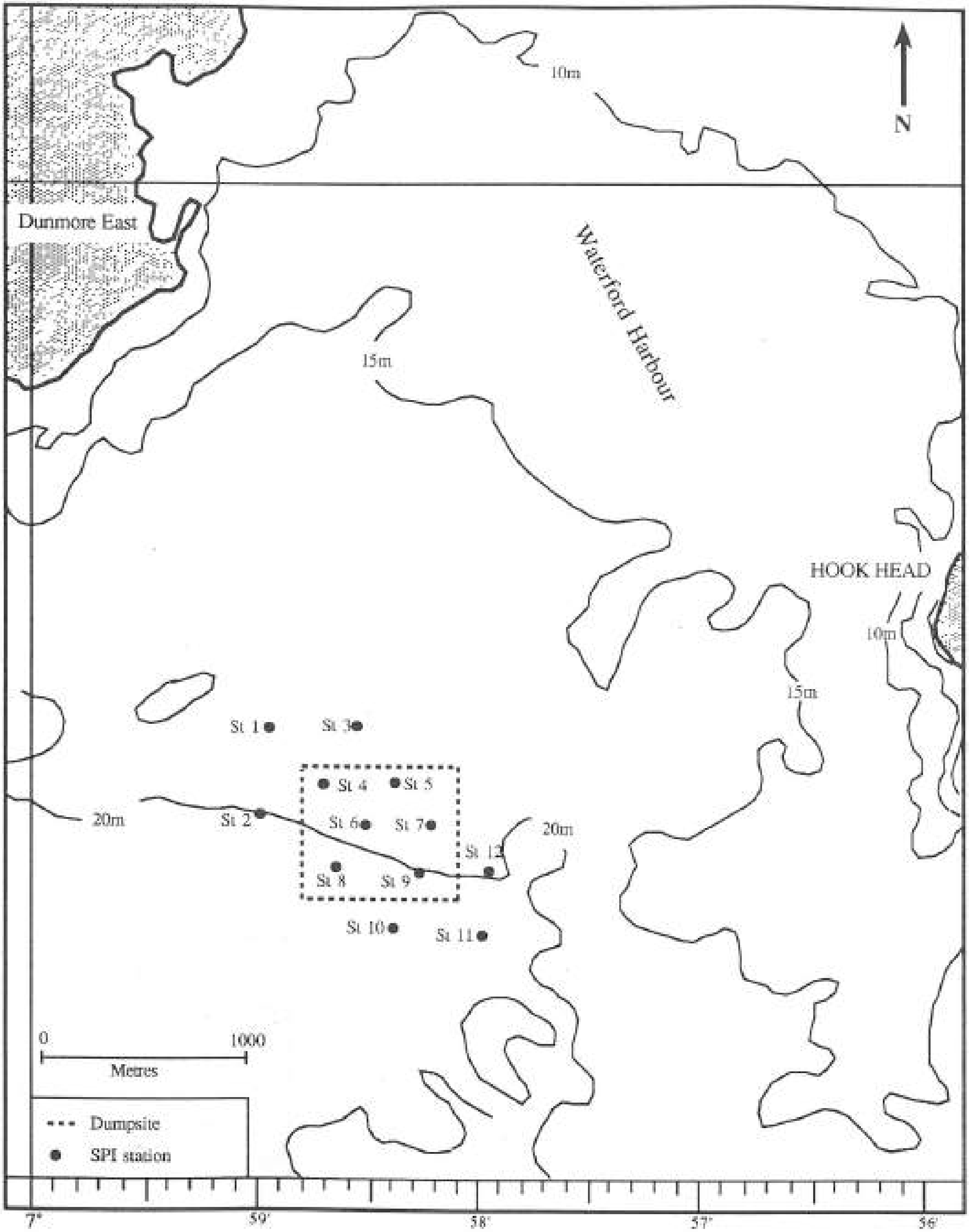


Figure 1. Sediment Profile Imager (SPI) stations in the vicinity of the dumpsite in Waterford Harbour, 30th January1999.

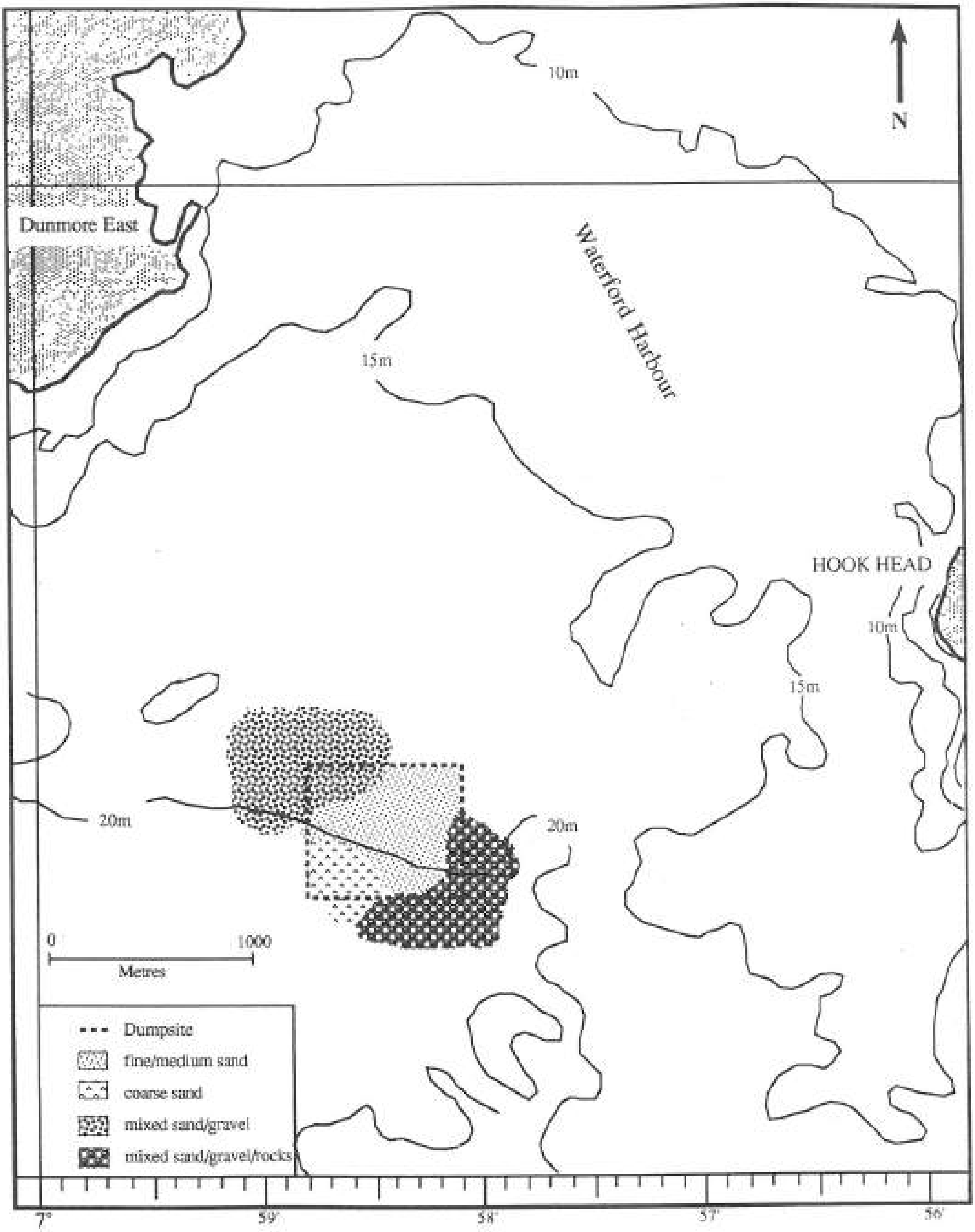


Figure 2. Original sediment type in the vicinity of the dredge spoil dump site, Waterford Harbour, 30th January1999.

Appendix I: Representative Photographs From The SPI Survey, Waterford Harbour , 30th January 1999

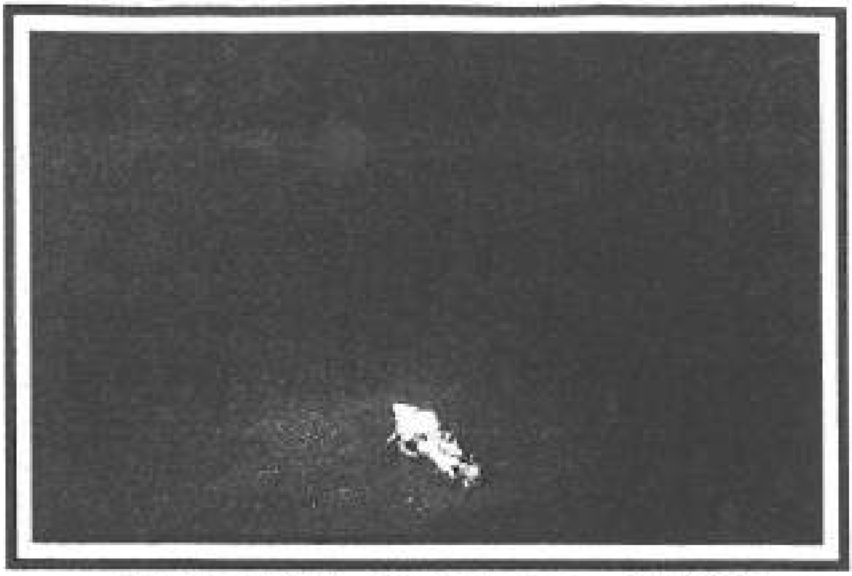


Photo 1, Waterford Harbour, 30-1-99.

Photo 2, Waterford Harbour, 30-1-99.

Photo 3, Waterford Harbour, 30-1-99.

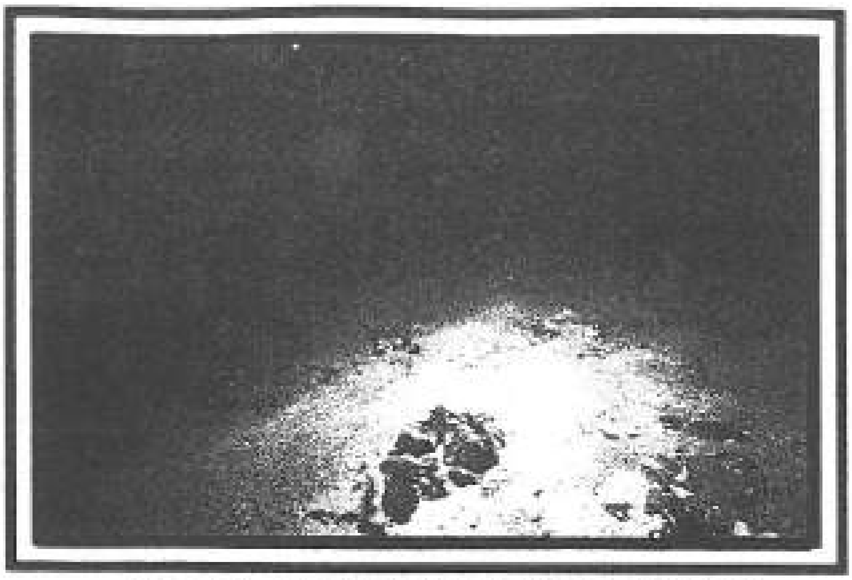


Photo 4, Waterford Harbour, 30-1-99.

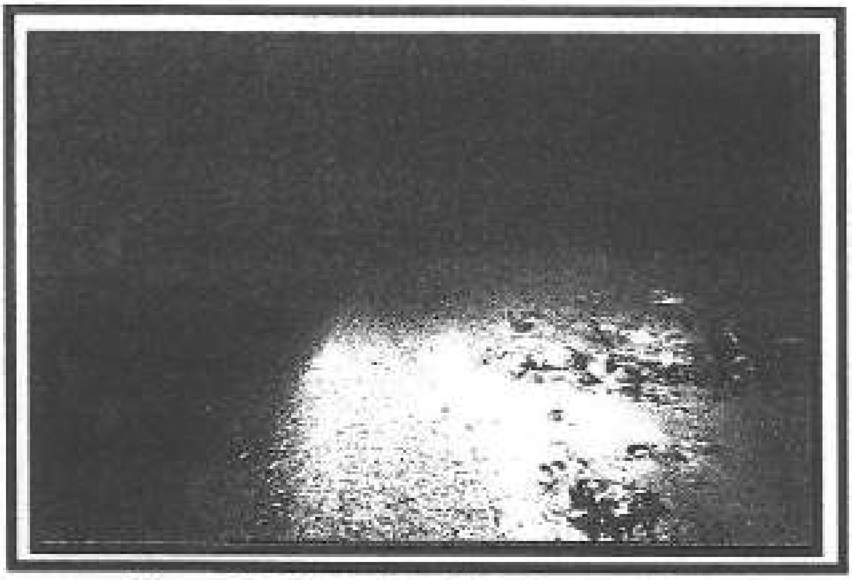


Photo 5, Waterford Harbour, 30-1-99.

Photo 6, Waterford Harbour, 30-1-99.

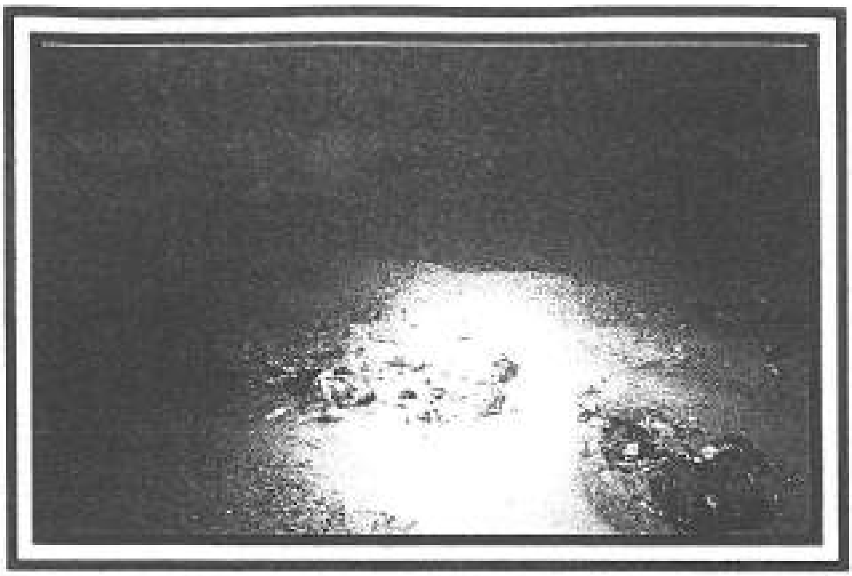


Photo 7, Waterford Harbour, 30-1-99.

Photo 8, Waterford Harbour, 30-1-99.

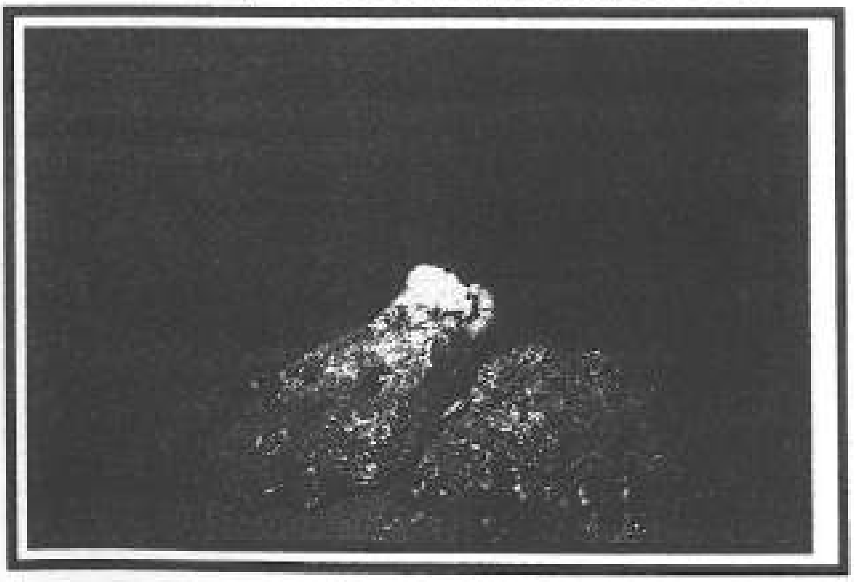


Photo 9, Waterford Harbour, 30-1-99.

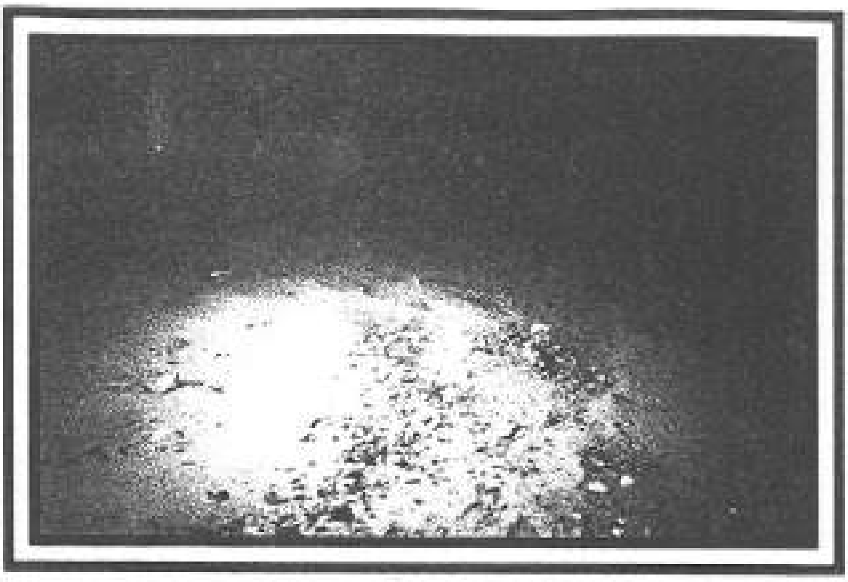


Photo 10, Waterford Harbour, 30-1-99.

Photo 11, Waterford Harbour, 30-1-99.

Photo 12, Waterford Harbour, 30-1-99.

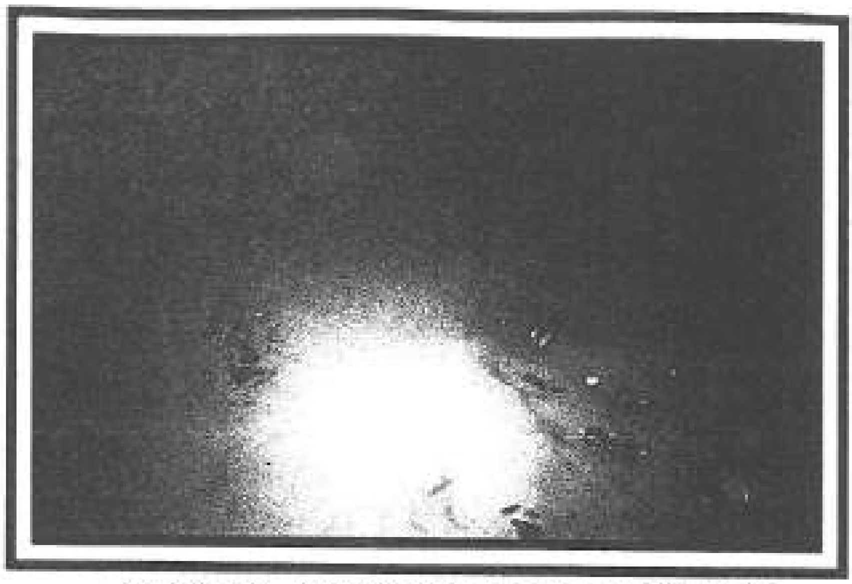


Photo 13, Waterford Harbour, 30-1-99.

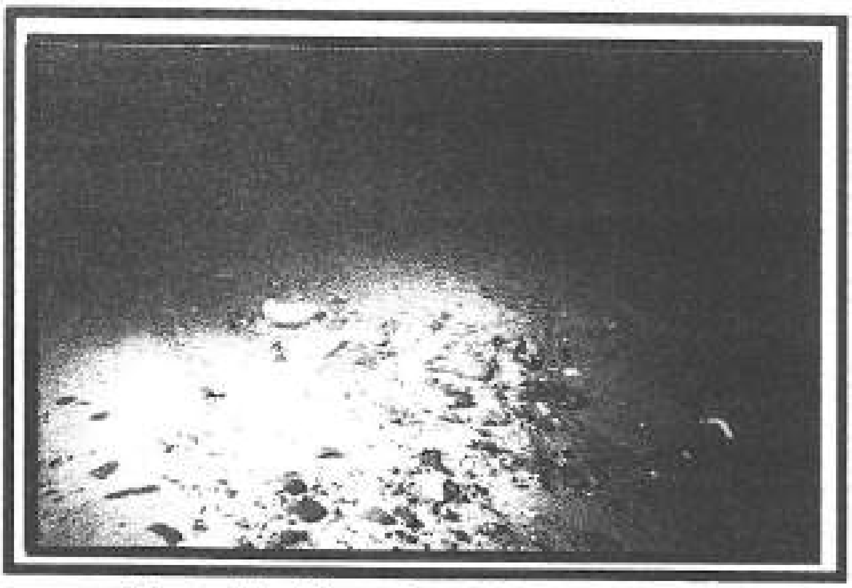
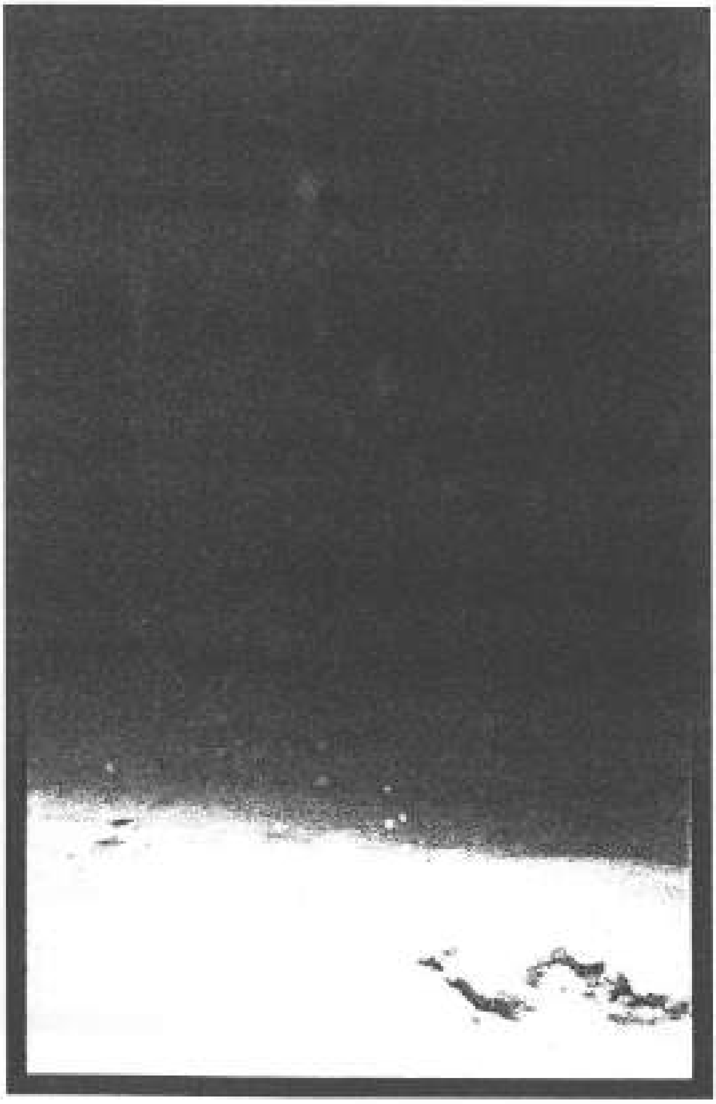


Photo 14, Waterford Harbour, 30-1-99.

Photo 15, Waterford Harbour, 30-1-99.

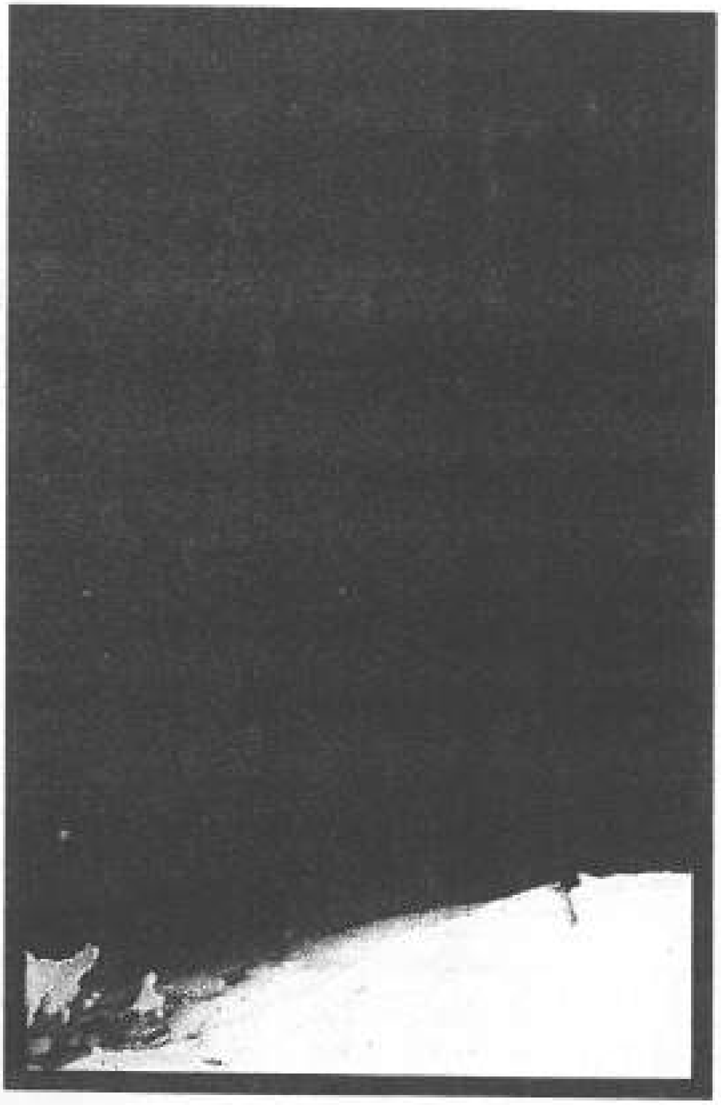
Appendix II: Representative Photographs From The Dive survey, Waterford Harbour , 30th January 1999

SPI image from station 1, Waterford Harbour, 30-1-99.

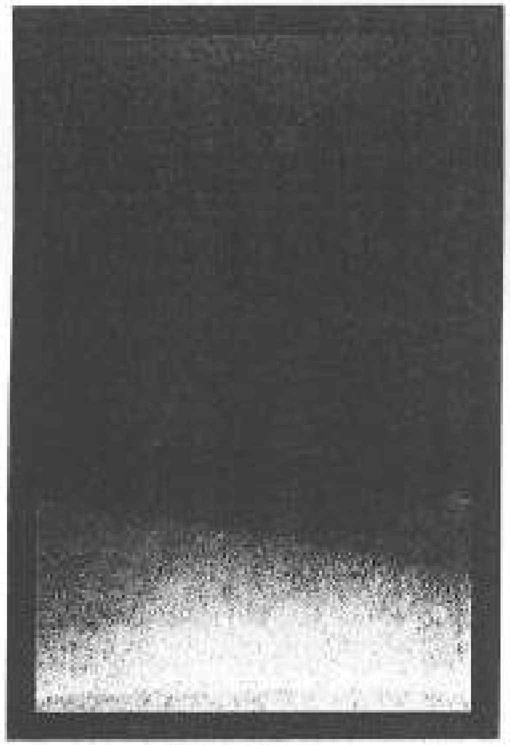


SPI image from station 2, Waterford Harbour, 30-1-99.

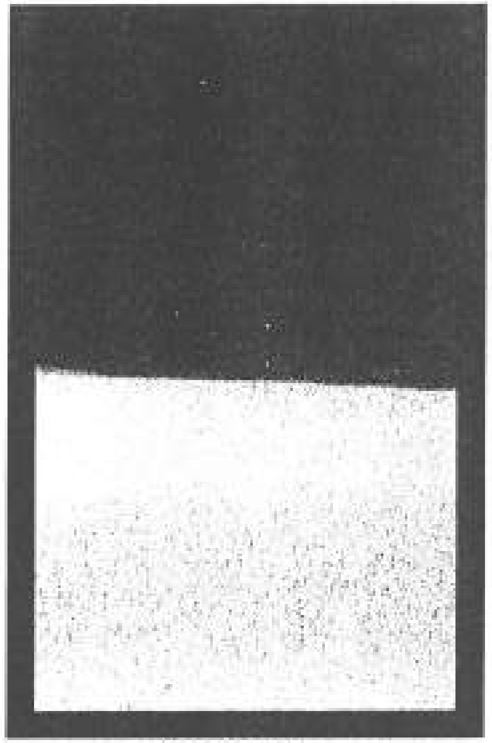
SPI image from station 3, Waterford Harbour, 30-1-99.



SPI image, station 4, Waterford Harbour, 30-1-99.

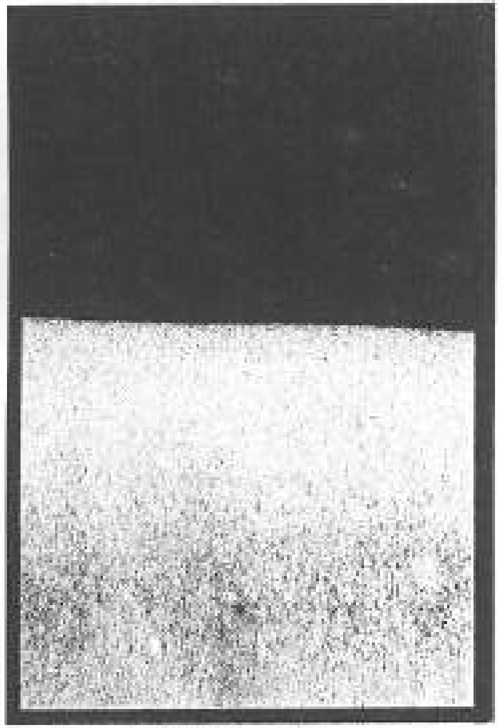


Station 5



Station 6

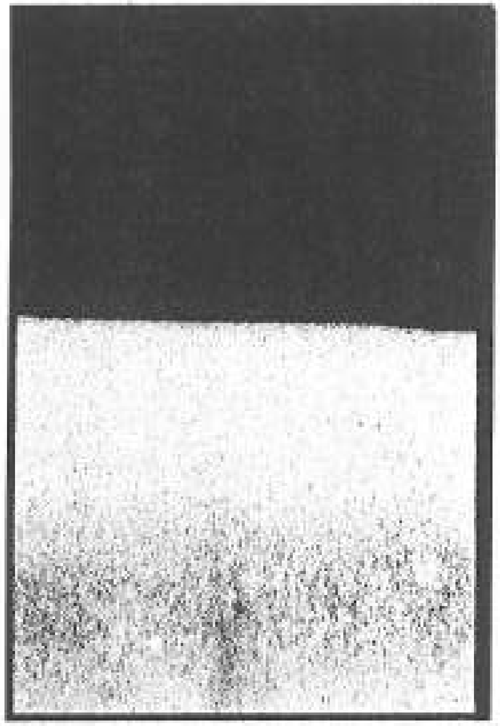
SPI images from Waterford Harbour, 30-1-99.



Station 7

Station 8

SPI images from Waterford Harbour, 30-1-99



Station 9

Station 10

SPI images from Waterford Harbour, 30-1-99.


Station 11


Station 12

SPI images from Waterford Harbour, 30-1-99.

Appendix III: Sediment Profile Imagery: apparatus and applications

SPI

SEDIMENT PROFILE IMAGERY

Sea floor mapping and monitoring technology pioneered and developed in Europe by Aqua-Fact International Services Ltd.

What is SPI?

SPI or Sediment Profile Imagery, is an innovative and cost efficient method of surveying and/or monitoring lake or marine aquatic environments with a view to establishing the environmental status of these habitats or as part of a site suitability study. The traditional method of sample collection and subsequent laboratory analysis is time consuming and expensive and data return time to the manager and/or legislator is slow. **SPI** is based on single lens reflex (SLR) camera photography and computer-based image analysis which greatly accelerates the time required to write reports and provide relevant data to the client/legislator in a matter of weeks. Aqua-Fact International is the only company offering **SPI** technology on a commercial basis in Europe and has been doing so since its foundation in 1987.

SPI image taken at 1,500m, off the Aleutian Islands USA, showing a feather star and starfish arm.

How SPI Works

SPI takes images of the upper 25cm of the sea floor for later analysis in the laboratory. Physical, chemical and biological parameters which can be measured include:

- Grain size
- Surface boundary roughness
- Mud clasts
- Redox depth
- Gas pockets
- Dredged material
- Tube types and density
- Faecal pellet layer
- Feeding voids

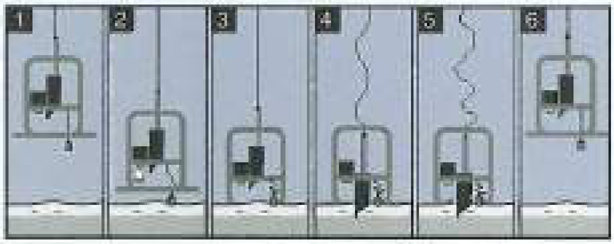
SPI image taken in the Firth of Clyde, Scotland showing tube worms and a highly variable redox discontinuity

Aqua-Fact International Services Limited

SPI

SEDIMENT PROFILE IMAGERY

To this basic system, Aqua-Fact has added an additional camera which takes a photograph of the sediment surface before the prism penetrates the sediment.



1. Deployed from boat
2. Approaching seafloor. Secondary camera triggered, taking vertical image of seafloor
3. On the seafloor
4. "Down" position intersecting the sediment-water interface. SPI camera is triggered
5. After a short time delay to allow full penetration SPI camera captures image
6. The machine is raised from the seafloor and the process is repeated to obtain replicate

Advantages of SPI

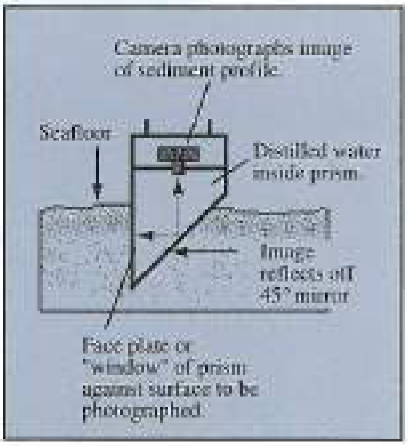
With the growing requirements for environmental impact assessment and monitoring, **SPI** provides State Authorities, commercial enterprises and engineering consultants with an up-to-date and high technology technique in assessing the status of the habitat in question. It also provides the user with a very cost-effective and rapid survey method which gives a significant competitive edge to the contract price.

SPI, SLR system being deployed in the Aegean Sea

Technical Details

- SLR camera depth rated to 4,000m
- Digital camera depth rated to 4,000m
- Diver operated camera for use in waters *c.* 40m
- Up to 120 images can be captured on each deployment
- Image capture and recycle time is approximately 1 minute
- Image quality is not impaired by water turbidity

Diver operated SPI being used to monitor organic enrichment on fish farms in Norway



SPI has been successfully deployed by Aqua-Fact in the following range of surveys:

- **Impact Surveys of Aquaculture** Ireland, Scotland, Norway, Italy and Greece
- **Dredge Disposal Surveys** Ireland, France
- **Sewage Disposal Studies** Ireland, Scotland, Greece
- **Cold Seep surveys** Ireland, Aleutian Trench
- **Macrofaunal studies** Ireland, France, Balearic Islands, Spain, Barents Sea, Aleutian Trench, Adriatic Sea

Aqua Fact

Aqua-Fact International Services Limited

[redacted]

APPENDIX F-4

Marine Sediment and Benthic Studies
Waterford Harbour
Dredging and Disposal Operations

Produced by

AQUAFACT International Services Ltd

On behalf of

Port of Waterford Company

November 2017

AQUAFACT INTERNATIONAL SERVICES LTD.,

[redacted]

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1. Introduction

The Port of Waterford Company is applying to the Department of Environment, Community and Local Government (Foreshore Unit) to carry out a dredging regime within the port for the period 2018-2026. In addition, a Dumping at Sea (DaS) permit is being sought from the EPA to allow the dredged material to be disposed of in the designated spoil ground outside the harbour. The Port of Waterford's current dredging and disposal at sea regime is licensed by Permit No. S0012-02 and covers the period 2014 to 2021. The disposal site is currently licensed for the 2014-2021 campaign to dispose dredge material excavated from Waterford Port. This new license is being sought within the active license period as two areas of dredging require extending for navigational safety and some minor increase in disposal tonnages are requested.

AQUAFACT International Services Ltd. was commissioned by the Port of Waterford Company to carry out a subtidal benthic survey of Waterford Harbour and the spoil ground in 2013 as part of the previous foreshore licence and DaS application (Permit No. S0012-02). This report provides a recap of the 2013 subtidal benthic survey which is still relevant as a baseline study for the current application and an update to the sediment chemistry section following the collection of sediment samples at the request of the Marine Institute in order to determine suitability for disposal at sea.

Figures 2.1 and 2.2 shows the locations of the dredge areas within Waterford Harbour and the location of the spoil disposal site.

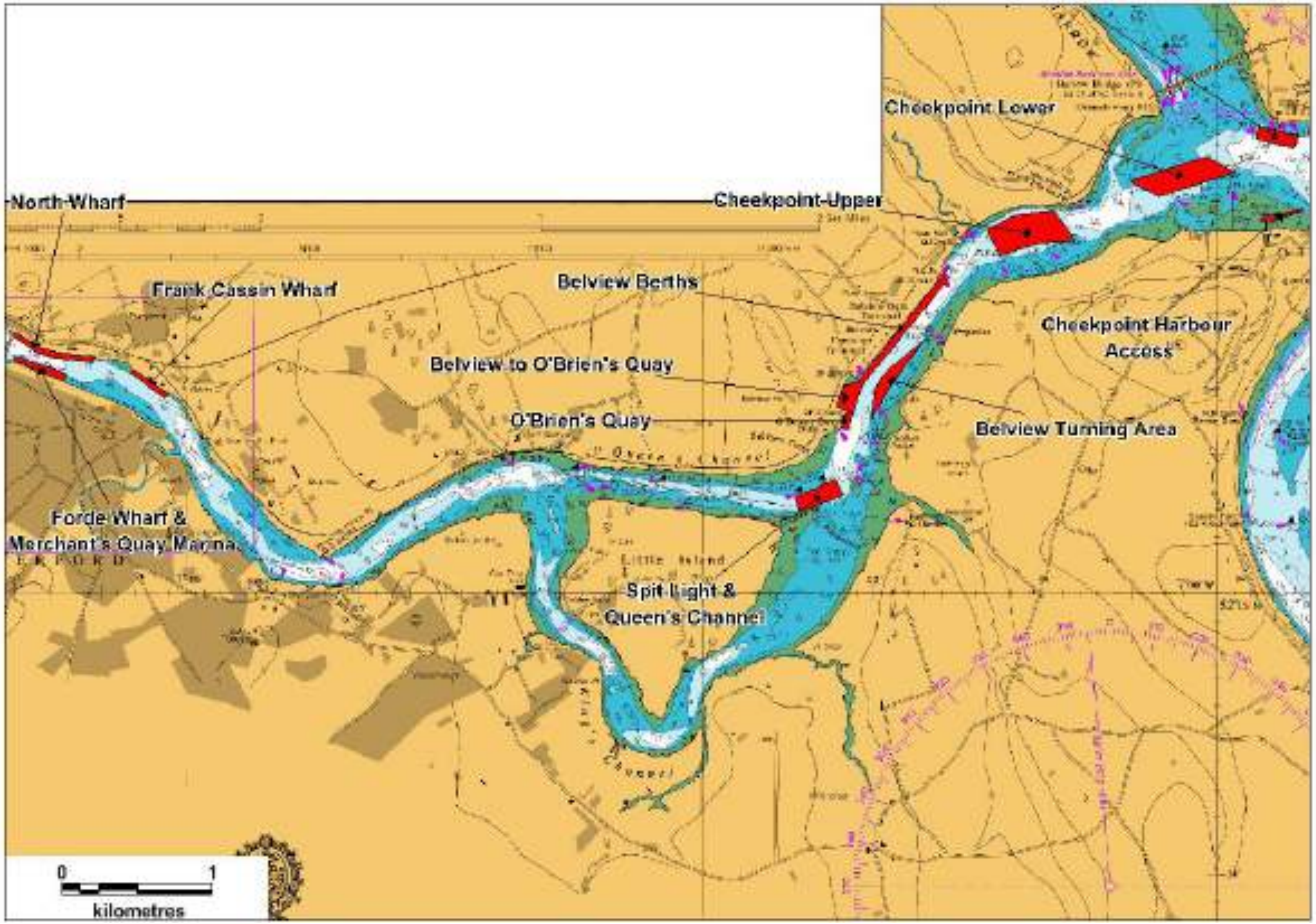

Figure 1.1: Location of Waterford Port's dredge sites in the Inner Harbour.

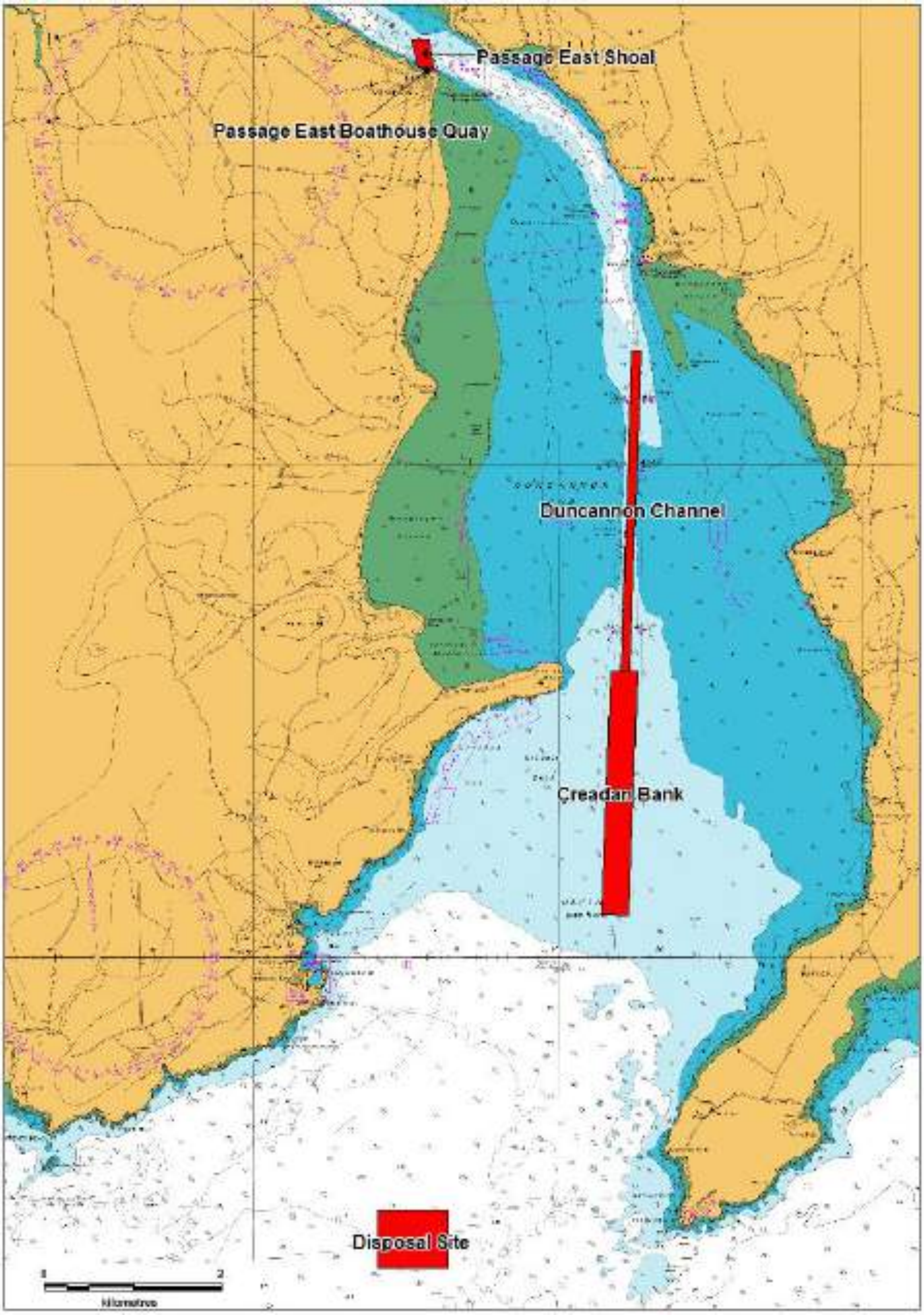

Figure 1.2: Location of Waterford Port's dredge site in the Outer Harbour and the spoil disposal site.

2. Faunal Benthic Survey

2.1. Materials & Methods

2.1.1. Sampling Procedure

To carry out the subtidal benthic assessment of the Waterford Harbour area, AQUAFACT sampled a total of 9 stations. The location of the sampling sites can be seen in Figure 2.1 and the station coordinates can be seen in Table 2.1. Sampling took place on the 10th April 2013 from AQUAFACT's 6.8m Lencraft RIB. A Foreshore License was granted by the Department of the Environment, Community and Local Government to carry out the grab sampling. There was a southwesterly force 4-5 breeze blowing with a swell outside the harbour.

AQUAFACT has in-house standard operational procedures for benthic sampling and these were followed for this project. Additionally, the recently published MESH report on "Recommended Standard methods and procedures" was adhered to.

A 0.025m^2 Day grab was used to sample Waterford Harbour. On arrival at each sampling station, the vessel location was recorded using DGPS (lat/long). Additional information such as date, time, site name, sample code and depth were recorded in a data sheet.

Two replicate grab samples were taken at the faunal stations and a third for sediment grain size and organic carbon analysis. The grab deployment and recovery rates did not exceed 1 metre/sec. This was to ensure minimal interference with the sediment surface as the grab descended. Upon retrieval of the grab a description of the sediment type was noted in the sample data sheet. Notes were also made on colour, texture, smell and presence of animals.

A digital image of each sample (including sample label) was taken and its reference number entered in the sample data sheet. These images can be seen in Appendix 1. The grab sampler was cleaned between stations to prevent cross contamination.

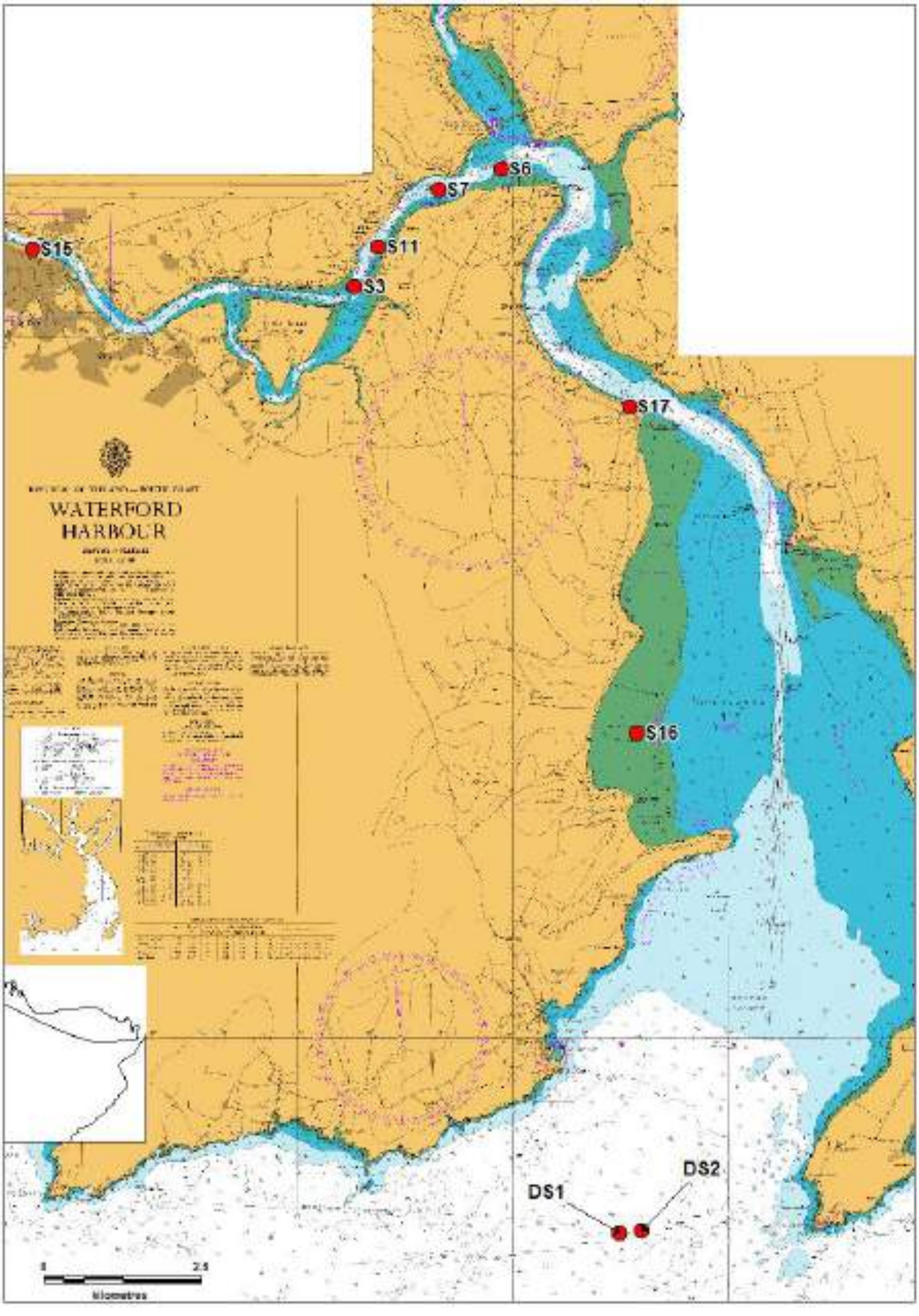

Figure 2.1: Location of faunal stations sampled on the 10th April 2013.

Table 2.1: Station coordinates and depths

Station	Longitude	Latitude	Easting	Northing	Depth (m)
S3	-7.03923	52.25812	265655.9	112204.7	12
S6	-7.00383	52.27449	268048.2	114059.3	9.5
S7	-7.01883	52.2702	267030.6	113567.9	2.3
S11	-7.03244	52.26337	266111.9	112795.4	9.5
S15	-7.11289	52.26288	260619.8	112670.6	2.1
S16	-6.97226	52.19394	270330.2	105126	2.2
S17	-6.97392	52.24057	270143.5	110313.1	4.5
DS1	-6.9764	52.1224	270159.4	97162.09	18.9
DS2	-6.97131	52.1227	270507.6	97200.4	16.1

The samples collected for faunal analysis were carefully and gently sieved on a 1mm mesh sieve as a sediment water suspension for the retention of fauna. Great care was taken during the sieving process in order to minimise damage to taxa such as spionids, scale worms, phyllodocids and amphipods. The sample residue was carefully flushed into a pre-labelled (internally and externally) container from below. Each label contained the sample code and date. The samples were stained immediately with Eosin-briebrich scarlet and fixed immediately in with 4% w/v buffered formaldehyde solution (10% w/v buffered formaldehyde solution for very organic mud). These samples were ultimately preserved in 70% alcohol upon return to the laboratory.

In addition to the grab sampling at the two stations located in the spoil disposal site (DS1 and DS2), a drop-down video camera was also deployed to capture footage of the disposal site.

2.1.2. Sample Processing

All faunal samples were placed in an illuminated shallow white tray and sorted first by eye to remove large specimens and then sorted under a stereo microscope (x 10 magnification). Following the removal of larger specimens, the samples were placed into Petri dishes, approximately one half teaspoon at a time and sorted using a binocular microscope at x25 magnification.

The fauna was sorted into four main groups: Polychaeta, Mollusca, Crustacea and others. The 'others' group consisted of echinoderms, nematodes, nemerteans, cnidarians and other lesser phyla. The fauna were maintained in stabilised 70% industrial methylated spirit (IMS) following retrieval and identified to species level where practical using a binocular microscope, a compound microscope and all relevant taxonomic keys. After identification and enumeration, specimens were separated and stored to species level.

The sediment granulometric analysis was carried out by AQUAFACT using the traditional granulometric approach. Traditional analysis involved the dry sieving of approximately 100g of sediment using a series of Wentworth graded sieves. The process involved the separation of the sediment fractions by passing them through a series of sieves. Each sieve retained a fraction of the sediment, which were later weighed and a percentage of the total was calculated. Table 2.2 shows the classification of sediment particle size ranges into size classes. Sieves, which corresponded to the range of particle sizes (Table 2.2), were used in the analysis. Appendix 2 provides the detailed granulometric methodology.

Table 2.2: The classification of sediment particle size ranges into size classes (adapted from Buchanan, 1984)

Range of Particle Size	Classification	Phi Unit
<63µm	Silt/Clay	>4 Ø
63-125 µm	Very Fine Sand	4 Ø, 3.5 Ø
125-250 µm	Fine Sand	3 Ø, 2.5 Ø
250-500 µm	Medium Sand	2 Ø, 1.5 Ø
500-1000 µm	Coarse Sand	1 Ø, 1.5 Ø
1000-2000 µm (1 – 2mm)	Very Coarse Sand	0 Ø, -0.5 Ø
2000 – 4000 µm (2 – 4mm)	Very Fine Gravel	-1 Ø, -1.5 Ø
4000 -8000 µm (4 – 8mm)	Fine Gravel	-2 Ø, -2.5 Ø
8 -64 mm	Medium, Coarse & Very Coarse Gravel	-3 Ø to -5.5 Ø
64 – 256 mm	Cobble	-6 Ø to -7.5 Ø
>256 mm	Boulder	< -8 Ø

The additional sediment samples collected from the faunal stations had their organic carbon analysis performed by ALS Laboratories in Loughrea using the Loss on Ignition method. Appendix 2 provides the methodology.

2.1.3. Data Analysis

Statistical evaluation of the faunal data was undertaken using PRIMER v.6 (Plymouth Routines in Ecological Research). Univariate statistics in the form of diversity indices are calculated. Numbers of species and numbers of individuals per sample will be calculated and the following diversity indices will be utilised:

1) Margalef's species richness index (D) (Margalef, 1958),

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals

S is the number of species

2) Pielou's Evenness index (J) (Pielou, 1977)

$$J = \frac{H'(\text{observed})}{H'_{max}}$$

where: H'_{max} is the maximum possible diversity, which could be achieved if all species were equally abundant (= $\log_2 S$)

3) Shannon-Wiener diversity index (H') (Pielou, 1977)

$$H' = -\sum_{i=1}^{S} p_i(\log_2 p_i)$$

where: p_I is the proportion of the total count accounted for by the i^{th} taxa

4) Simpson's Diversity Index (Simpson, 1949)

$$1-\lambda' = 1-\{\Sigma_i N_i(N_i-1)\} / \{N(N-1)\}$$

where N is the number of individuals of species i.

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The Shannon-Wiener index incorporates both species richness and the evenness component of diversity (Shannon & Weaver, 1949) and Simpson's index is a more explicit measure of the latter, i.e. the proportional numerical dominance of species in the sample (Simpson, 1949).

The PRIMER programme (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. All species/abundance data from the grab surveys was square root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER ®. The square root transformation was used in order to allow the intermediate abundant species to play a part in the similarity calculation. All species/abundance data from the samples was used to prepare a Bray-Curtis similarity matrix. The similarity matrix was then be used in classification/cluster analysis. The aim of this analysis was to find "natural groupings' of samples, i.e. samples within a group that are more similar to each other, than they are similar to samples in different groups (Clarke & Warwick, *loc. cit.*). The PRIMER programme CLUSTER carried out this analysis by successively fusing the samples into groups and the groups into larger clusters, beginning with the highest mutual similarities then gradually reducing the similarity level at which groups are formed. The result was represented graphically in a dendrogram, the x-axis representing the full set of samples and the y-axis representing similarity levels at which two samples/groups are said to have fused. SIMPROF (Similarity Profile) permutation tests were incorporated into the CLUSTER analysis to identify statistically significant evidence of genuine clusters in samples which are *a priori* unstructured.

The Bray-Curtis similarity matrix was also be subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskal & Wish, 1978), using the PRIMER programme MDS. This programme produced an ordination, which is a map of the samples in two- or three-dimensions, whereby the placement of samples reflects the similarity of their biological communities, rather than their simple geographical location (Clarke & Warwick, 2001). With regard to stress values, they give an indication of how well the multi-dimensional similarity matrix is represented by the two-dimensional plot. They are calculated by comparing the interpoint distances in the similarity matrix with the corresponding interpoint distances on the 2-d plot. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase, not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient). Clarke & Warwick (*loc. cit.*) have provided a classification of the reliability of MDS plots based on stress values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for 2-d ordinations of the type used in this study. Their classification is given below:

- Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.
- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful 2-d picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.

- Stress values > 0.30: The data points are close to being randomly distributed in the 2-d ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. In the case of this study, the moderate number of data points indicates that the stress value can be interpreted more or less directly. While the above classification is arbitrary, it does provide a framework that has proved effective in this type of analysis.

The species, which are responsible for the grouping of samples in cluster and ordination analyses, were identified using the PRIMER programme SIMPER (Clarke & Warwick, 1994). This programme determined the percentage contribution of each species to the dissimilarity/similarity within and between each sample group.

2.2. Results

2.2.1. Community Analysis

The taxonomic identification of the benthic infauna across all 9 stations sampled in Waterford Harbour and the spoil ground yielded a total count of 54 taxa ascribed to 7 phyla. Of the 54 taxa, 2 could not be enumerated due to their colonial nature and the remaining 52 taxa consisted of 1,381 individuals. Of the 54 taxa identified, 35 were identified to species level. The remaining 19 could not be identified to species level for the following reasons: 6 were juveniles, 10 were partial/damaged and 3 were indeterminate. Appendix 3 shows the faunal abundances from the Waterford Harbour and the spoil ground.

Of the 54 taxa present, 20 were annelids (segmented worms), 16 were crustaceans (crabs, shrimps, prawns), 13 were molluscs (mussels, cockles, snails etc.), 2 were colonial bryozoans (moss animals), 1 was an echinoderm (brittlestars, sea cucumbers), 1 was a nemertean (ribbon worm) and 1 was a nematode (round worm).

2.2.1.1. UNIVARIATE ANALYSIS

The colonial bryozoans that could not be enumerated were removed prior to statistical analysis. Univariate statistical analyses were carried out on the combined station-by-station faunal data. The following parameters were calculated and can be seen in Table 2.3: taxon numbers, number of individuals, richness, evenness, Shannon-Weiner diversity and Simpson's Diversity. Taxon numbers ranged from 3 (S15) to 18 (DS1). Number of individuals ranged from 3 (S15) to 1,016 (S3). Richness ranged from 1.53 (S11) to 4.2 (DS1). Evenness ranged from 0.27 (S3) to 1 (S15). Shannon-Weiner diversity ranged from 1.09 (S3) to 3.1 (DS1). Simpson's diversity ranged from 0.29 (S3) to 1 (S15).

Table 2.3: Univariate measures of community structure.

Station	No. Taxa	No. Individuals	Richness	Evenness	Shannon-Weiner Diversity	Simpson's Diversity
S3	16	1016	2.17	0.27	1.09	0.29
S6	7	13	2.34	0.95	2.66	0.90
S7	11	167	1.95	0.62	2.15	0.70
S11	7	51	1.53	0.62	1.74	0.63
S15	3	3	1.82	1.00	1.58	1.00
S16	7	18	2.08	0.75	2.10	0.69
S17	6	12	2.01	0.88	2.28	0.82
DS1	18	57	4.20	0.74	3.10	0.81
DS2	12	44	2.91	0.66	2.36	0.67

2.2.1.2. MULTIVARIATE ANALYSIS

The same data set used above for the univariate analyses was also used for the multivariate analyses. The dendrogramme and the MDS plot can be seen in Figures 2.2 and 2.3 respectively. SIMPROF analysis revealed 6 statistically significant groupings between the 9 stations (the samples connected by red lines cannot be significantly differentiated). The stress level on the MDS plot indicates a good representation of the data with no real prospect of misinterpretation of overall structure.

A clear divide can be seen between those stations in the outer harbour and spoil ground (S16, DS1 and DS2; Groups e and f) and those in the inner harbour inside Passage East (S3, S6, S7, S11, S15 and S17; Groups a to d).

Group f (spoil ground stations DS1 and DS2) had a 52.17% similarity level. This group contained 23 taxa comprising 101 individuals. Of the 23 species, 17 were present twice or less. One colonial epifaunal species were observed at these stations. The SIMPER analysis revealed that 4 species accounted for c. 75% of the within group similarity: the polychaete *Magelona johnstoni* (40.16%), the bivalve mollusc *Abra* sp. (juvenile) (14.5%), the cumacean crustacean *Pseudocuma longicornis* (11.84%) and the polychaete *Magelona* sp. (partial/damaged) (8.37%). These two stations had the highest richness and diversity levels. Table 2.4 shows the full SIMPER results. This group conforms to the JNCC habitat SS.SSA.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (EUNIS Code: A5.242).

Group e contained only station S16 and separated from **Group f** at a 5.41% similarity level. This group contained 7 taxa comprising 18 individuals. Of the 7 species, 6 were present twice or less. Four species accounted for c. 83% of the faunal abundance of this group: the amphipod crustacean *Bathyporeia elegans* (55.6%), the polychaete *Nephtys* sp. (partial/damaged) (11.1%), the cumacean crustacean *Vaunthompsonia cristata* (11.1%) and the polychaete *Owenia fusiformis* (5.6%). As there was only 1 station in this group, SIMPER analysis could not be carried out. Richness and diversity values were low for this station. This group conforms to the JNCC habitat SS.SSA.IFiSa.NcirBat *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (EUNIS Code: A5.233).

These two groups separated from all other groups at a 2.97% similarity level. Stations S6 and S17 formed **Group c** at a 55.64% similarity level. This group contained 9 taxa comprising 25 individuals. Of the 9 species, 5 were present twice or less. Two colonial epifaunal species were observed at these stations. The SIMPER analysis revealed that 4 species accounted for 100% of the within group similarity: the oligochaetes *Tubificoides pseudogaster* agg. (29.3%) and *T. benedii* (29.3%), the polychaete *Nephtys hombergii* (20.7%) and the bivalve mollusc *Macoma balthica* (20.7%). These two stations had moderate richness and diversity levels. Table 2.4 shows the full SIMPER results. This group conforms to the JNCC habitat SS.SMU.SMuVS.NhomTubi *Nephtys hombergii* and *Tubificoides* spp. in variable salinity infralittoral soft mud (EUNIS Code: A5.323).

Group d separated from **Group c** at a 28.04% similarity level. **Group d** had a 49.39% similarity level and contained stations S7 and S11. This group contained 14 taxa comprising 218 individuals. Of the 14 species, 9 were present twice or less. The SIMPER analysis revealed that 3 species accounted for just over 91% of the within group similarity: the polychaete *Capitella* sp. complex (42.5%) and the oligochaetes *Tubificoides pseudogaster* agg. (37%) and *T. benedii* (12%). These two stations had low to moderate richness and diversity levels. Table 2.4 shows the full SIMPER results. This group conforms to the JNCC habitat SS.SMU.SMuVS.CapTubi *Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment (EUNIS Code: A5.325).

Group b which only contained station S3 separated from **Groups c** and **d** at a 17.98% similarity level. This group contained 16 taxa comprising 1,016 individuals. Of the 16 species, 8 were present twice or less. One species accounted for c. 84% of the faunal abundance of this group: the oligochaete

Tubificoides benedii. As there was only 1 station in this group, SIMPER analysis could not be carried out. Richness levels were moderate at this station and diversity levels were low due to the dominance by one species. This group conforms to the JNCC habitat SS.SMU.SMuVS.OlVS Oligochaetes in variable or reduced salinity infralittoral muddy sediment (EUNIS Code: A5.326).

Group a, which contained only station S15 separated from **Groups b**, **c** and **d** at a 6.63% similarity level. This group contained 3 taxa comprising 3 individuals. All three taxa were only present once. This was an extremely species impoverished site. The species present were: Nematoda, the amphipod crustacean *Corophium volutator* and the isopod crustacean *Cyathura carinata.* As there was only 1 station in this group, SIMPER analysis could not be carried out. Richness and diversity levels were low at this station. This group conforms to the JNCC habitat SS.SMU.SMuVS.MoMu Infralittoral fluid mobile mud (EUNIS Code: A5.324).

Figure 2.4 shows the distribution of the faunal groups through the Waterford Harbour area.

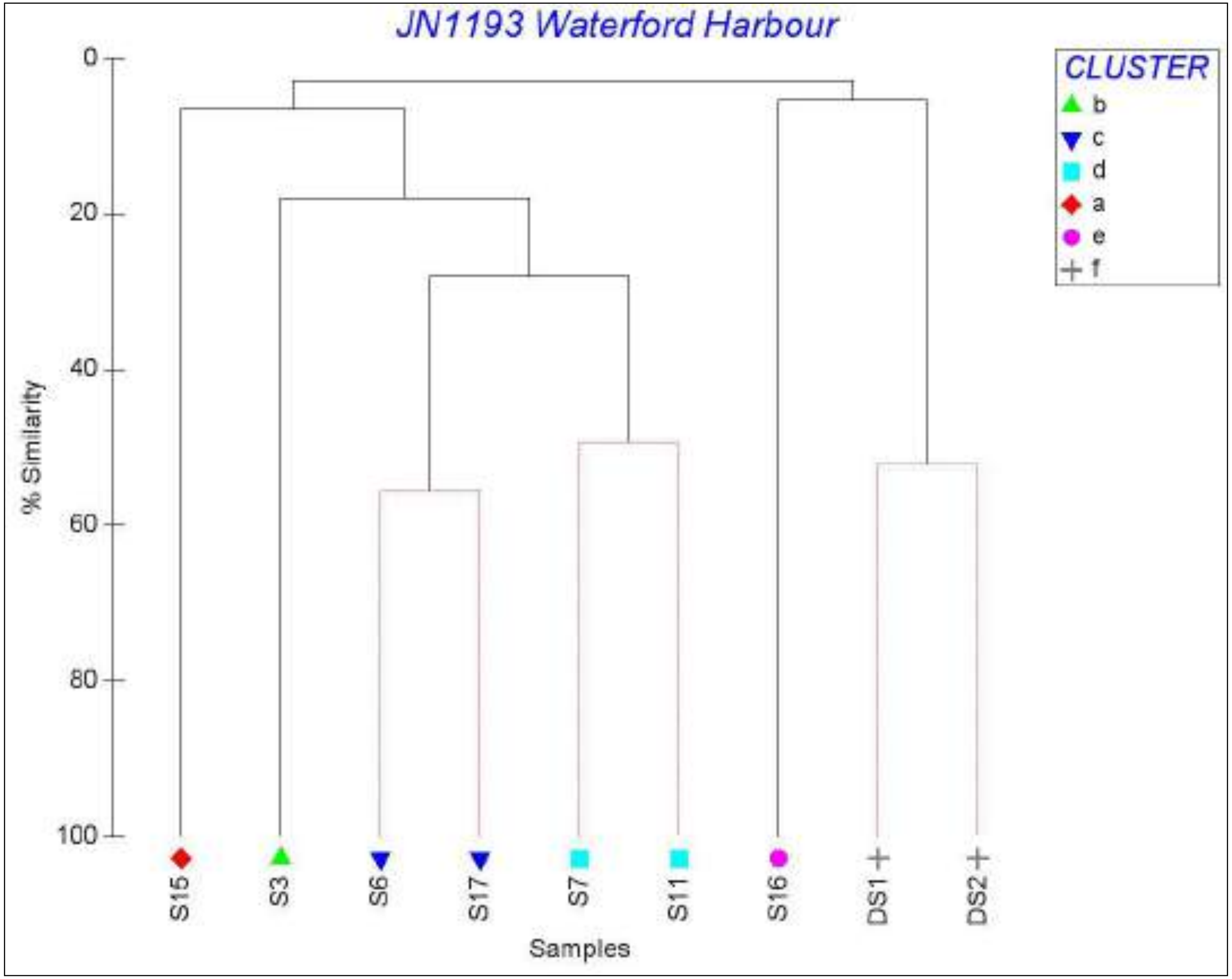

Figure 2.2: Dendrogram produced from Cluster analysis.

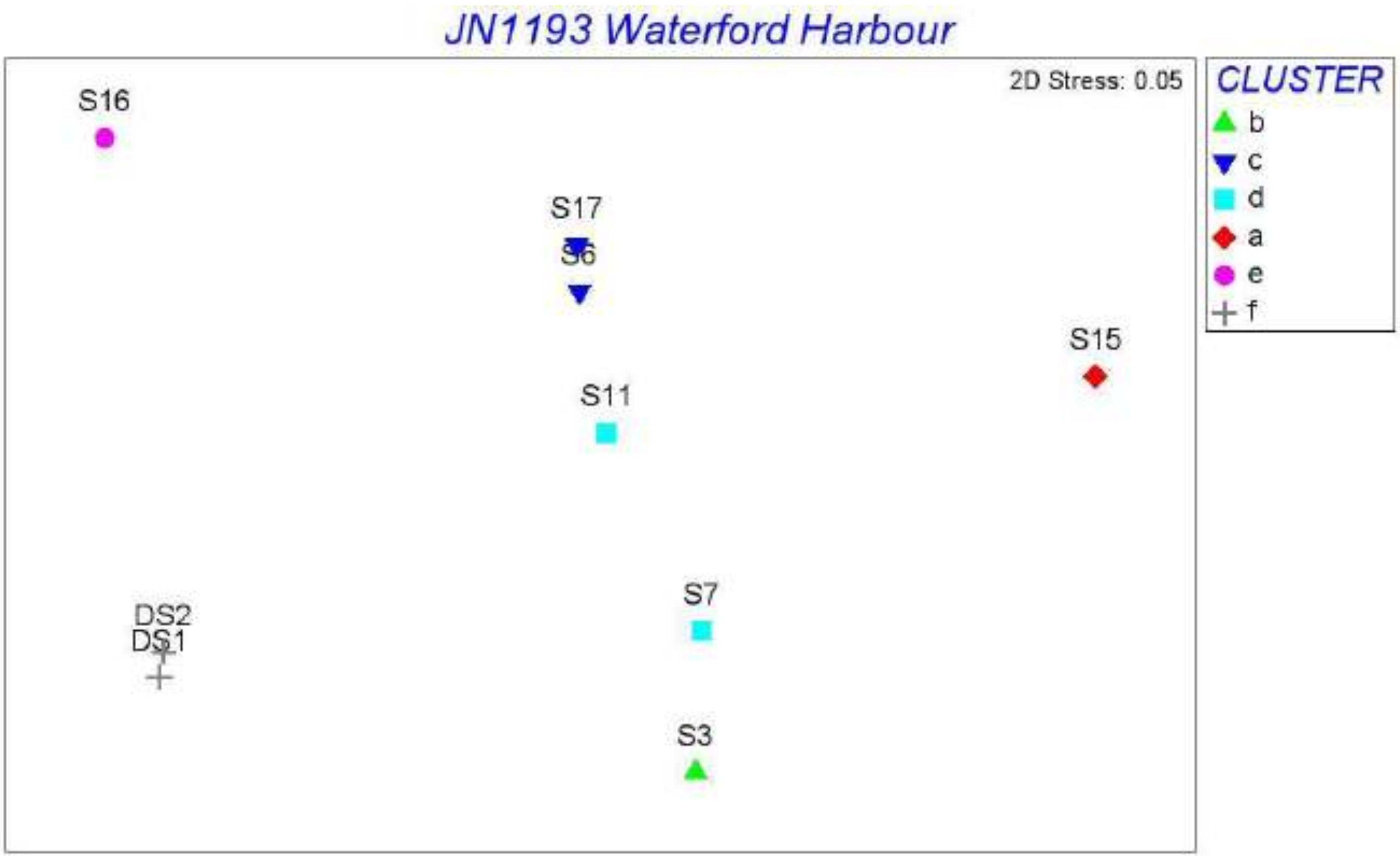

Figure 2.3: MDS plot.

Table 2.4: SIMPER Results

Group a Less than 2 samples in group					
Group b Less than 2 samples in group					
Group c Average similarity 55.64%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Tubificoides pseudogaster aggregate	1.57	16.3	#######	29.29	29.29
Tubificoides benedii	1.41	16.3	#######	29.29	58.58
Nephtys hombergii	1	11.52	#######	20.71	79.29
Macoma balthica	1.37	11.52	#######	20.71	100
Group d Average similarity 49.39%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Capitella sp. complex	6.37	20.98	#######	42.47	42.47
Tubificoides pseudogaster aggregate	6.24	18.29	#######	37.02	79.49
Tubificoides benedii	2.64	5.93	#######	12.01	91.51
Group e Less than 2 samples in group					
Group f Average similarity 52.17%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Magelona johnstoni	4.9	20.95	#######	40.16	40.16
Abra sp. (juvenile)	2.45	7.57	#######	14.5	54.66
Pseudocuma longicornis	1.57	6.18	#######	11.84	66.51
Magelona sp. (partial/damaged)	1.62	4.37	#######	8.37	74.88
Perioculodes longimanus	1	4.37	#######	8.37	83.25
Diastylis sp. (partial/damaged)	1.37	4.37	#######	8.37	91.63

####### indicates that Sim/SD could not be calculated as there was only 2 stations in the group.

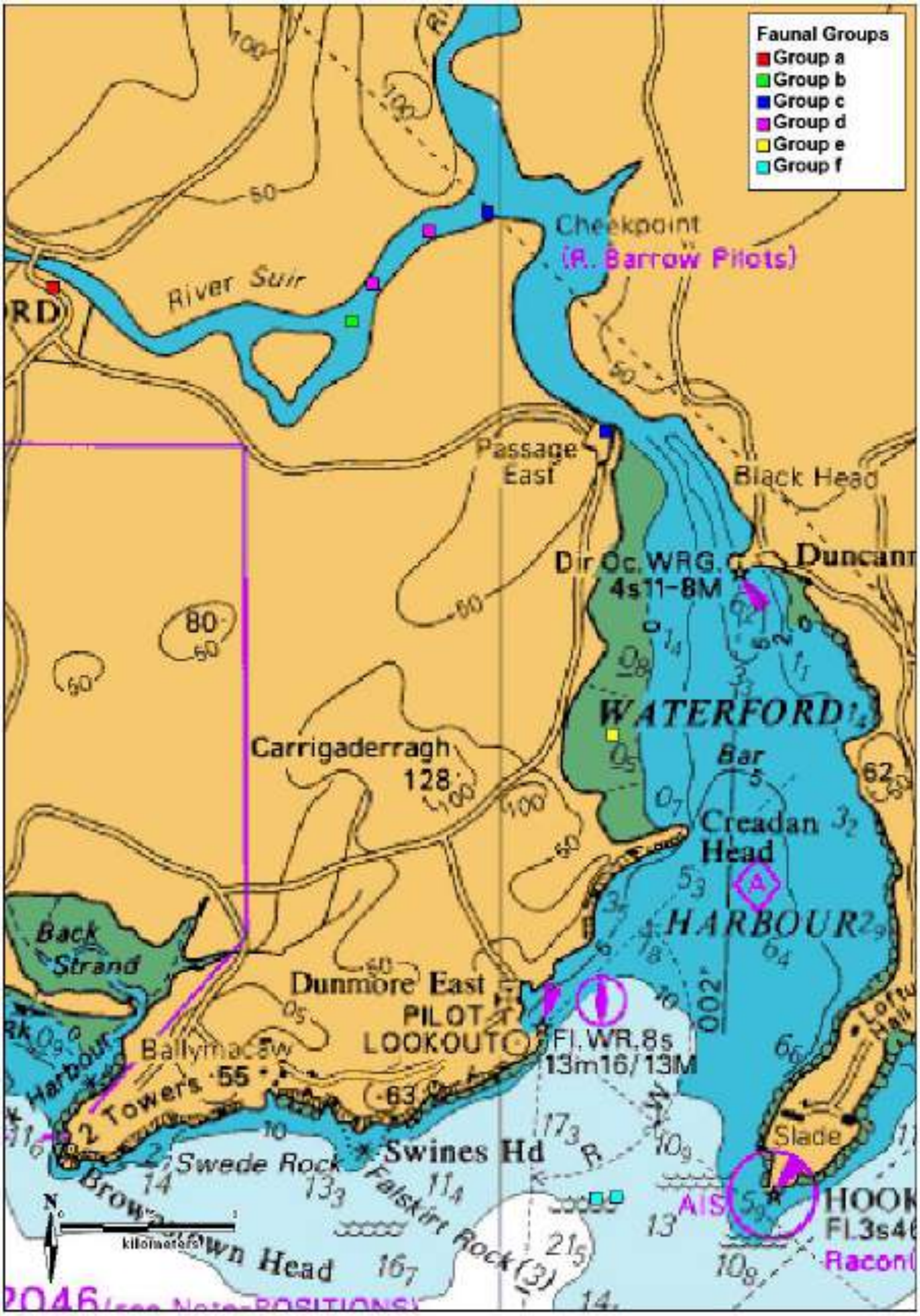

Figure 2.4: Location of faunal groupings in the Waterford Harbour area.

2.2.2. Community Sediment Characteristics

Table 2.5 shows the sediment characteristics of the faunal stations. Station S15 contained the highest percentage of gravel (5.1%), very coarse sand (5.8%) and coarse sand (8.1%). Station S11 had the highest percentage of medium sand (7.6%). Station S16 had the highest percentage of fine sand (20.7%). Station DS1 had the highest percentage of very fine sand (76.5%) and station S3 had the highest percentage of silt-clay (46.4%). The sediment sampled from the area was classified according to Folk (1954) as sand in the spoil ground and outer harbour area and varied between muddy sand, slightly gravelly muddy sand and gravelly muddy sand in the inner harbour area. The substrata type at all stations can be seen graphically in Figure 2.5 below. Figure 2.6 shows two snapshots of the sedimentary environment in the spoil ground. Organic matter values ranged from 0.81 (S16) to 10.6 (S11).

Table 2.5: Sediment characteristics of the faunal stations.

Station	Gravel (>2mm)	Very Coarse Sand (1-2mm)	Coarse Sand (0.5-1mm)	Medium Sand (0.25-0.5mm)	Fine Sand (125-250μm)	Very Fine Sand (62.5-125μm)	Silt-Clay (<63μm)	Folk Classification	LOI (%)
S3	3.8	3.6	3.8	5.2	6.7	30.5	46.4	Slightly gravelly muddy sand	6.53
S6	0.3	2.4	3.1	3.3	11.3	54.7	24.8	Muddy sand	8.49
S7	0.1	0.8	0.9	1.1	20.4	61.9	14.7	Muddy sand	2.78
S11	1.1	4.3	6.9	7.6	17.3	29.7	33.1	Slightly gravelly muddy sand	10.6
S15	5.1	5.8	8.1	6.3	11.4	27.8	35.5	Gravelly muddy sand	6.48
S16	0.1	0.2	0.2	0.6	20.7	75.9	2.3	Sand	0.81
S17	1.2	3	2.7	4.1	10.9	38	40.2	Slightly gravelly muddy sand	4.94
DS1	0.2	0.7	0.5	0.7	15.9	76.5	5.6	Sand	0.98
DS2	0.6	1	0.5	0.8	16.2	72.1	8.9	Sand	1.28

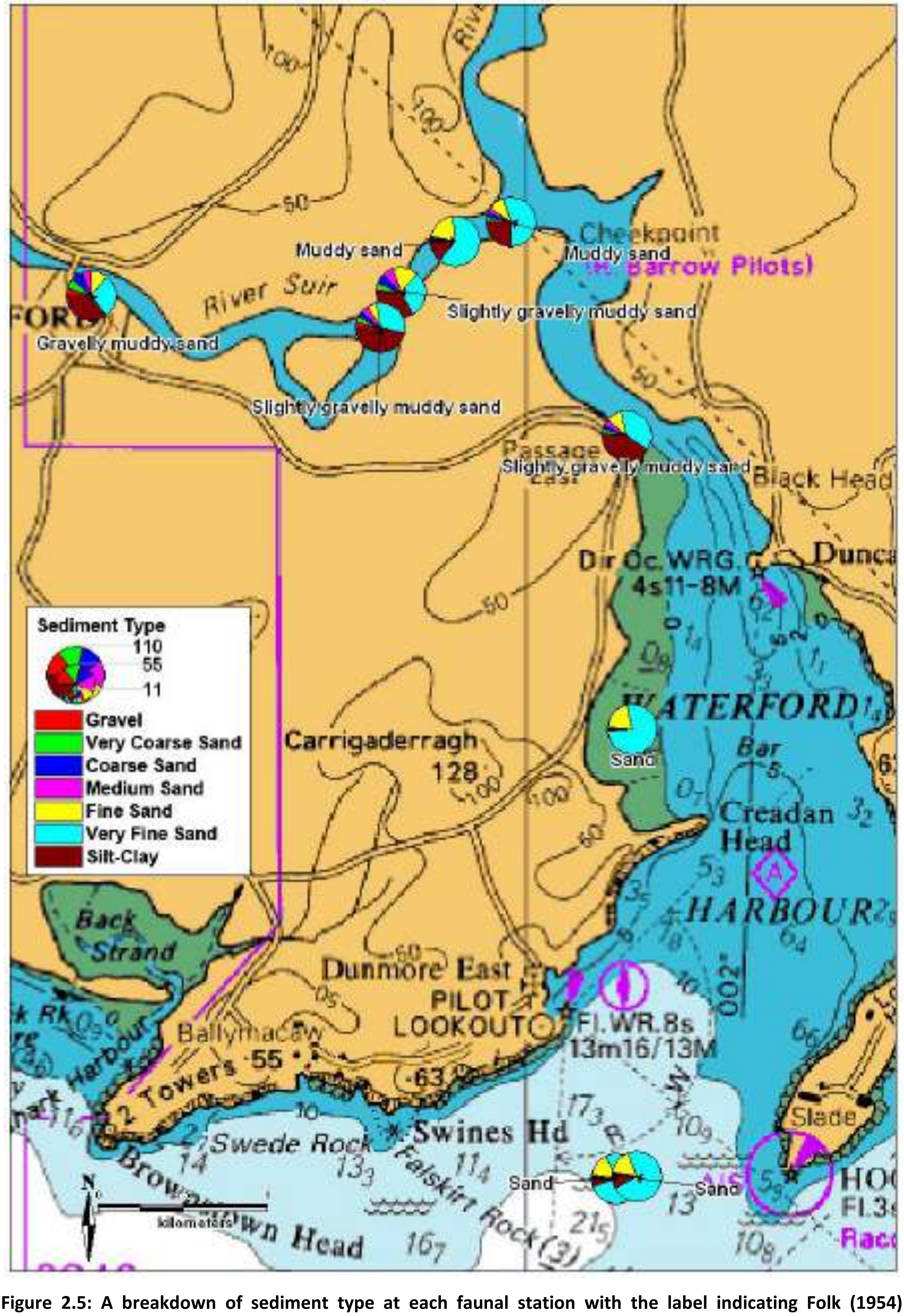

Figure 2.5: A breakdown of sediment type at each faunal station with the label indicating Folk (1954) classification.

Figure 2.6: Snapshot of the sedimentary environment in the spoil ground.

2.2.3. Discussion

Waterford Harbour was surveyed in 2008 as part of a Special Area of Conservation (SAC) characterisation project for the National Parks and Wildlife Service (NPWS). This survey revealed that the estuarine stations were generally characterised by low numbers of species and individuals (Kennedy, 2008). Community types in the inner estuary (inside Cheek Point) consisted of fluid mobile mud communities, firm mud or clay communities dominated by the polychaete *Polydora ciliata* and the amphipod *Corophium volutator,* oligochaete-dominated communities and communities dominated by the polychaete *Nephtys hombergii* and the bivalve *Macoma balthica*.

In the more seaward harbour area south of Cheek Point, the northern part was classified as *Nephtys hombergii* and *Macoma baltica* in infralittoral muddy sand (Kennedy, 2008). The southern area of the harbour was mostly classified as *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.

The NPWS conservation objectives for the River Barrow and River Nore SAC (002162), classify the outer estuary as a 'fine sand with *Angula* (*Fabulina*) *fabula* community and the inner part up to Cheek Point as a 'sand to muddy fine sand community complex' with patches of intertidal 'muddy estuarine community complex' (NPWS, 2011).

The area outside the harbour is sandy, grading into gravelly sand towards the spoil ground area. Previous benthic surveys of the spoil ground have documented coarse gravelly sands occurring in the spoil ground. Given its use as a dump site, the nature of the seafloor in the spoil ground varies from coarse gravels to fine sand and silt (AQUAFACT, 1996a, b; 1999, 2000; 2003).

In the present survey, a clear divide was seen between the stations in the outer harbour and spoil ground and those in the inner harbour inside Passage East. The spoil ground contained the highest richness and diversity of all stations sampled with the community in the spoil ground conforming to the JNCC habitat SS.SSA.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (EUNIS Code: A5.242). The mud/sand flats opposite the Duncannon Bar conformed to the JNCC habitat SS.SSA.IFiSa.NcirBat *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (EUNIS Code: A5.233).

The area between Passage East and Cheek Point had moderate richness and diversity levels and resembled the JNCC habitat SS.SMU.SMuVS.NhomTubi *Nephtys hombergii* and *Tubificoides* spp. in variable salinity infralittoral soft mud (EUNIS Code: A5.323). The area between Belview Point and Snowhill Point was characterised by the polychaete *Capitella* sp. complex and the oligochaetes *Tubificoides pseudogaster* agg. and *T. benedii*. This community conformed to the JNCC habitat SS.SMU.SMuVS.CapTubi *Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment (EUNIS Code: A5.325).

The area off Belview Point was characterised by the oligochaete *Tubificoides benedii* and conformed to the JNCC habitat SS.SMU.SMuVS.OlVS Oligochaetes in variable or reduced salinity infralittoral muddy sediment (EUNIS Code: A5.326). A species impoverished site was present in the inner estuary at Waterford port (opposite Ferrybank) and this site conformed to the JNCC habitat SS.SMU.SMuVS.MoMu Infralittoral fluid mobile mud (EUNIS Code: A5.324). These results resemble those of Kennedy (2008).

3. Dredge Material Characterisation Survey

3.1. Materials & Methods

3.1.1. Sampling Procedure & Processing

On the 7th April 2017, 16 sites were sampled for sediment analysis by [redacted] for physical and chemical analysis as per a request from the Marine Institute (see Appendix 4). Figure 3.1 shows the station locations and Table 3.1 shows the station coordinates.

One grab sample was taken at each of the stations and the samples were divided as follows:

- Into labelled 1l plastic bags for sediment grain size analysis;
- Into 125ml glass jars for organochlorine, PCB (polychlorinated biphenyl) and total extractable hydrocarbon analyses;
- Into 1kg plastic pots for metal analysis;
- Into 250ml amber glass jars for PAH (polycyclic aromatic hydrocarbon) analysis;
- Into 250ml amber glass jars for TBT (tributyl tin) and DBT (dibutyl tin) analysis
- Into labelled 1kg plastic pots for total organic carbon and carbonate analysis;

The above analyses were carried out by the National Laboratory Service in Leeds.

On the 10th April 2013, 2 stations were sampled for radiological analysis at the request of the Radiological Protection Institute of Ireland (RPII). There was no requirement on the part of the RPII to analyse additional samples in 2017 as the samples analysed previously are sufficient to cover the area of the intended dredging operation. The station locations can be seen in Figure 3.1 and the coordinates can be seen in Table 3.1. At both stations, *c.* 500g of sediment were removed and placed in a labelled plastic container and couriered to RPII for analysis. The samples were prepared by placing an aliquot in a well-defined counting geometry. These were then measured on a high-resolution gamma spectrometer. Appropriate density corrections were applied to the resultant spectra to take account of the differences in sample density.

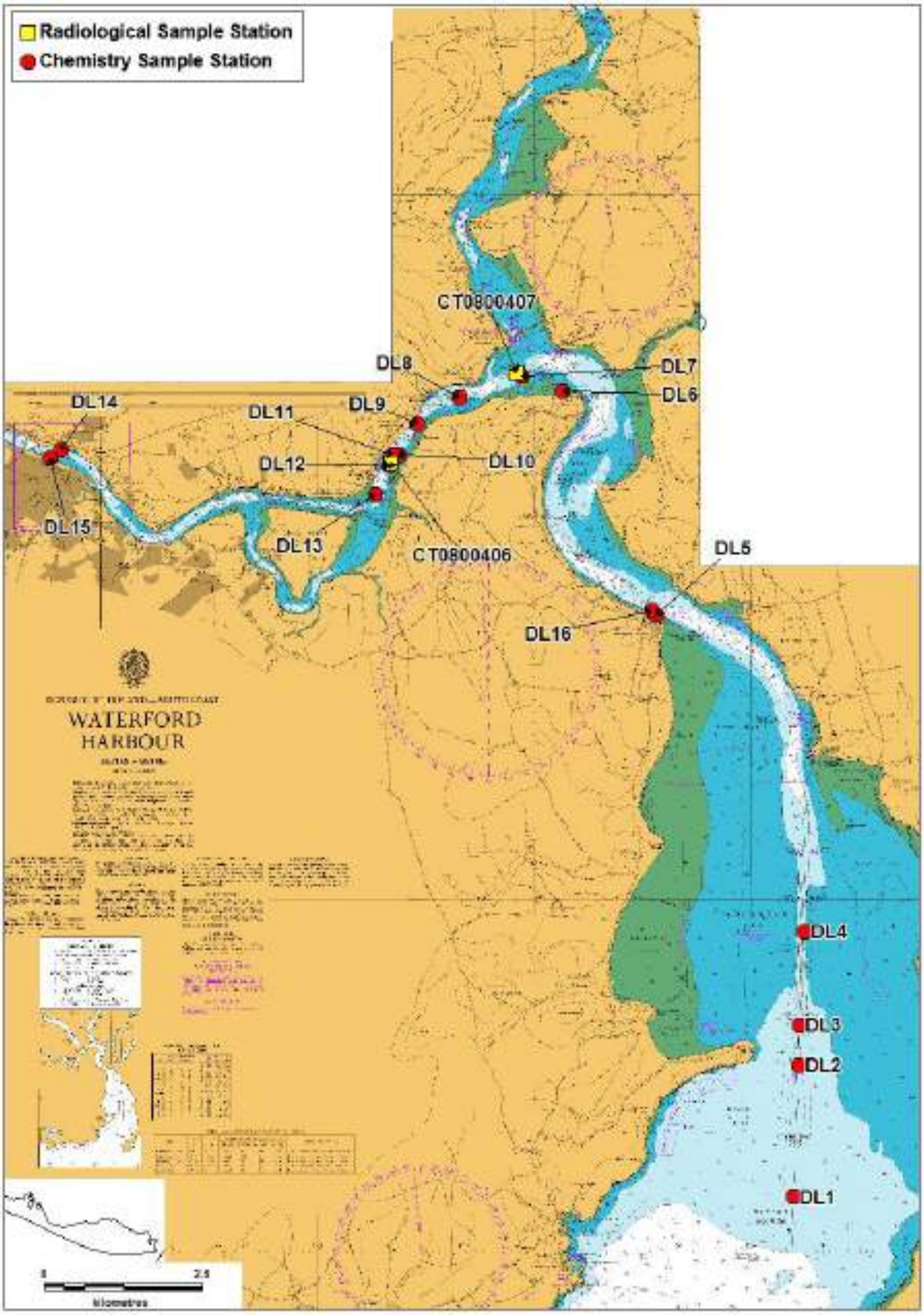

Figure 3.1: Location of chemistry and radiological sampling sites

Table 3.1: Coordinates of stations sampled for physical, chemical and radiological analysis.

Station	Requirement	Latitude	Longitude
DL1	Phy/Chem	52.15792	-6.94109
DL2	Phy/Chem	52.17669	-6.93981
DL3	Phy/Chem	52.18233	-6.93975
DL4	Phy/Chem	52.19566	-6.93851
DL5	Phy/Chem	52.24055	-6.97269
DL6	Phy/Chem	52.27234	-6.99426
DL7	Phy/Chem	52.27449	-7.00383
DL8	Phy/Chem	52.2715	-7.01833
DL9	Phy/Chem	52.26777	-7.02808
DL10	Phy/Chem	52.26337	-7.03244
DL11	Phy/Chem	52.26341	-7.03382
DL12	Phy/Chem	52.26194	-7.03453
DL13	Phy/Chem	52.25772	-7.03784
DL14	Phy/Chem	52.264	-7.11058
DL15	Phy/Chem	52.26288	-7.11289
DL16	Phy/Chem	52.24134	-6.97368
CT0800407	Radiological	52.27512	-7.0052
CT0800408	Radiological	52.19605	-6.93938

3.2. Physical / Chemical Results

3.2.1. Parameter Code 1

Table 3.2 shows the visual inspection information, which includes colour and sediment type. As can be seen in Table 3.2 sample DL14 consisted of stone and therefore no chemical analysis could be carried out on this sample.

Table 3.2: Visual Inspection

Station	Description
DL1	Brown Sand
DL2	Brown Sand
DL3	Brown Sandy Clay
DL4	Brown Sandy Clay
DL5	Brown clay
DL6	Brown sandy clay
DL7	Brown clay
DL8	Brown clay
DL9	Brown clay
DL10	Brown sand
DL11	Brown clay
DL12	Brown sand

Station	Description
DL13	Brown sandy clay
DL14	Stone
DL15	Black clay
DL16	Brown sand

3.2.2. Parameter Code 2

The water content and density results can be seen in Table 3.3. Values ranged from 1.06 (DL11) to 1.68g/ml (DL16) for density and from 13.5 (DL16) to 58.7% (S11) for moisture content.

Table 3.3: Moisture content and density

Station	Density (g/ml)	Moisture Content (%)
DL1	1.47	25.3
DL2	1.44	28.8
DL3	1.41	30.9
DL4	1.19	41
DL5	1.11	51.1
DL6	1.12	37.6
DL7	1.19	49.7
DL8	1.32	22.8
DL9	1.32	24.3
DL10	1.38	32.1
DL11	1.06	58.7
DL12	1.31	28.1
DL13	1.36	31
DL15	1.13	52.3
DL16	1.68	13.5

3.2.3. Parameter Code 3

Table 3.4 shows the granulometry results broken down into % gravel (>2mm), sand (<2mm >63μm) and mud (<63μm). Gravel ranged from 0.00335 (DL7) to 64.36% (DL9), sand ranged from 31.513 (DL9) to 94.61% (DL1) and silt-clay ranged from 1.0764 (DL16) to 67.297% (DL11).

Table 3.4: Granulometry results

Station	% Gravel (>2mm)	% Sand (<2mm - > 63μm	% Silt-Clay (<63μm)
DL1	0.2046	94.61	5.22
DL2	0.6643	91.0818	8.3246
DL3	0.01356	86.55968	13.441
DL4	0.0137	54.114	45.845
DL5	0.988	38.1079	60.84
DL6	0.0311	49.5142	50.52
DL7	0.00335	45.49669	54.51
DL8	44.86	32.517	22.622
DL9	64.36	31.513	4.04291
DL10	2.0179	81.562	16.486
DL11	0.0686	32.6299	67.297
DL12	2.6898	87.31	10.0604
DL13	49.09	47.942	2.929
DL15	1.647	42.878	55.492
DL16	54.234	44.69	1.0764

3.2.4. Parameter Code 4

3.2.4.1. CODE 4A

Table 3.5 shows the total organic carbon results. Values ranged from 1.33 (DL16) to 10% (S11).

Table 3.5: Total organic carbon results

Station	% LOI @ 500°C
DL1	1.75
DL2	2.05
DL3	2.58
DL4	5.52

Station	% LOI @ 500°C
DL5	7.87
DL6	5.55
DL7	7.04
DL8	2.81
DL9	9.91
DL10	2.57
DL11	10
DL12	3.18
DL13	4.34
DL15	6.22
DL16	1.33

3.2.4.2. CODE 4C

Table 3.7 shows the metal results. Mercury (Hg) levels ranged from <0.01 (DL1, 2, 8, 9 and 16) to 0.133mg/kg (DL15). Aluminium (Al) levels ranged from 4,640 (DL8) to 29,700mg/kg (DL13). Arsenic (As) levels ranged from 8.56 (DL4) to 26.3mg/kg (DL8). Cadmium (Cd) levels ranged from 0.042 (DL16) to 0.421mg/kg (DL11). Chromium (Cr) levels ranged from 11.3 (DL9) to 66.8mg/kg (DL15). Copper (Cu) levels ranged from 3.44 (DL1) to 15.4mg/kg (DL11). Results for Lithium (Li) levels ranged from 6.41 (DL9) to 34.2mg/kg (DL11). Nickel (Ni) levels ranged from 6.1 (DL9) to 23.5mg/kg (DL11). Zinc (Zn) levels ranged from 20 (DL9) to 103mg/kg (DL11).

The guidance values for metals (Cronin *et al.,* 2006) can be seen in Table 3.8 below. Cadmium, Chromium, Copper, Mercury and Zinc were all below the lower level guidance values. Nickel was below the lower level guidance values with the exception of two stations (DL11 and 13), which were below the upper guidance value. Arsenic values were below the lower guidance level at 3 stations (DL4, 6 and 7), the remaining stations were below the upper level guidance values.

Table 3.6: Metal results.

Station	Hg mg/kg	Al mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Li mg/kg	Ni mg/kg	Zn mg/kg
DL1	<0.01	12500	13.3	0.067	31.7	3.44	16.3	11.9	58.9
DL2	<0.01	11000	11	0.069	23.9	3.57	16.8	11.8	63.8
DL3	0.0111	14600	10	0.097	25.9	4.1	19.7	12.5	63.1
DL4	0.0343	17100	8.56	0.211	33	8.07	25.1	15.7	69

Station	Hg mg/kg	Al mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Li mg/kg	Ni mg/kg	Zn mg/kg
DL5	0.0427	20600	10.7	0.24	41.2	11.7	31.4	19.9	82.3
DL6	0.0582	21900	8.96	0.311	42.2	10.7	29.2	18.5	82.8
DL7	0.0456	25200	8.61	0.251	41.5	9.77	27.8	18	79.1
DL8	<0.01	4640	26.3	0.05	13.1	11	12.4	11.9	33.9
DL9	<0.01	5540	10.8	0.045	11.3	3.59	6.41	6.1	20
DL10	0.0132	10200	11.4	0.093	19.8	3.57	15.2	10.1	53.8
DL11	0.0723	27000	10.5	0.421	52.3	15.4	34.2	23.5	103
DL12	0.0133	8990	22.9	0.092	18	5.04	15.7	10.2	56.5
DL13	0.0171	29700	14.1	0.147	38.7	8.94	32.4	21.1	64
DL15	0.133	28300	9.6	0.397	66.8	13.9	31.1	20.8	98
DL16	<0.01	9880	12.2	0.042	22.3	5.01	16.9	12.5	33.2

Table 3.7: Proposed metal guidance values for sediment quality guidelines (Cronin *et al.,* 2006).

Metal	Lower level	Upper Level
As (mg/kg)	9*	70#
Cd (mg.kg)	0.7	4.2
Cr (mg/kg)	120	370
Cu (mg/kg)	40	110^
Pb (mg/kg)	60	218
Hg (mg/kg)	0.2	0.7
Ni (mg/kg)	21	60
Zn (mg/kg)	160	410

* ERL (rounded up) – No background Irish data

In some locations natural levels of arsenic will exceed this value and in such instances this guidance value will not be appropriate.

^ PEL as ERM considered high

3.2.4.3. CODE 4D

Tables 3.9 and 3.10 show the organochlorines including ɣ-HCH (Lindane) and PCB results. Aldrin, Endrin and Isodrin were <0.5µg/kg at all stations analysed. DDT-op, DDT-pp, HCH alpha, HCH beta, HCH delta, HCB and HCBD were all <0.1µg/kg at all stations analysed. HCH gamma was <0.1µg/kg at all stations except one (DL6). TDE-pp was <0.1µg/kg at all stations except three (DL6, 11 and 15). DDE-pp was <0.1µg/kg at all stations except five (DL5, 6, 7, 11 and 15). Dieldrin was <1µg/kg at all stations analysed. PCB 052 was <0.1μg/kg at all stations. PCB 028 was <0.1μg/kg at all stations except DL5, 6, 7, 11 and 15 which ranged from 0.12 (DL5 and 7) to 0.238μg/kg (DL15). PCB 101 was <0.1μg/kg at all but two stations (DL5-0.111μg/kg and DL15-0.115μg/kg). PCB 118 was <0.1μg/kg at all but three stations (DL5-0.1μg/kg, DL11-0.112μg/kg and DL15-0.114). PCB 138 was <0.1μg/kg at all stations except DL5, 6, 11 and 15 which ranged from 0.103 (DL6) to 0.397μg/kg (DL5). PCB 153 was <0.1μg/kg at all stations except DL4, 5, 6, 11 and 15 which ranged from 0.101 (DL4) to 0.408μg/kg (DL5). PCB 180 was <0.1μg/kg at all but two stations (DL5-0.377μg/kg and DL15-0.113μg/kg).

The guidance values for organochlorines and PCBs (Cronin *et al.,* 2006) can be seen in Table 3.11 below. All PCBs are below the lower guidance level. HCB and ɣ-HCH were below the lower guidance level at all stations.

Table 3.8: Organochlorine results.

Station	Aldrin ug/kg	DDE-pp ug/kg	DDT-op ug/kg	DDT-pp ug/kg	Dieldrin ug/kg	Endrin ug/kg	HCH Alpha ug/kg	HCH Beta ug/kg	HCH Delta ug/kg	HCH Gamma ug/kg	HCB ug/kg	HCBD ug/kg	Isodrin ug/kg	TDE-pp ug/kg
DL1	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL2	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL3	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL4	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL5	<0.5	0.135	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL6	<0.5	0.146	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	0.16	<0.1	<0.1	<0.5	0.109
DL7	<0.5	0.114	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL8	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL9	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL10	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL11	<0.5	0.218	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.147
DL12	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL13	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
DL15	<0.5	0.241	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.154
DL16	<0.5	<0.1	<0.1	<0.1	<1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1

Table 3.9: PCB Results.

Station	PCB 028 ug/kg	PCB 052 ug/kg	PCB 101 ug/kg	PCB 118 ug/kg	PCB 138 ug/kg	PCB 153 ug/kg	PCB 180 ug/kg
DL1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL4	<0.1	<0.1	<0.1	<0.1	<0.1	0.101	<0.1
DL5	0.12	<0.1	0.111	0.1	0.397	0.408	0.377
DL6	0.144	<0.1	<0.1	<0.1	0.103	0.12	<0.1
DL7	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL11	0.191	<0.1	<0.1	0.112	0.143	0.174	<0.1
DL12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DL15	0.238	<0.1	0.115	0.114	0.155	0.194	0.113
DL16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3.10: Proposed organochlorine and PCB guidance values for sediment quality guidelines (Cronin *et al.,* 2006).

Parameter	Lower level	Upper Level
ɣ-HCH (Lindane) (μg/kg)	0.3	1
HCB (μg/kg)	0.3	1
PCB (individual congeners of ICES 7) (μg/kg)	1	180
PCB (Σ ICES 7) (μg/kg)	7	1260

3.2.4.4. CODE 4E

Table 3.12 shows the total extractable hydrocarbon results. Values ranged from 5.31 (DL1) to 252mg/kg (DL11). All were below the lower guidance level of 1000mg/kg (1 g/kg) (Cronin *et al.,* 2006).

Table 3.11: Total extractable hydrocarbon results.

Station	Hydrocarbons mg/kg
DL1	5.31
DL2	12
DL3	21.3
DL4	118
DL5	14.8
DL6	97.9
DL7	144
DL8	20.8
DL9	152
DL10	46.5
DL11	252
DL12	126
DL13	27
DL15	215
DL16	6.94

3.2.4.5. CODE 4F

Table 3.13 shows the dibutyl and tributyl tin results. Values ranged from <0.001 (DL1, 2, 8, 9, 13 and 16) to <0.007mg/kg (DL11). The guidance values for the sum of TBT and DBT range from a lower level of 0.1 to an upper level of 0.5mg/kg (Cronin *et al.,* 2006). All are below the lower limit.

Table 3.12: Dibutyl and tributyl tin results.

Station	DBT mg/kg	TBT mg/kg
DL1	<0.004	<0.001
DL2	<0.004	<0.001
DL3	<0.005	<0.002
DL4	<0.005	<0.002
DL5	<0.006	<0.002
DL6	<0.005	<0.002
DL7	<0.006	<0.002
DL8	<0.004	<0.001
DL9	<0.003	<0.001

Station	DBT mg/kg	TBT mg/kg
DL10	<0.005	<0.002
DL11	<0.007	<0.002
DL12	<0.004	0.00139
DL13	<0.004	<0.001
DL15	<0.004	0.00241
DL16	<0.003	<0.001

3.2.4.6. CODE 4G

Table 3.14 shows the PAH results. Acenaphthene levels ranged from <1 (DL1, 3, 8, 9, 10, 16) to 11.9µg/kg (DL2). Acenaphthylene levels ranged from <1 (DL1, 2, 3, 8, 9, 10, 13 and 16) to 2.89µg/kg (DL15). Anthracene levels ranged from <1 (DL1, 8 and 16) to 15.3µg/kg (DL11). Benzo (a) anthracene levels ranged from <1 (DL1) to 71.9µg/kg (DL11). Benzo (a) pyrene levels ranged from <1 (DL1) to 73.1µg/kg (DL11). Benzo (b) fluoranthene levels ranged from 1.52 (DL1) to 80.7µg/kg (DL11). Benzo (ghi) perylene levels ranged from 1.11 (DL1) to 53µg/kg (DL11). Benzo (k) fluoranthene levels ranged from <1 (DL1) to 40µg/kg (DL11). Chrysene levels ranged from <3 (DL1, 8 and 16) to 56.9µg/kg (DL6). Dibenzo (a,h) anthracene levels ranged from <1 (DL1, 8, 10 and 16) to 14.3µg/kg (DL11). Fluoranthene levels ranged from 1.26 (DL1) to 142µg/kg (DL11). Fluorene levels ranged from <5 (DL1, 2, 3, 4, 7, 8, 9, 10, 13 and 16) to 22.1µg/kg (DL12). Indeno 1,2,3 – cd pyrene levels ranged from 1.21 (DL1) to 58.6µg/kg (DL11). Naphthalene levels ranged from <5 (DL1, 2, 3, 8, 9, 10, 13 and 16) to 32.5µg/kg (DL12). Phenanthrene levels ranged from <5 (DL1, 3, 8 and 16) to 60.1µg/kg (DL6). Pyrene levels ranged from <1 (DL1) to 116µg/kg (DL11).

The lower level guidance values for the sum of all 16 PAHs is 4000 µg/kg (Cronin *et al.,* 2006). All are below the lower limit.

Table 3.13: PAH results.

Sample Number	DL1	DL2	DL3	DL4	DL5	DL6	DL7	DL8	DL9	DL10	DL11	DL12	DL13	DL15	DL16
PAH Acenaphthene ug/kg	<1	11.9	<1	1.64	1.92	3.69	2.35	<1	<1	<1	2.25	5.42	1.12	3.07	<1
PAH Acenaphthylene ug/kg	<1	<1	<1	1.83	1.51	2.79	1.22	<1	<1	<1	2.03	1.24	<1	2.89	<1
PAH Anthracene ug/kg	<1	5.67	1.19	7.34	7.02	12.9	7.73	<1	2.5	2.05	15.3	5.53	2.63	11.5	<1
PAH Benzo a anthracene ug/kg	<1	17.8	7.04	35.3	38.4	71.2	38.1	2.69	7.6	6.21	71.9	20.9	6.84	59.3	2.23
PAH Benzo (a) pyrene ug/kg	<1	19.5	7.97	38.2	42.8	66.9	38.3	3.16	8.67	6.21	73.1	25.4	6.22	66.3	2.62
PAH Benzo b fluoranthene ug/kg	1.52	18.7	8.27	40.3	51.8	68.6	43.1	4.04	9.22	7.48	80.7	26.5	8.62	67.2	3.02
PAH Benzo ghi perylene ug/kg	1.11	12	5.7	30.3	37.5	48.2	33.6	2.58	5.71	4.96	53	17.2	5.56	46.7	1.92
PAH Benzo k fluoranthene ug/kg	<1	10.1	3.91	21	25.9	35.9	21.7	1.84	4.52	3.51	40	12.6	3.27	36.7	1.38
PAH Chrysene ug/kg	<3	15.1	5.47	27.8	31.8	56.9	32	<3	6.79	4.94	56.2	21.1	6.78	46.4	<3
PAH Dibenzo a,h anthracene ug/kg	<1	3.36	1.36	6.77	8.31	12.4	7.08	<1	1.41	<1	14.3	5.79	1.45	11.8	<1
PAH Fluoranthene ug/kg	1.26	47.6	12.2	48.7	72.2	114	87.7	6.58	19.3	12.7	142	34.7	12.2	110	4.18
PAH Fluorene ug/kg	<5	<5	<5	<5	5.87	7.89	<5	<5	<5	<5	6.9	22.1	<5	7.46	<5
PAH Indeno 1,2,3 – cd pyrene ug/kg	1.21	12.7	5.85	33.3	44.4	52.7	36.7	2.8	6.66	5.2	58.6	16	4.08	50.5	2
PAH Naphthalene ug/kg	<5	<5	<5	9	13.2	15.1	12	<5	<5	<5	12.4	32.5	<5	14.4	<5
PAH Phenanthrene ug/kg	<5	34.2	<5	30.8	32.9	60.1	32.5	<5	9.77	7.69	48.9	56.4	11.7	40.9	<5
PAH Pyrene ug/kg	<1	36.1	10.9	53.6	59.7	106	62.4	5.34	15	10.4	116	29.5	11.8	99.9	4.02

3.3. *Radiological Results*

Table 3.15 shows the radiological results from the two stations analysed. The dumping of these materials at sea will not result in a radiological hazard.

Table 3.14: Radiological results.

Station No.	RPII Ref	Nuclide	Activity Concentration (Bq/kg, dry)
CT0800407	C1300257	K-40	386 ± 6
		I-131	nd
		Cs-134	nd
		Cs-137	4.4 ± 0.1
		Ra-226	16.8 ± 10.4
		Ra-228	19.0 ± 6.1
		U-235	1.5 ± 0.1
		U-238	33.4 ± 1.5
CT0800408	C1300258	K-40	352 ± 6
		I-131	nd
		Cs-134	nd
		Cs-137	2.7 ± 0.1
		Ra-226	14.2 ± 7.8
		Ra-228	16.7 ± 5.8
		U-235	0.98 ± 0.06
		U-238	21.8 ± 1.4

4. Impact Assessment

4.1. Impacts from Dredging

ABP Marine Environmental Research Ltd. (ABPmer) modelled the impact of plough dredging at Cheek Point Lower (ABPmer, 2017). The modelling showed that the dispersed sediment would move throughout the estuary, with the vast majority moving up-estuary, but would generally be confined to the area between Buttermilk Point and Little Island. The greatest effects were seen throughout the estuary at the end of the plough disturbance scenario (8 days with ploughing ceasing on Day 4). These effects decay to background levels within about four days following cessation of ploughing on falling spring tides. Most material would be moved (transported and eroded) on the flood tide and during spring tides whereas neap tides would predominantly be accretional.

The modelling identified locations of temporary sediment storage (later eroded) as well as sediment ‘sinks’, where accretion would be more permanent, notably the southern edge of the Cheekpoint section, adjacent to the maintained channel. Maximum SSC (suspended sediment concentrations) (above background) at the point of disturbance were around 2,500 mg/l near-bed at the time of peak flows and 1,500 mg/l during slack flows. One day following completion of plough disturbance, peak SSC would reduce by over an order of magnitude at the disturbance site.

Maximum concentrations away from the disturbance location, for the most part, would occur on peak flood flows as ‘pulses’ that rarely last for longer than 30 minutes per tide. Individual spikes can reach 1,000 mg/l at some locations. Elevated SSC that last for several hours are generally in the range 150-250 mg/l, depending on location, on spring flood tides, and lower on ebb tides. Average elevated concentrations are rarely above 50 mg/l. These values compare against the measured background SSC level, which were recorded between 350 and 600 mg/l between Carters Patch and the River Barrow, on a typical spring tide, increasing to up to 1,000 mg/l during an observed storm event. Sedimentation as a result of the plough disturbance is for the most part temporary, accumulating during periods of slack water, or in areas of eddy circulation. With the exception of identified ‘sink’ areas, accumulations are small, a few millimetres to 1 to 2 centimetres. Most accumulations are re-eroded on the following peak flows (predominantly on the flood). In the areas around Carters Patch sedimentation of up to 1.5 cm was present for a maximum period of 6 hours before being re-eroded and in all cases, sedimentation rates and SSC levels increase after *circa* 2 days of ploughing. This indicates that this is the timescale for disturbed material (probably the coarser fraction) to move up- and down-estuary, before returning through the Cheekpoint area.

Delft Hydraulics modelled the impacts of dredging activities at the Duncannon Bar on the spreading of suspended sediment in the estuary of the River Suir (Eysink *et al.,* 2000). Environmental Tracing Systems (ETS) undertook a fluorescent particle tracing study in order to determine the fate of dredged material from Cheek Point Harbour (ETS, 1998). The turbidity generated by the dredging activity must be weighed against the turbidity which results from natural processes (*e.g.* storm surges) and the background turbidity (*e.g.* navigation) that occurs in the dredging areas before, during and after the dredging activity. The majority of suspended sediment generated due to dredging activities is at depth (*i.e.* close to the seafloor). In their initial deliberations Delft Hydraulics (Eysink *et al.,* 2000) considered that the additional turbidity above background levels 50m around the dredging Trailing Suction Hopper Dredge would be of the order of c. 250-300mg/l of suspended solids. However, the modelling concluded that the increase in suspended sediment concentrations above background would be of the order of 100mg/l within 50m of the dredger. Assuming suspended solids in the channel are at the upper end of this observed range i.e. 100mg/l, the suspended solids concentrations local to the dredger are likely to increase to the order of 250mg/l at Cheekpoint and 200mg/l at Duncannon Bar.

Turbidity monitoring was carried out during a trailer suction hopper dredging period in February 2012 and February 2013 (IDS Monitoring Ltd., 2013), two plough dredging campaigns in January and February 2017 and a trailer suction hopper dredging March 2017 (IDS Monitoring Ltd., 2017). The data collected showed that there was no significant change in the turbidity levels at the upstream and downstream monitoring stations during any of the dredging campaigns at Cheekpoint. Turbidity variance between the two plough dredging campaigns undertaken was not discernible. Turbidity variance between plough dredging campaigns and TSHD dredging was not discernible. A review of the data regarding ambient suspended sediments during the non-dredging periods strongly suggests that there are large plumes of sediment mobilised naturally in the harbour and that these migrate past the monitoring stations. If the dredging significantly added to the suspended sediment load, it is likely that this would have been detected at some point on either station. The pattern of suspended sediments is similar to that before dredging and the range of turbidity is also similar. Any differences observed during dredging were not greater than differences observed from periods without dredging and are accounted for as natural temporal variation and are caused by the strong tidal and fluvial flows.

4.1.1. Water Quality

As the material is not contaminated, the only potential impact on water quality is suspended sediment concentrations. As evidenced by IDS Monitoring Ltd. (2013; 2017), the dredging operations in the Cheek Point area will not significantly alter suspended sediment concentrations above back ground levels. The maximum SSC (above background) predicted at the point of disturbance (1500-2,500 mg/l) rarely last for longer than 30 minutes per tide. Only concentrations in the range 150-250 mg/l would last for several hours, depending on location, on spring flood tides, and lower on ebb tides. Average elevated concentrations are rarely above 50 mg/l. This is a highly turbid area naturally due to the confluence of the Suir and Barrow Rivers. Suspended sediment is not a contaminant and although it is released into the surrounding water column during the dredging process, levels are comparable with naturally occurring levels and it will not negatively affect water quality and will not contravene the Water Framework Directive 2000/60/EC, The Marine Strategy Framework Directive 2008/56/EC or the Priority Substances Directive 2008/105/EC.

4.1.2. Benthic Communities

Benthic communities in the dredge areas will be removed by the dredging operations. The benthic communities in the dredge areas typically species poor and are characterised by oligochaetes *Tubificoides benedii* and *Capitella* sp. These are opportunistic species adapted to a disturbed habitat. While these species will be removed during the dredging operation, colonisation will occur quickly from the surrounding areas and return the community to its pre-dredging state.

4.1.3. Conservation Sites

This issue is examined in the accompanying Natura Impact Statement.

4.2. Impacts from Disposal

A sand dispersion study was carried out by Delft Hydraulics to determine the long-term spreading at the disposal site using a Delft 3D model system (Eysink *et al.,* 2001). The dispersion model predicts that following the initial dump, the sand from the heap is deposited in the direct vicinity of the dump site at the north-western and at the south-eastern side. Due to this process the height of the sand heap is reduced while it is spread out over a larger area. The model simulations following continual annual dumping show initially a general tendency of sand dispersion from the disposal area towards the east and particularly towards the northwest. After 5 years the dispersion towards the northwest is somewhat stronger than after the initial dump whereas dispersion towards the southeast starts to develop. This is caused by the higher spoil heap due to repetitive spoil dumping. This dispersion continues in the following 10 years; at the northwest side the sand dispersion gradually turns north towards the estuary mouth and at the southeast side it further extends along the 20m contour.

The dispersion along the eastern side of the disposal site is limited to a distance of *ca* 300m from the site in the first 5 years. At the northwestern side, the sedimentation continues progressively during the first 6 years after the first spoil dumping. In the first 2 years, most of the sand remains with a distance of 400m from the disposal site. This distance gradually increases to 600m in the next 3 years and to *ca* 2km 15 years after the first spoil dumping. The sedimentation rate close to the disposal site increases for the first 6 years and then gradually reduces again after the last spoil dumping. The annual maximum sedimentation rate at a distance of 200m amounts to 20cm and reduces to 11cm at a distance of 400m. Beyond a distance of 600m it becomes very low

(<7cm/year). It may be concluded that the material does not disperse rapidly or over a very large area of the estuary with time (Malone O'Regan, 2002).

4.2.1. Water Quality

The concentrations of Suspended Particulate Matter (SPM) will increase in the area of the disposal site following each dump; however, the increase will be limited in magnitude and size (Malone O'Regan, 2002). The fine silt particles will mix and settle relatively fast in the deep water. The additional concentration peak in a radius of 50m from the disposal site is estimated to be 20 – 40 mg/l. These levels are well within natural background levels and as a result will not have a negative impact on water quality. As above, suspended sediments are not a contaminant and will not contravene the Water Framework Directive 2000/60/EC, the Marine Strategy Framework Directive 2008/56/EC or Priority Substances Directive 2008/105/EC.

4.2.2. Benthic Communities

Benthic communities within the spoil ground will be buried by the disposal of spoil. The current community in the spoil ground is dominated by the polychaete *Magelona johnstoni*, the bivalve mollusc *Abra* sp., the cumacean crustacean *Pseudocuma longicornis* and the polychaete *Magelona* sp. This community has established itself at the site despite the continual disposal operations in the area. So while the community will be buried by the spoil, the spoil will spread out and the infaunal species will recolonise from the surround areas and also if the spoil depth is not too deep the infauna will be able to migrate to the surface of the spoil heap.

4.2.3. Conservation Sites

This issue is examined in the accompanying Natura Impact Statement

5. Discussion/Conclusion

The dredging and disposal operations will disturb the benthic communities in the affected areas. The benthic communities in these areas are adapted to repeated disturbances by dredging and disposal and recovery begins almost immediately following the cessation of the activity.

The dredging operations (plough and TSHD) will not significantly impact on the habitats and species in the estuary. Maximum levels of SSC are very localised, very short-term (30 minutes) and reduce to background levels within hours. Increases in sedimentation rates are very low and temporary, being resuspended on the subsequent peak flow. SSC monitoring during dredging campaigns shows that the dredging operations do not significantly alter suspended sediment concentrations above back ground levels and will not negatively affect water quality (IDS Monitoring Ltd., 2013, 2017). The concentrations of Suspended Particulate Matter (SPM) will increase in the area of the disposal site following each dump; however, the increase will be limited in magnitude and size (Malone O'Regan, 2002). The fine silt particles will mix and settle relatively fast in the deep water. The additional concentration peak in a radius of 50m from the disposal site is estimated to be 20 – 40 mg/l. These levels are well within natural background levels and as a result will not have a negative impact on water quality.

The suitability of the spoil for disposal at sea will be determined by the Marine Institute and the Radiological Institute of Ireland have deemed the material not to be a radiological hazard.

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Appendix 1
Photographic Log

Station	Photo
S3	
S6	
S7	
S11	

Station	Photo
S15	
S16	
S17	
DS1	

Station	Photo
DS2	

Appendix 2

AQUAFACT Sediment Analysis Methodologies

Granulometry

1. Approximately 25g of dried sediment is weighed out and placed in a labelled 1L glass beaker to which 100 ml of a 6 percent hydrogen peroxide solution was then added. This was allowed to stand overnight in a fume hood.
2. The beaker is placed on a hot plate and heated gently. Small quantities of hydrogen peroxide are added to the beaker until there is no further reaction. This peroxide treatment removes any organic material from the sediment which can interfere with grain size determination.
3. The beaker is then emptied of sediment and rinsed into a. 63µm sieve. This is then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve is then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution is added to the beaker and this solution is stirred for ten minutes and then allowed to stand overnight. This treatment helps to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution is washed and rinsed into a 63µm sieve. The retained sampled is carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.
6. When dry this sediment is sieved through a series of graduated sieves ranging from 4 mm down to 63µm for 10 minutes using an automated column shaker. The fraction of sediment retained in each of the different sized sieves is weighed and recorded.
7. The silt/clay fraction is determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.

Organic Content

1. The collected sediments should be transferred to aluminium trays, homogenised by hand and dried in an oven at 100º C for 24 hours.
2. A sample of dried sediment should be placed in a mortar and pestle and ground down to a fine powder.
3. 1g of this ground sediment should be weighed into a pre-weighed crucible and placed in a muffle furnace at 450ºC for a period of 6 hours.
4. The sediment samples should be then allowed to cool in a dessicator for 1 hour before being weighed again.
5. The organic content of the sample is determined by expressing as a percentage the weight of the sediment after ignition over the initial weight of the sediment.

Appendix 3
Faunal Abundance

Station	Qualifier			S3a	S3b	S6a	S6b	S7a	S7b	S11a	S11b	S15a	S15b	S16a	S16b	S17a	S17b	DS1a	DS1b	DS2a	DS2b
NEMATODA		HD	1																		
Nematoda		HD	1	2		1		1					1								
NEMERTEA		G	1																		
Nemertea	indet	G	1															1			
ANNELIDA		P	1																		
POLYCHAETA		P	2																		
PHYLLODOCIDA		P	3																		
Polynoidae		P	25																		
Polynoidae	partial/damaged	P	25																	1	
Phyllodocidae		P	114																		
Eteone longa aggregate		P	118	1					1		1										
Glyceridae		P	254																		
Glycera sp.	partial/damaged	P	255																		1
Glycera tridactyla		P	265															1			
Nereididae		P	458																		
Hediste diversicolor		P	462	1																	
Nephtyidae		P	490																		
Nephtys sp.	partial/damaged	P	494			2				1				2				1			
Nephtys hombergii		P	499				1										1				
SPIONIDA		P	707																		
Spionidae		P	720																		
Spionidae	partial/damaged	P	720					2													
Pygospio elegans		P	776		2			12													
Spiophanes bombyx		P	794															1			
Streblospio shrubsolii		P	799	16	17																
Magelonidae		P	802																		
Magelona sp.	partial/damaged	P	803																1	3	2
Magelona johnstoni		P		3														3	20	11	14
Cirratulidae		P	822																		
Cirratulidae	partial/damaged	P	822															1			
CAPITELLIDA		P	902																		

Station	Qualifier			S3a	S3b	S6a	S6b	S7a	S7b	S11a	S11b	S15a	S15b	S16a	S16b	S17a	S17b	DS1a	DS1b	DS2a	DS2b
Capitellidae		P	903																		
Capitella sp. complex		P	906					6	54	1	24										
OWENIIDA		P	1089																		
Oweniidae		P	1090																		
Owenia fusiformis		P	1098											1							
SABELLIDA		P	1256																		
Sabellidae		P	1257																		
Manayunkia aestuarina		P	1294	1																	
OLIGOCHAETA		P	1402																		
TUBIFICIDA		P	1403																		
Tubificidae		P	1425																		
Heterochaeta costata		P	1479	24	15																
Tubificoides pseudogaster aggregate		P	1498	4	16	1	2	21	45	1	18					2					
Tubificoides benedii		P	1490	642	212	1	1	5	10	1	1					2					
CRUSTACEA		R	1																		
COPEPODA		R	142																		
HARPACTICOIDA		R	785																		
Miraciidae		R	1144																		
Miraciidae	indet	R	1144					1													
EUMALACOSTRACA		S	23																		
MYSIDACEA		S	25																		
Mysidae		S	31																		
Gastrosaccinae	juvenile	S	39											1							
Neomysis integer		S	76		1																
AMPHIPODA		S	97																		
Oedicerotidae		S	118																		
Perioculodes longimanus		S	131															1			1
Pontoporeiidae		S	450																		
Bathyporeia sp.	partial/damaged	S	451			1												1			
Bathyporeia elegans		S	452											4	6						

Station	Qualifier			S3a	S3b	S6a	S6b	S7a	S7b	S11a	S11b	S15a	S15b	S16a	S16b	S17a	S17b	DS 1a	DS 1b	DS 2a	DS 2b
Corophiidae		S	604																		
Monocorophium sextonae		S	615					2													
Corophium volutator		S	616	33				5	1				1								
ISOPODA		S	790																		
Anthuridae		S	801																		
Cyathura carinata		S	805									1									
TANAIDACEA		S	1099																		
Anarthruidae		S	1115																		
Tanaopsis graciloides		S	1142					1													
CUMACEA		S	1183																		
Bodotriidae		S	1184																		
Vaunthompsonia cristata		S	1191											1	1				1		
Pseudocumatidae		S	1231																		
Pseudocuma sp.	partial/damaged	S	1234																1		
Pseudocuma longicornis		S	1236																3	1	1
Diastylidae		S	1244																		
Diastylis sp.	partial/damaged	S	1224																3	1	
Diastylis bradyi		S	1248																		1
DECAPODA		S	1276																		
Crangonidae		S	1380																		
Crangon crangon		S	1385							1											
MOLLUSCA		W	1																		
GASTROPODA		W	88																		
MESOGASTROPODA		W	256																		
Hydrobiidae		W	381																		
Hydrobia ulvae		W	385	1	2																
NEOGASTROPODA		W	670																		
Mangeliidae		W	771																		
Bela brachystoma		W																1	1		

Station	Qualifier			S3a	S3b	S6a	S6b	S7a	S7b	S11a	S11b	S15a	S15b	S16a	S16b	S17 a	S17 b	DS 1a	DS 1b	DS 2a	DS 2b
PELECYPODA		W	1560																		
Bivalvia	partial/damaged	W	1560														1			1	
NUCULOIDA		W	1561																		
Nuculidae		W	1563																		
Nucula nitidosa		W	1569																2		
MYTILOIDA		W	1689																		
Mytilidae		W	1691																		
Mytilidae	juvenile	W	1691	1																	
Mytilus edulis		W	1695														5				
VENEROIDA		W	1815																		
Mactridae		W	1967																		
Mactridae	juvenile	W	1967																3		
Tellinidae		W	2008																		
Angulus tenuis		W	2012												1						
Angulus sp.	juvenile	W	2018															1			1
Angulus fabula		W	2019												1						
Macoma balthica		W	2029		2	3					2					1					
Semelidae		W	2057																		
Abra sp.	juvenile	W	2058															1	9		3
Scrobicularia plana		W	2068	15	5																
BRYOZOA		Y	1																		
STENOLAEMATA		Y	2																		
CYCLOSTOMATIDA		y	3																		
Crisiidae		Y	4																		
Crisia eburnea		Y	17														+				
GYMNOLAEMATA			69																		
CHEILOSTOMATIDA		Y	149																		
Membraniporidae		Y	168																		
Conopeum reticulum		Y	172													+	+				+
ECHINODERMATA		ZB	1																		
OPHIUROIDEA		ZB	105																		
Ophiuroidea	juvenile	ZB	105																		2

Appendix 4
MI Sediment Analysis Requirement

[redacted]

[redacted]

3 March 2017

Re: Sampling and Analysis Plan – Port of Waterford

Dear [redacted]

A sampling and analysis plan is detailed below for dredging in the Port of waterford. This plan is designed to cover the dredging and dumping at sea of 190 000 m^3 of sediment.

Your selected analysing laboratory must be able to meet the quality requirements for this project. You should give your contractor a copy of this plan. You will need to draw their attention especially to Section 3 and Section 4 to confirm that they are capable of meeting the quality assurance standards.

If you need clarification on anything, please don't hesitate to contact me.

Best regards,

[redacted]

____

[redacted]

Marine Environment Chemist

1.0 Sample location and analyses required:

The following surface samples, as listed in Table 1 (below) should be taken[1]. Sample locations are shown in Figure 1 at the end of this document.

Table 1. Locations and details of proposed samples

Sample No.	Longitude (° W) *	Latitude (°N) *	Parameters for analysis
1	52.15792	-6.94109	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
2	52.17669	-6.93981	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
3	52.18233	-6.93975	1, 2, 3, 4a, 4b, 4c, 4f
4	52.19566	-6.93851	1, 2, 3, 4a, 4b, 4c, 4f
5	52.24055	-6.97269	1, 2, 3, 4a, 4b, 4c, 4f
6	52.27234	-6.99426	1, 2, 3, 4a, 4b, 4c, 4f
7	52.27449	-7.00383	1, 2, 3, 4a, 4b, 4c, 4f
8	52.27150	-7.01833	1, 2, 3, 4a, 4b, 4c, 4f
9	52.26777	-7.02808	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
10	52.26337	-7.03244	1, 2, 3, 4a, 4b, 4c, 4f
11	52.26341	-7.03382	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
12	52.26194	-7.03453	1, 2, 3, 4a, 4b, 4c, 4f
13	52.25772	-7.03784	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
14	52.26400	-7.11058	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
15	52.26288	-7.11289	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
16	52.24134	-6.97368	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g

* Positions given in decimal degrees, WGS84S

2.0 Parameter Code:

1. Visual inspection, to include colour, texture, odour, presence of animals etc
2. Water content, density (taking into account sample collection and handling)
3. Granulometry including % gravel (> 2mm fraction), % sand (< 2mm fraction) and % mud (< 63µm fraction).
4. The following determinants in the sand-mud (< 2mm) fraction * :
   a) total organic carbon

[1] Further sampling and analysis, at depth if necessary, may be required in the event that problem areas of heavy contamination are identified as a result of the initial testing.

b) carbonate

c) mercury, arsenic, cadmium, copper, lead, zinc, chromium, nickel, lithium, aluminium.

d) organochlorines HCH and γ-HCH (Lindane), and PCBs (to be reported as the 7 individual CB congeners: 28, 52, 101, 118, 138, 153, 180).

e) total extractable hydrocarbons.

f) tributyltin (TBT) and dibutyltin (DBT)

g) Polycyclic aromatic hydrocarbons (PAH) - Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (ghi) perylene, Benzo (k) fluoranthene, Chrysene, Dibenz (a,h) anthracene, Flourene, Fluoranthene, Indeno 1,2,3 – cd pyrene, Naphthalene, Phenanthrene, Pyrene.

h) Toxicity tests (Microtox or whole sediment bioassay) using appropriate representative aquatic species. (This requirement will depend on the results of the chemical analyses.)

where the gravel fraction (> 2mm) constitutes a significant part of the total sediment, this should be taken into account in the calculation of the concentrations.

3.0 Important notes:

3.1 Details of the methodologies used must be furnished with the results. This should include sampling, sub sampling and analytical methods used for each determinant

3.2 Appropriate marine CRM are to be analysed during each batch of analyses and the results to be reported along with sample results.

3.3 The required detection limits for the various determinants are given in Table 2. below.

Table 2. Maximum limits of detection required

Contaminant	Concentration	Units (dry wt)
Mercury	0.05	mg kg^{-1}
Arsenic	1.0	mg kg^{-1}
Cadmium	0.1	mg kg^{-1}
Copper	5.0	mg kg^{-1}
Lead	5.0	mg kg^{-1}
Zinc	10	mg kg^{-1}
Chromium	5.0	mg kg^{-1}
Nickel	15	mg kg^{-1}
Total extractable hydrocarbons	10.0	mg kg^{-1}
TBT and DBT (not organotin)	0.01	mg kg^{-1}

PCB – individual congener	0.1	µg kg^{-1}
OCP – individual compound	1.0	µg kg^{-1}
PAH – individual compound	20	µg kg^{-1}

4.0 Reporting requirements

Reports should include the following information

4.1 Date of sampling

4.2 Location of samples eg ING or lat/long.

4.3 Treatment of samples and indication of sub sampling, compositing etc.

4.4 Tabulated geophysical and chemical test results

4.5 Completed excel spreadsheet for results

4.6 Summary method details

4.7 Method performance specifications: Limit of detection, Precision, Bias

4.8 Clear expression of units and indication of wet weight or dry weight basis

4.9 Blanks & in-house references to be run with each sample batch, and reported with sample results.

4.10 Appropriate Certified Reference Materials (CRM) to be run with each sample batch, and reported in full with sample results.

4.11 If determinant is not detected, report less than values, and indicate LoD/ LoQ used. Other quality assurance information (e.g. accreditation status)

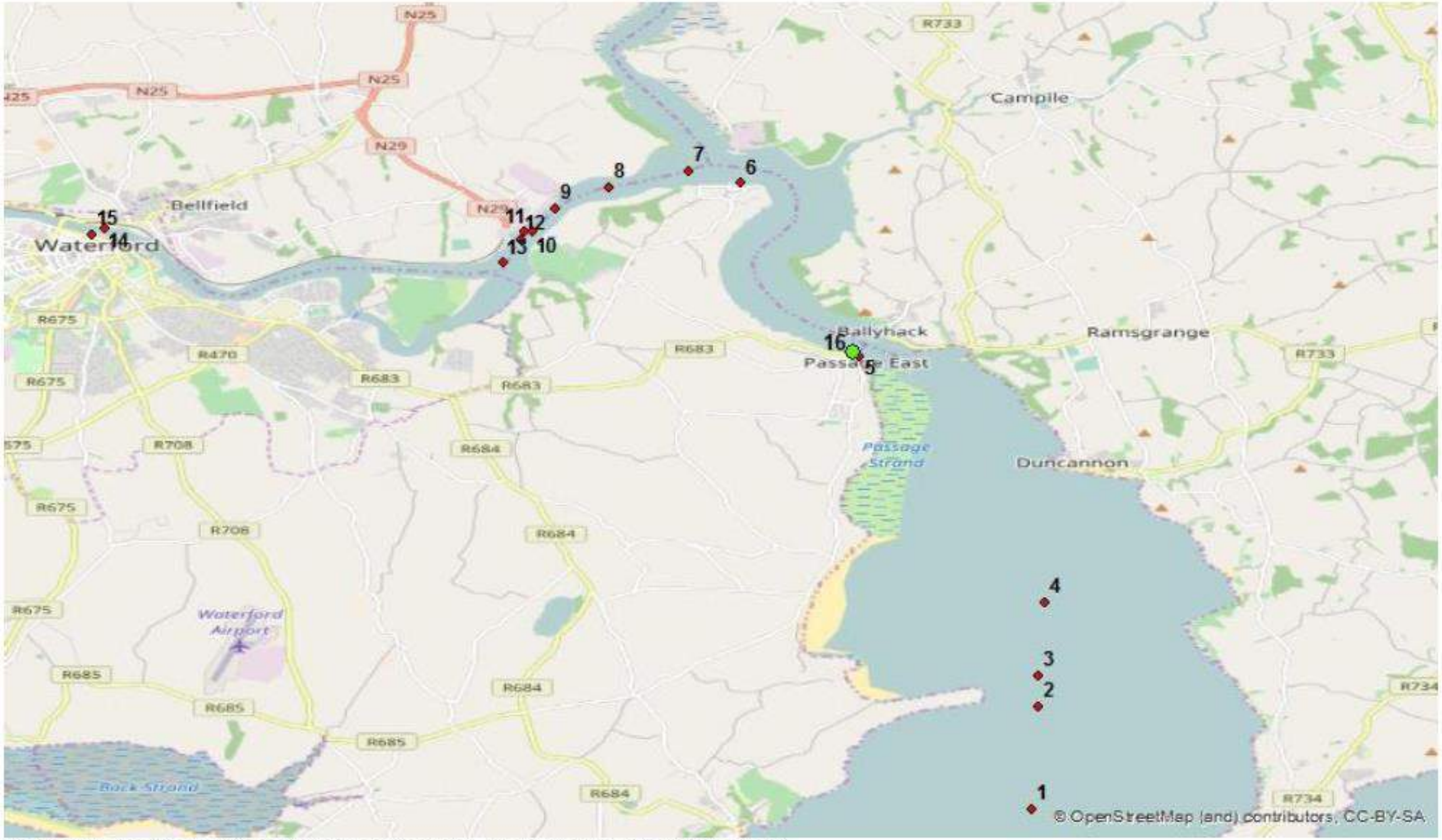

Figure 1: Sampling stations, Waterford Estuary. Co-ordinates given in Table 1.)

APPENDIX F-5

Photographic Survey of a Dredge Spoil Disposal Site

In Waterford Harbour

September 2020

Produced by

AQUAFACT International Services Ltd

On behalf of

Port of Waterford

Issued September 2020

AQUAFACT INTERNATIONAL SERVICES Ltd

[redacted]

Report Approval Sheet

Client	Port of Waterford
Report Title	Photographic Survey of a Dredge Spoil Disposal Site In Waterford Harbour
Job Number	JN1660
Report Status	Final
Issue Date	1st October 2020

Rev	Status	Issue Date	Document File Name	Author (s)	Approved by:
1	Draft	30.09.2020	JN1660 Waterford Disposal	[redacted]	BOC
2	Draft	30.09.2020	JN1660 Waterford Disposal		BOC
3	Final	01.10.20	JN1660 Waterford Disposal		BOC

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AQUAFACT

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Appendix 1. Sediment Profile Images, Waterford Harbour, 10th September 2020

Appendix 2. Particle Size Distribution Results from Spoil Material, 2020

1. Introduction

This report documents the environmental conditions of the seabed at a licensed dredge spoil disposal site off Hook Head, Co Waterford (see Figure 1-1). In order to maintain chartered depths in Waterford Harbour, the Port of Waterford Company must carry out maintenance dredging at a number of sites throughout the harbour. The sand bars at Duncannon and Cheekpoint and the berths at Belview are the primary dredging areas and require dredging at least twice a year with spoil material deposited at the licensed site, which has been used since 1996.

1.1. Site description

Hook Head is a long narrow headland running south into the sea 25 km south east of Waterford City. It forms the eastern side of Waterford Harbour, which is the mouth of the Rivers Suir, Nore and Barrow, and is a major seaport. The fishing port of Dunmore East is 7 km to the west across the harbour. The coastline is predominantly rocky, with old red sandstone cliffs in the Dunmore East area and limestone rocky foreshore around Hook Head.

Offshore tidal streams are mostly rectilinear and vary from 0.5 to over 1 knot. In the near coastal environment, the presence of the estuary creates strong tides, particularly on the ebb, giving rise to over-falls at certain times in the area west of Hook Head. The general spectrum of tides would appear to indicate a residual away from the harbour entrance, with a westerly component.

The licensed disposal site is located in the mouth of the harbour (see Figure 1-1) and defined by the co-ordinates:

52° 07.45 N, 06° 58.80 W; 52° 07.45 N, 06° 58.10 W;
52° 07.10 N, 06° 58.10 W; 52° 07.10 N, 06° 58.80 W.

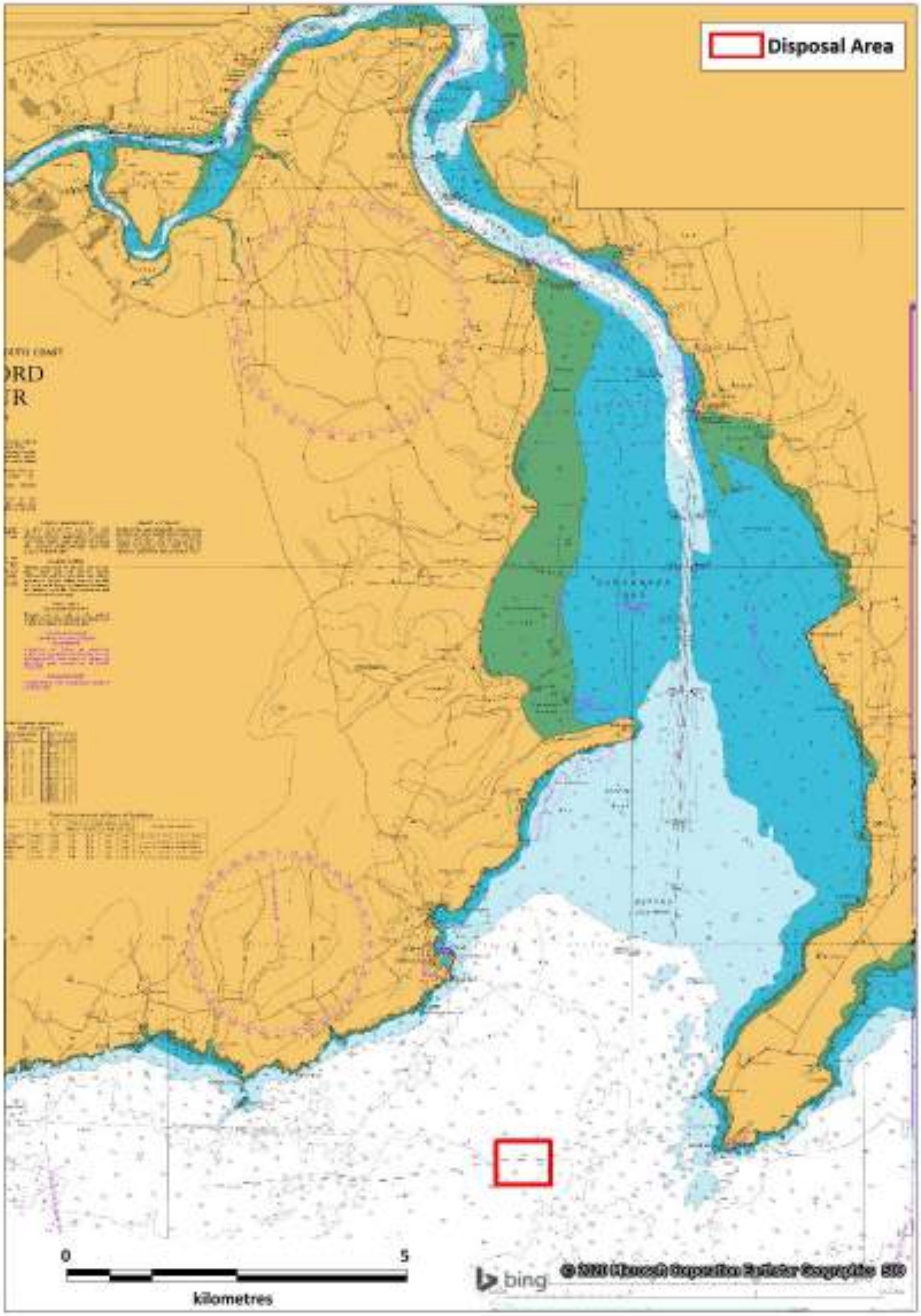


Figure 1-1: Map showing the location of the disposal site in Waterford Harbour, Co. Waterford.

2. Sampling Procedure

All survey work was conducted on 10th September 2020 when weather conditions were optimal with calm seas and bright sunshine. The survey was timed to coincide with the flooding tide to optimise underwater visibility, which was moderate to good at *ca*.5 m at all stations.

The underwater survey involved direct observation, sampling and recording of benthic conditions (through *in situ* photographs and annotations) at 9 stations as outlined in Figure 2-1 and their co-ordinates included in Table 2-1. Station coordinates were input to an onboard GPS and on arrival at each station a shot line was deployed to aid in station positioning.

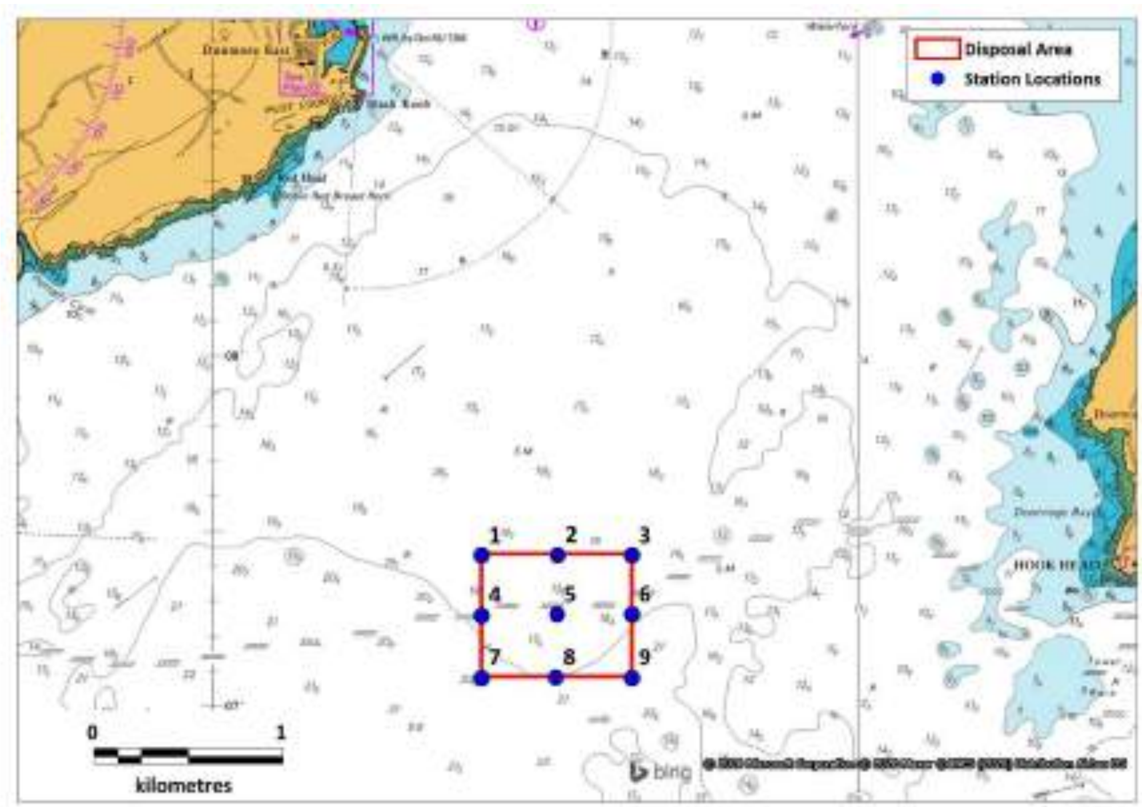


Figure 2-1 Stations sampled at the disposal site, Waterford Harbour, 10th September 2020

Table 2-1 Station Coordinates, Waterford Harbour, 10th September 2020

Station	*Latitude*	*Longitude*
1	52.12417	-6.980
2	52.12419	-6.97406
3	52.12417	-6.96833
4	52.12131	-6.98001
5	52.12135	-6.97415
6	52.12137	-6.96832
7	52.11833	-6.980
8	52.11836	-6.9742
9	52.11833	-6.96833

A high end dSLR Nikon D200 in a Subal ND20 underwater housing fitted with a 12-24mm lens and two INON strobes was used to photograph the seafloor features.

In order to examine the nature of the seafloor extensively, Sediment Profile Imagery (SPI) was also employed. This system is comprised of a digital SLR camera in a water-tight pressure vessel that is mounted above a prism that penetrates the upper 25cm of sediment (see Figure 2-2). The sediment profile is viewed through a Plexiglas® (Polymethyl methacrylate) window as an image reflected to the camera lens via a plane mirror. Illumination is provided by an internally mounted strobe. The diver depresses the unit into the seafloor and manually triggers the camera. This process is repeated at each station investigated. The prism unit is filled with distilled water – thus ambient water clarity is never a limiting factor in image quality.

A great deal of information about benthic processes is available from sediment profile images. Measurable parameters, many of which are calculated directly by image analysis, include physical/chemical parameters (*i.e.* sediment type measured as grain size major mode, prism penetration depth providing a relative indication of sediment shear strength, sediment surface relief, condition of mud clasts, redox potential discontinuity depth and degree of contrast, sediment gas voids) and biological parameters (*i.e.* infaunal successional stage of a well-documented successional paradigm for soft marine sediments (see Pearson and Rosenberg, 1978), degree of sediment reworking, dominant faunal type, epifauna and infauna, depth of faunal activity, presence of microbial aggregations).

Figure 2-2: Diver operated Sediment Profile Imaging camera. The left-hand image gives a view of the camera at the sediment surface. The right-hand image shows the SPI camera when inserted into the sediment.

SPI is particularly useful in the analysis of disposal sites. The extent and dispersion patterns of material can be quickly assessed and recovery rates of the bottom visually estimated. Dredge spoil material is normally of a different texture/grain size to a disposal sites natural sea floor and a visual record can be made of the layering of this material over the bottom.

3. Results

3.1. Recent Disposal Activity

The amount of material (dry tonnage) from the dredge locations deposited at the disposal site for 2019 and 2020 is presented in Table 3-1. In total, 403,328 tonnes were deposited in 2019 and 261,005 tonnes in 2020. The material was predominantly of a muddy sand composition from dredging operations at Duncannon Bar, Cheek Point and Belview (see Appendix 2).

Table 3-1 Dry tonnage disposal activity for 2019 and 2020

2019	***Duncannon***	***Cheekpoint***	***Belview***	***Total***
January	54,433			54,433
March	124,080	70,523	9,068	203,671
May		33,218	11,489	44,707
November	54,856	42,829	2,833	100,517
				403,328

2020	***Duncannon***	***Cheekpoint***	***Belview***	***Total***
March	196,507	64,498	0	261,005

3.2. Photographic Record

3.2.1. Station 1

Station 1 was located to the north west of the site and is located within a disposal exclusion zone at this corner of the site (see Figure 2.1). The seafloor consisted of fine sand that was formed into small waves and troughs s by the action of tidal currents (Plate 3-1). Pock marks in the sediment indicated the presence of infaunal polychaetes.

Plate 3-1 Station 1, Waterford Disposal site, 10th September 2020

3.2.2. Station 2

The seafloor at station 2 consisted of fine sand that was formed into small waves by the action of tidal currents (Plate 3-2). Apart from a small hermit crab (*Pagurus bernhardus*) there was little else of note on the surface (Plate 3-3).

Plate 3-2 Station 2, Waterford Disposal site, 10th September 2020

Plate 3-3 Hermit crab at Station 2, Waterford Disposal site, 10th September 2020

3.2.3. Station 3

Station 3 was located to the north east of the site. The seafloor consisted of fine sand formed into small waves (Plate 3-4). Casts originated from the burrowing activity of polychaetes were present on the sediment surface and a place, *Pleuronectes platessa*, was encountered resting on the bottom (Plate 3-5).

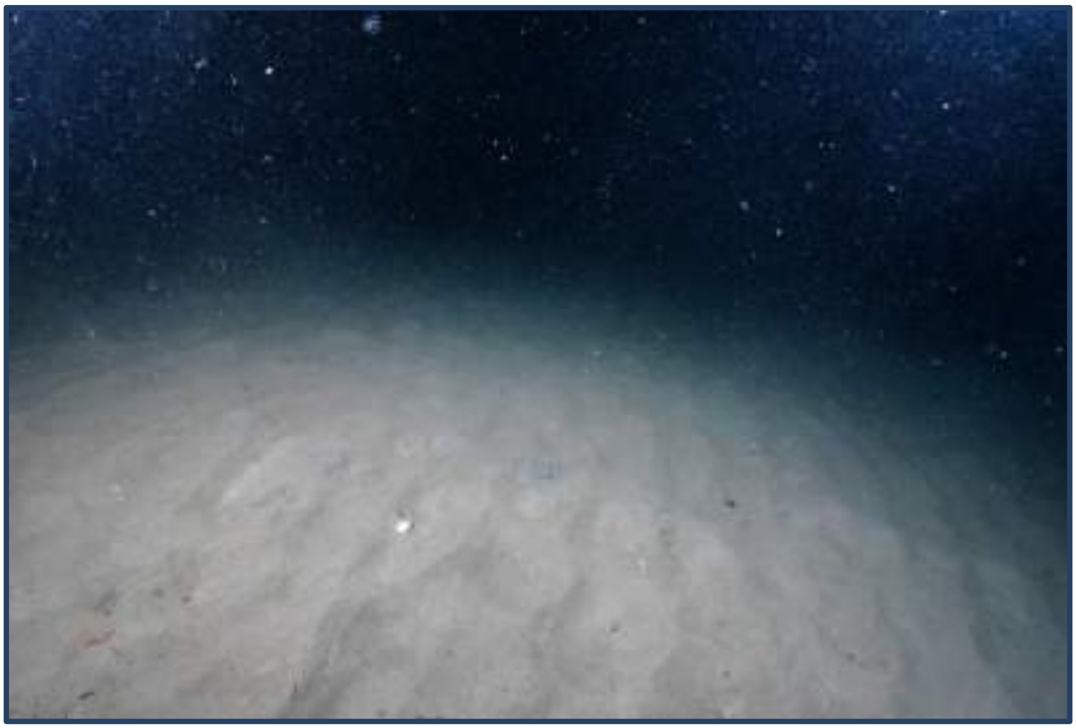


Plate 3-4 Station 3, Waterford Disposal site, 10th September 2020

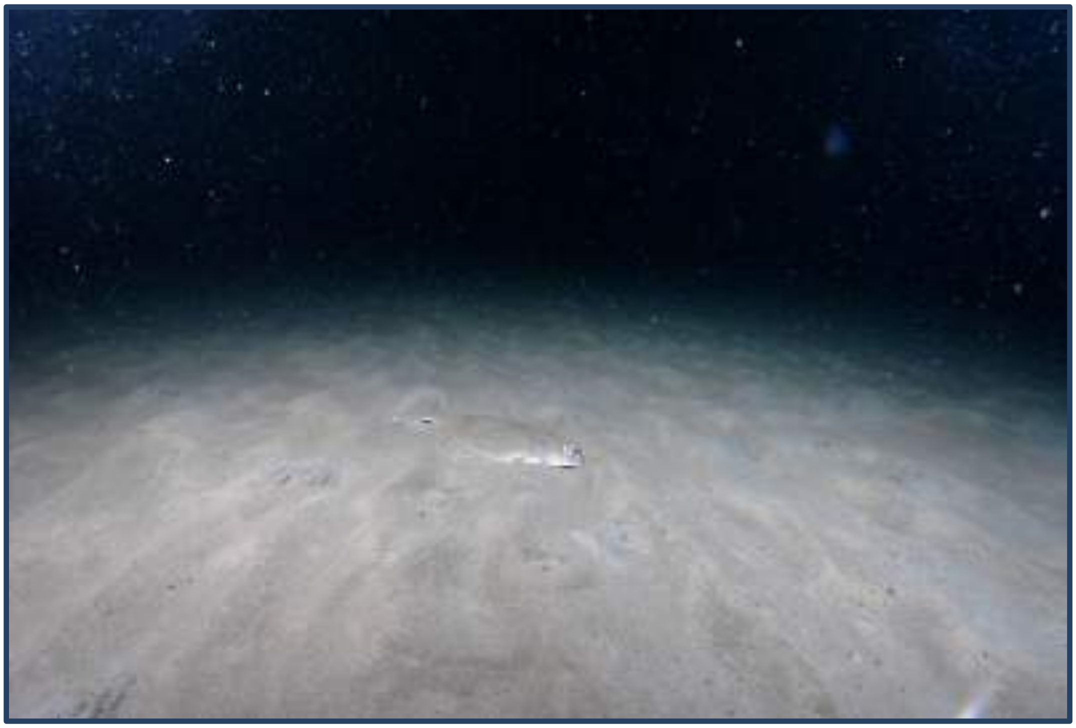


Plate 3-5 *Pleuronectes platessa* at Station 3, Waterford Disposal site, 10th September 2020

3.2.4. Station 4

The seafloor at Station 4 consisted of fine sand formed into small waves (Plate 3-6). Apart from some broken shell and small particles of drift algae, there were no other features of note on the seafloor.

Plate 3-6 Station 4, Waterford Disposal site, 10th September 2020

3.2.5. Station 5

Station 5 was located in the centre of the disposal site. As for the other stations, the seafloor consisted of fine clean sand formed into small waves by the action of tidal currents (Plate 3-7). A small hermit crab (*P. bernhardus*) and place (*P. platessa*) were imaged on the sediment surface along with small particles of drift algae (Plate 3-8).

Plate 3-7 Station 5, Waterford Disposal site, 10th September 2020

Plate 3-8 Hermit crab at Station 5, Waterford Disposal site, 10th September 2020

3.2.6. Station 6

The seafloor at Station 6, located on the east side of the site, was composed of fine sand formed into small waves. A number of casts resulting from the burrowing activity of polychaetes (*Arenicola marina*) were present on the surface (Plate 3-9).

Plate 3-9 Station 6, Waterford Disposal site, 10th September 2020

3.2.7. Station 7

The seafloor at station 7 consisted of fine sand formed into small waves with old oyster shells scattered over its surface (Plate 3-10). Place (*P. platessa)* (Plate 3-10), swimming crab (*Liocarcinus depurator*) (Plate 3-11), and edible crab (*Cancer pagurus*) (Plate 3-12) were all imaged at this location. A large shoal of juvenile horse mackerel (*Trachurus trachurus*) were also recorded (Plate 3-13).

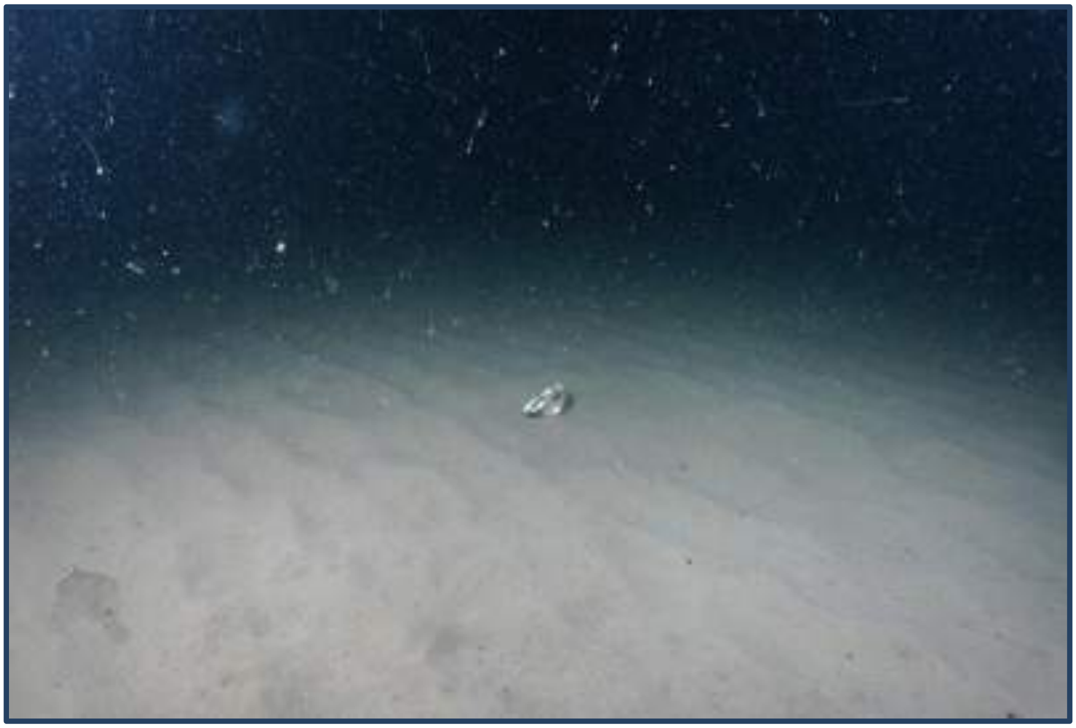


Plate 3-10 Station 7, Waterford Disposal site, 10th September 2020

Plate 3-11 Swimming crab, Waterford Disposal site, 10th September 2020

Plate 3-12 Edible crab, Waterford Disposal site, 10th September 2020

Plate 3-13 Juvenile horse mackerel, Station 7, Waterford Disposal site, 10th September 2020

3.2.8. Station 8

The seafloor at Station 8 was composed of fine sand formed into small waves. A number of casts resulting from the burrowing activity of polychaetes (*A. marina*) were present on the surface (Plate 3-14).

Plate 3-14 Station 8, Waterford Disposal site, 10th September 2020

3.2.9. Station 9

The seafloor at Station 9, located to the south east of the site, was composed of fine sand formed into small waves with casts of polychaetes (*A. marina*) present on the surface (Plate 3-14). A spider crab, *Maja squinado*, was imaged at this location (Plate 3-15).

Plate 3-15 Station 9, Waterford Disposal site, 10th September 2020

Plate 3-16 Spider crab, Waterford Disposal site, 10th September 2020

3.3. Sediment Profile Imagery

Sediment profile images, taken at each of the stations are included in Appendix I.

3.3.1. Sediment Type

The predominant sediment type at all stations was of fine sand with various amounts of silt-clay incorporated into the sand. The depth of fine sand was below the penetrative capacity of the camera (max 18.4 cm, Station 5). Silt-clay was evident at all stations but in particular Stations 2 and 5.

3.3.2. Mean Prism Penetration Depth

The mean prism penetration depth reflects both the grain size composition and compactness of the bottom deposits. Apart from Station 1, mean prism penetration was relatively good ranging from 6.57 cm at Station 9 to 18.4 cm at Station 5. The seafloor at Station 1 was relatively compact compared to the other stations and a mean penetration of 3.9 cm was achieved.

3.3.3. Surface Boundary Roughness

Surface boundary roughness is an indication of the unevenness of the sediment surface resulting from either bioturbation (animals in the sediment) or physical disturbance. This value varied considerably from station to station reflecting the uneven nature of the seafloor at the disposal site. This was attributed to physical disturbance and formation of sand waves and troughs caused by water movement.

3.3.4. Apparent Redox Potential Discontinuity (APRD)

The apparent redox potential discontinuity (ARPD) depths (depth of aerated sediment) were variable at all of the stations as evident by the grey/black streaks in the SPI images. This was particularly evident at Stations 9, 8 and 5 where reduced sediment was present up to the sediment water interface.

3.3.5. Infaunal Successional Stage

No infauna were observed in the images and given the disposal history of the site, all stations can be allocated a Stage I status, indicating recent disturbance.

4. Conclusion

The predominant sediment at all stations sampled during this survey was of fine sand that was formed into small waves and troughs by the action of bottom currents. Sediment profiles showed that silt-clay has been incorporated into the bottom although hadn't dispersed evenly through the sand and was seen as streaks and clumps in the SPI images. Small clumps of silt-clay were still evident on the sediment surface in the SPI images taken at Station 2 and presumable a remnant of the most recent disposal event that occurred in March-April 2020. Previous benthic surveys of the spoil ground documented fine to medium sand to the north of the disposal site that graduated into coarse gravelly sands to the south (AQUAFACT, 1996a, b; 1999, 2000; 2003). As was recorded by a limited video survey within the area in 2017 (Aquafact, 2017), the gravel that was previously recorded is now completely covered by a blanket of fine sand from the disposal events throughout the site. The granulometric component of this material is in keeping with the granulometric composition of the dredge material as outlined in Appendix 2.

During the disposal of spoil, the dredger steams to the licensed disposal site and slows to approximately one to two knots. The dredger then opens bottom doors or split along its hull to allow the release of its contents over several minutes. During the disposal operation, the dredger is travelling at between one to two knots within the disposal area. Due to this, the material is placed over a substantial portion of the disposal site and ensures against accumulation of material within an isolated area (*e.g.* the centre of the disposal site). This process is repeated for each disposal operation with the master of the vessel referring to the previous disposal areas used within the on-board tracking system and selecting a new disposal area (within the licensed area) not previously used in that campaign. By using as much of the disposal site as possible any impacts from the disposal activity are minimised. Evidence from the current survey suggests an even dispersion of material with no mounds or accumulations at any one spot.

Few macrofaunal species were recorded during the present survey and those that were (e.g. crabs) are mostly mobile and common from coastal areas allowing them to move freely in and out of the site. A number of grab samples were taken from the spoil ground in 2017 (Aquafact, 2017) and were found to contain the highest richness and diversity compared to other samples taken in the outer estuary. The species community identified from the samples conformed to the JNCC habitat SS.SSA.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (EUNIS Code: A5.242). Since those faunal samples were taken, there have been a number of disposal events as outlined in Section 3.1 with the result that this community would most likely have been buried as dredge spoil was deposited on the seafloor. However, while the community will be buried by the spoil, the spoil will spread out and the infaunal species will recolonise from the surround areas and also if the spoil depth is not too deep the infauna will be able to migrate to the surface of the spoil heap. The surface images indicated that infaunal activity was evident from the casts left on the sediment surface that result from the burrowing activity of polychaetes such as the lugworm, *A. marina.* However, there was no evidence of infaunal activity from the SPI images taken at each of the stations.

5. References

AQUAFACT. 1996a. Photographic and visual survey of the seabed in the areas of and around the proposed dumpsite in Waterford Harbour. 7th August 1996.

AQUAFACT. 1996b. Photographic and visual survey of the seabed in the areas of and around the proposed dumpsite in Waterford Harbour. 15th November 1996.

AQUAFACT. 1999. Photographic survey of a dredge spoil dumpsite Waterford Harbour. 30th January 1999.

AQUAFACT. 2000. Photographic survey of a dredge spoil dumpsite Waterford Harbour. 20th January 2000.

AQUAFACT. 2003. Photographic survey of a dredge spoil dumpsite Waterford Harbour. 12th February 2003.

AQUAFACT. 2017. Marine Sediment and Benthic Studies Waterford Harbour Dredging and Disposal Operations. November 20177.

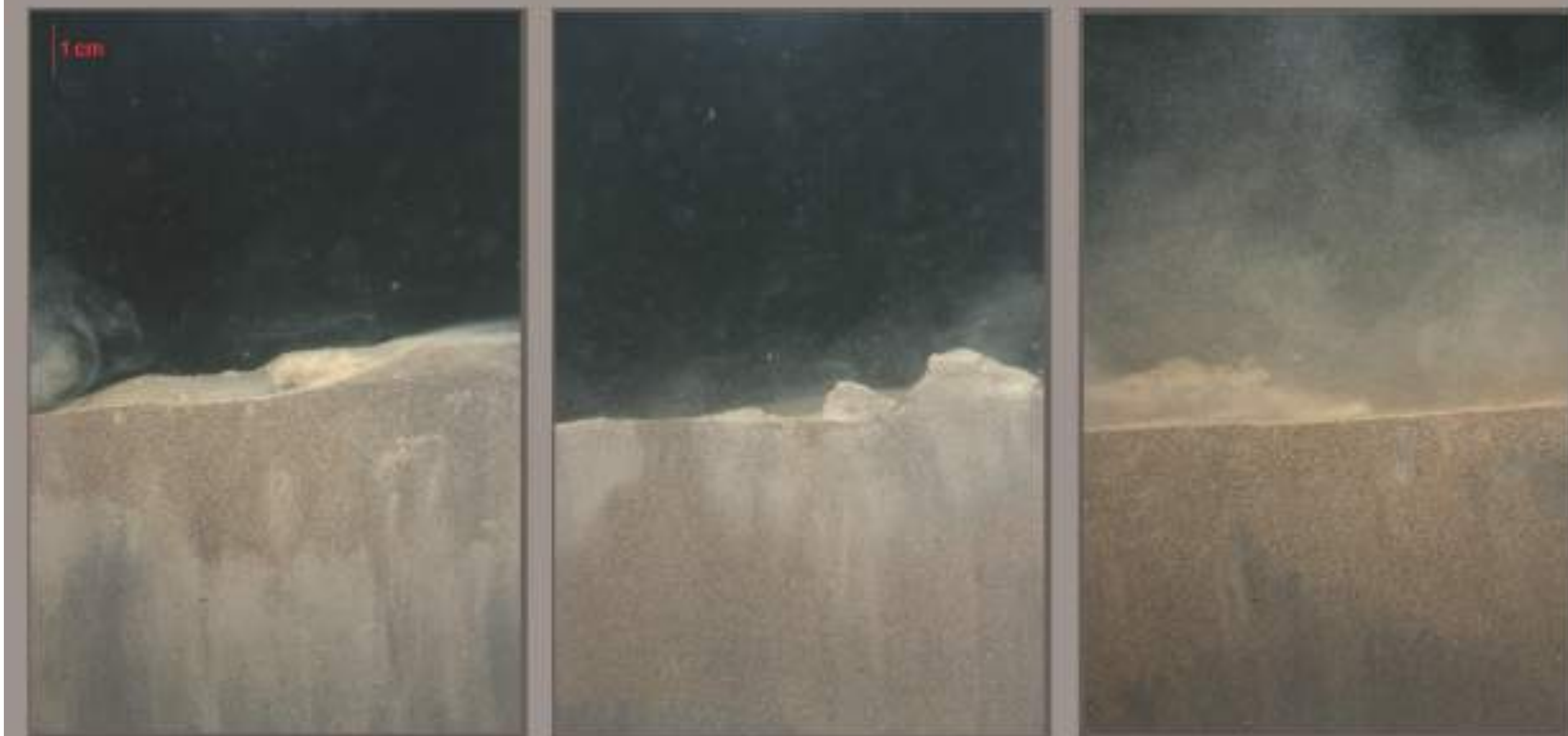
Appendix 1 Sediment Profile Images, Waterford Harbour, 10th September 2020

Station 1

10th September 2020
Waterford Harbour,
Co. Waterford

AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS

Station 2



10th September 2020
Waterford Harbour,
Co. Waterford

AQUAFACT
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Station 3

10th September 2020
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Station 4

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Station 5

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Station 6

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Station 7

10th September 2020
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AQUAFACT
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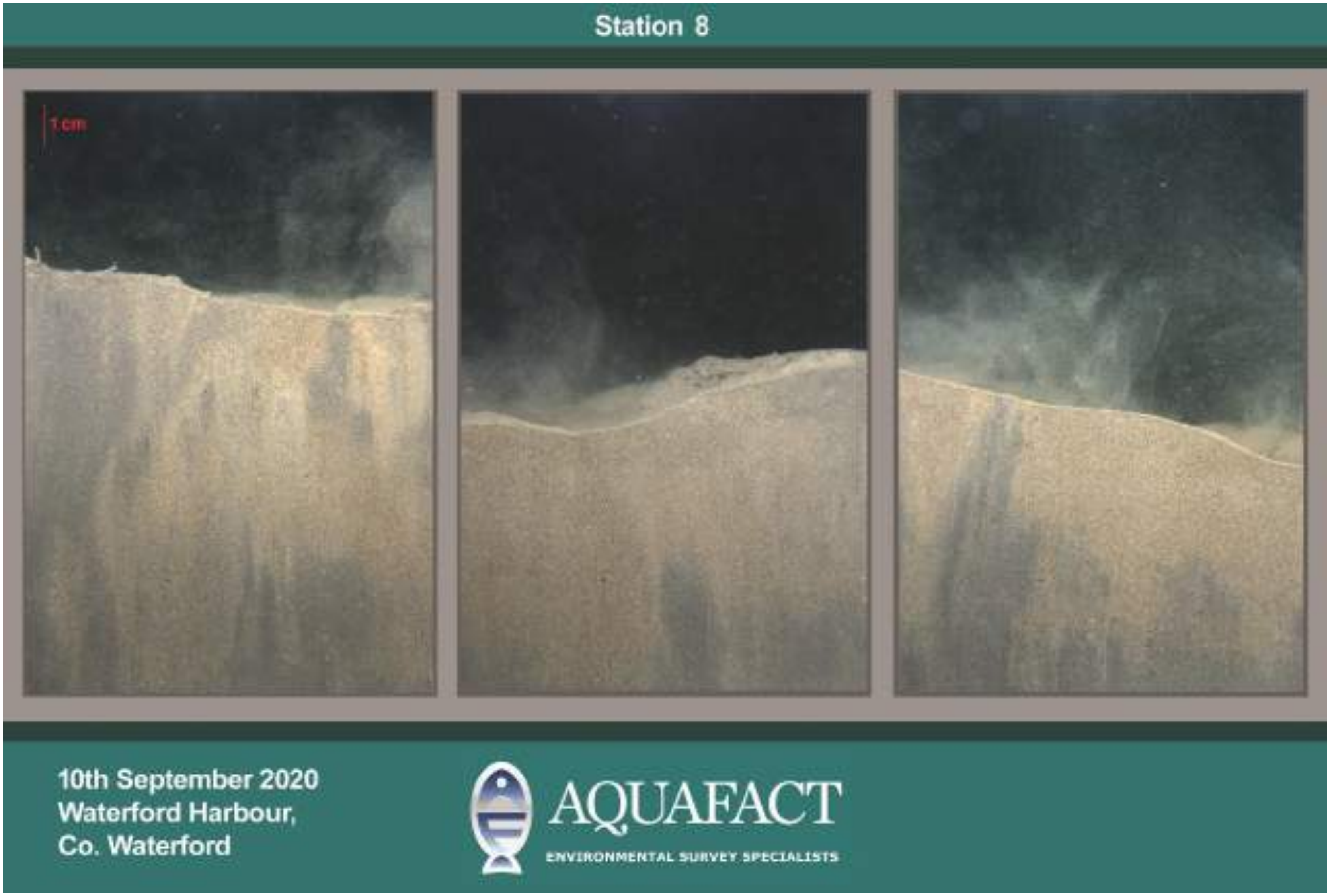
Station 8
1 cm
10th September 2020
Waterford Harbour,
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Station 9

10th September 2020
Waterford Harbour,
Co. Waterford

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Appendix 2. Particle Size Distribution Results from Spoil Material 2020

Station	Textural Group Classification	Folk and Ward Description	Folk and Ward Sorting	Major Sediment Fractions		
				% Gravel	% Sand	% Mud
Duncannon	Sand	Fine Sand	Moderately Sorted	0.0%	93.2%	6.8%
Duncannon	Sandy Mud	Very Coarse Silt	Poorly Sorted	0.0%	37.2%	62.8%
Cheekpoint	Sandy Mud	Very Coarse Silt	Poorly Sorted	0.0%	39.5%	60.5%
Belview	Gravelly Muddy Sand	Coarse Sand	Very Poorly Sorted	18.7%	70.8%	10.5%
Belview	Muddy Sand	Fine Sand	Very Poorly Sorted	0.0%	78.5%	21.5%
Belview	Slightly Gravelly Muddy Sand	Very Fine Sand	Very Poorly Sorted	0.2%	68.1%	31.7%