Fenit Harbour & Proposed Dumpsite

Baseline Characterisation Report

Produced by

AQUAFACT International Services Ltd

On behalf of

Malachy Walsh & Partners

September 2014

AQUAFACT INTERNATIONAL SERVICES ltd

12 KILKERRIN park

TUAM rd

GALWAY city

www.aquafact.ie

info@aquafact.ie

Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

AQUAFACT International Services Ltd. was commissioned by Malachy Walsh & Partners to carry out a baseline assessment of a proposed new dumpsite as part of the Fenit Harbour dredging campaign. Sediment characterisation was also required from the harbour area in line with Cronin *et al.* (2006) 'Guidelines for the assessment of dredge material for disposal in Irish waters'.

Fenit Harbour is located within the Tralee Bay and Magharees Peninsula, West to Cloghane cSAC (Site Code: IE002070) and within 1.1km of Tralee Bay Complex SPA (Site Code: IE004188) and within 760m of Akeragh, Banna and Barrow Harbour cSAC (Site Code: IE000332). The dumpsite is located *c.* 800m southeast of Magharee Islands cSAC (Site Code: IE002261), *c.* 1.5km northwest of Akeragh, Banna and Barrow Harbour cSAC (Site Code: IE000332), 3.1km northeast of Tralee Bay Complex SPA (Site Code: IE004188), 1.5km south of Magharee Islands SPA (Site Code: IE004125) and 1.9km northwest of Tralee Bay Compex SPA (Site Code: IE004188). The location of Fenit Harbour and dumpsite in relation to nearby cSACs and SPAs can be seen in Figure 1.1.

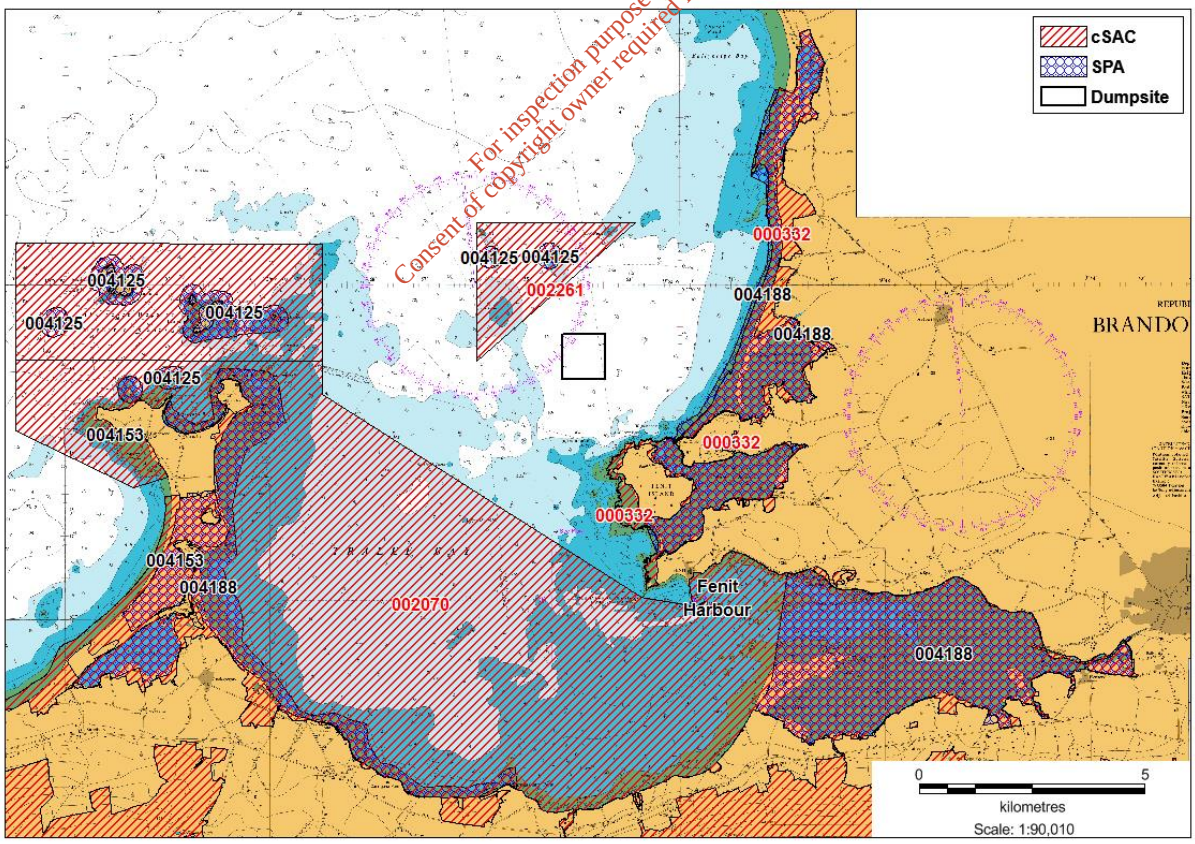

Figure 1.1: Location of Fenit Harbour and Dumpsite in relation to nearby cSACs and SPAs.

2. Description of Proposed Works

Fenit Harbour has a need for regular maintenance dredging. Historically this is done in a 3 or 5 year cycle depending on whether it is the commercial shipping berth or the inner marina harbour area. A dumping at sea site is required for the deposition of dredge material. Over the years a number of Dumping At Sea permits were issued by the Department of Marine and Department of Environment. The last permit expired in 2011 after the last dredging campaign was completed.

Presently there is a significant volume of material that has accumulated in the commercial berth which is actively used by Liebherr Crane shipping activities. Approximately 43,000m^3 of material needs to dredged and removed and deposited at the Dumping at sea site located in the outer Tralee Bay area.

Currently an application for a Dumping At Sea licence is being completed for submission to the EPA. The dredging will be undertaken using a suction hopper dredger which will be on site for a maximum of three weeks, subject to weather and tides. The suction hopper dredger enables removal of material from the bed in a controlled fashion. This type of dredger has greater controls in terms of accuracy of dredging and in minimisation of a plume within the water column.

The location of the dredging is adjacent to the main commercial pier on its northern side. The area or footprint to be dredged is 2.6 ha and is shown in Figure 2.1. The inner Tralee Bay area due east of the harbour has an area designated for shellfish, which in this case is the native oyster. Accordingly any potential impact on the shellfish areas has to be minimised ore removed.

During the dredging operations an array of turbidity monitors with alarms' will be placed due east of the dredge location so as to monitor any deterioration in water quality and any obvious large dispersion of a dredge plume. There will also be visual monitoring during dredge activities by harbour staff and the dredge captain.

The suction hopper dredger moves in a linear defined corridor and dredges in stages. In effect it does so by a series of passes over a defined footprint area until it reaches its design depth, which in this case is -7.5 for the berth and -5.5 for the ship manoeuvring area.

As the dredger progresses it fills its on board storage bay. When full the dredger then steams to the dumping at sea location. Once there the location within the footprint of the dump site is recorded and

then the dredger opens it sea doors and deposits the excavated silt material onto the sea bed. The area over which the dredger deposit each load is recorded with co-ordinates and the volume deposited is noted. Deposition is undertaken at optimum times of the tide, within good weather windows. There will also be monitoring of the plume at the deposition site as part of normal good practice.

Once the dredger is finished the disposal process it then steams back to port and recommences the dredging operation. This process is repeated until such time as all material is removed and the design depths are achieved. A bathymetry survey is then undertaken to confirm dredge depths.

Once dredging operations are completed a full report of the volumes removed and deposited will be produced. This will also include a drawing showing the dump footprint, its co-ordinates and the volumes deposited.

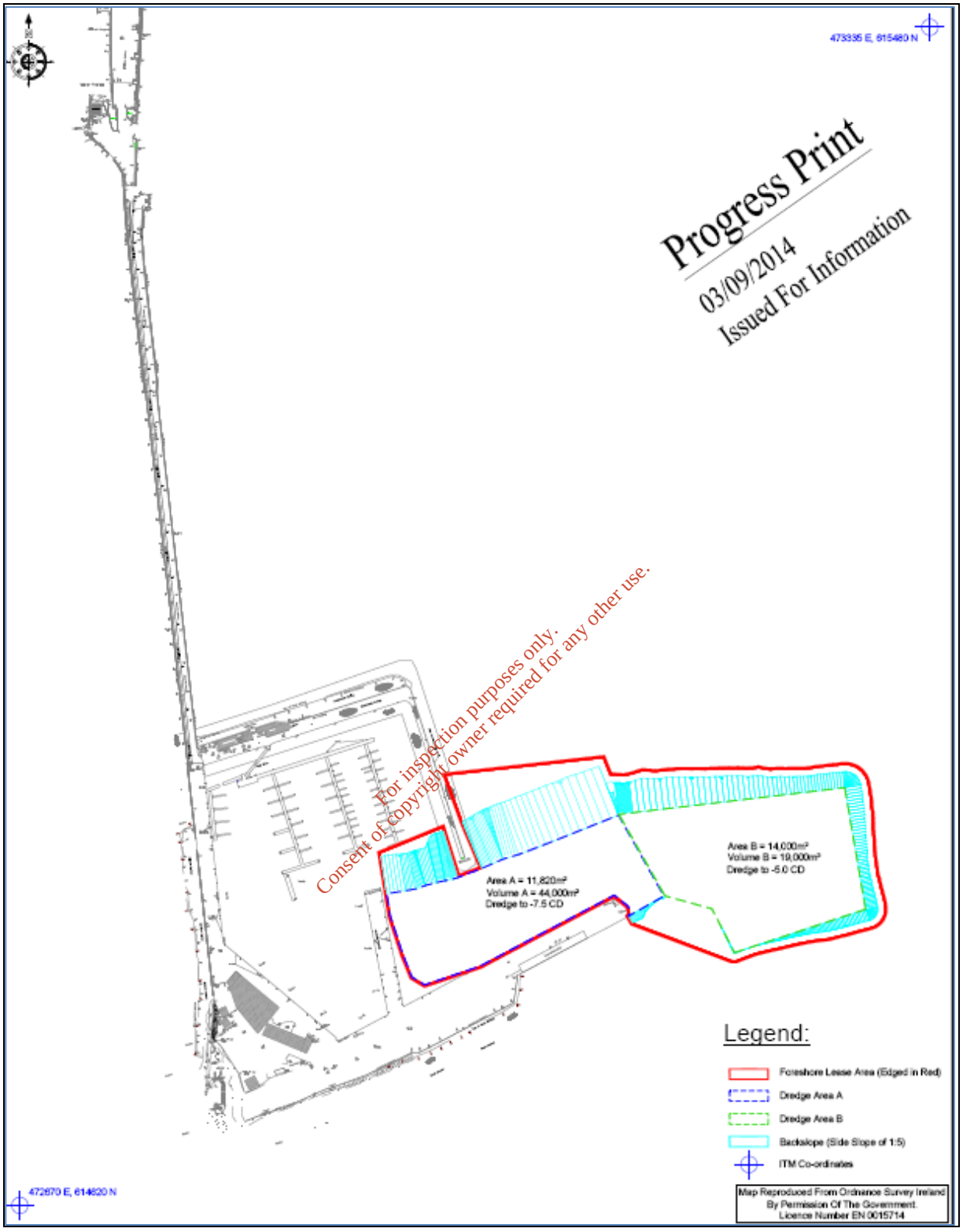

Figure 2.1: The area to be dredged.

3. Materials & Methods

3.1. Sampling Procedure

All sampling took place on the 23rd July 2014. 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" were adhered to.

To carry out the subtidal benthic faunal assessment of the proposed dumpsite, AQUAFACT sampled 8 sites within and around the dumpsite (see Figure 3.1). Station coordinates and depths can be seen in Table 3.1. Samples were retrieved using a 0.025m^2 van Veen grab.

Two replicate grab samples were taken at all 8 stations for faunal analysis. Each sample was 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. Very stiff clay was fragmented very carefully by hand. 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. The grab sampler was cleaned between stations to prevent cross contamination.

An additional sample was collected at all 8 stations for grain size analysis and organic carbon content. All sampling jars were marked externally with date, station number, sample number and survey reference number and placed in a cooler box.

To carry out the sediment characterisation survey, one grab sample was collected at 7 stations in the harbour and 3 stations in the dumpsite (correspond to stations DS1, DS2 and DS3 from the faunal survey – these stations which were selected by the Marine Institute had to be relocated due to hard ground at the original DS2 and DS3 sites). Figure 2.2 shows the station locations and Table 3.2 shows the station coordinates and depths. The grab samples were divided up for contaminant analysis, organic carbon content, particle size analysis, sediment density and moisture content. All sampling jars

were marked externally with date, station number, sample number and survey reference number and placed in a cooler box. Table 3.3 shows the required determinands at each station.

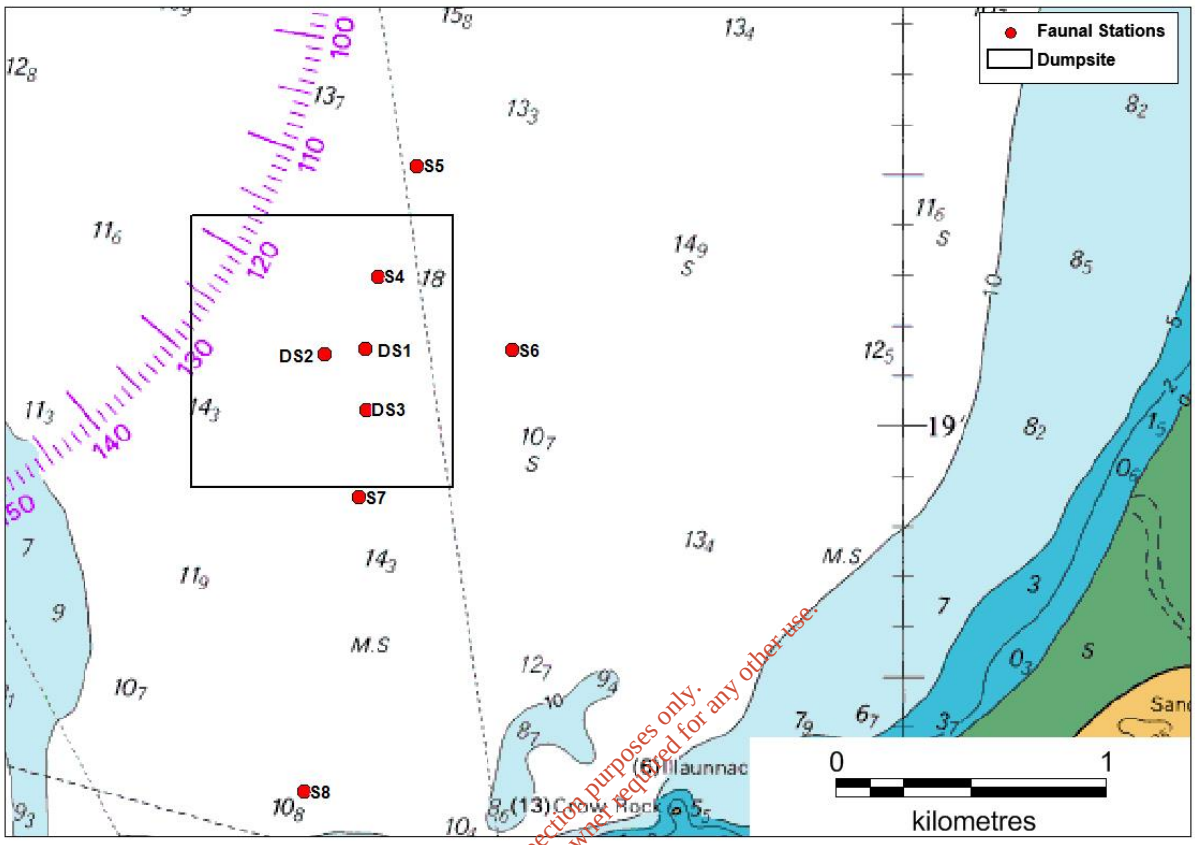

Figure 3.1: Faunal survey station locations

Table 3.1: Coordinates of faunal grab sampling stations.

Station	Longitude	Latitude	Depth (m)
DS1	-9.89643	52.31958	17.8
DS2	-9.89866	52.31941	17.6
DS3	-9.89639	52.31756	17.7
S4	-9.89575	52.32199	19.5
S5	-9.89363	52.32566	20.5
S6	-9.88843	52.31953	19.2
S7	-9.89678	52.31465	17.7
S8	-9.89977	52.30488	15.9

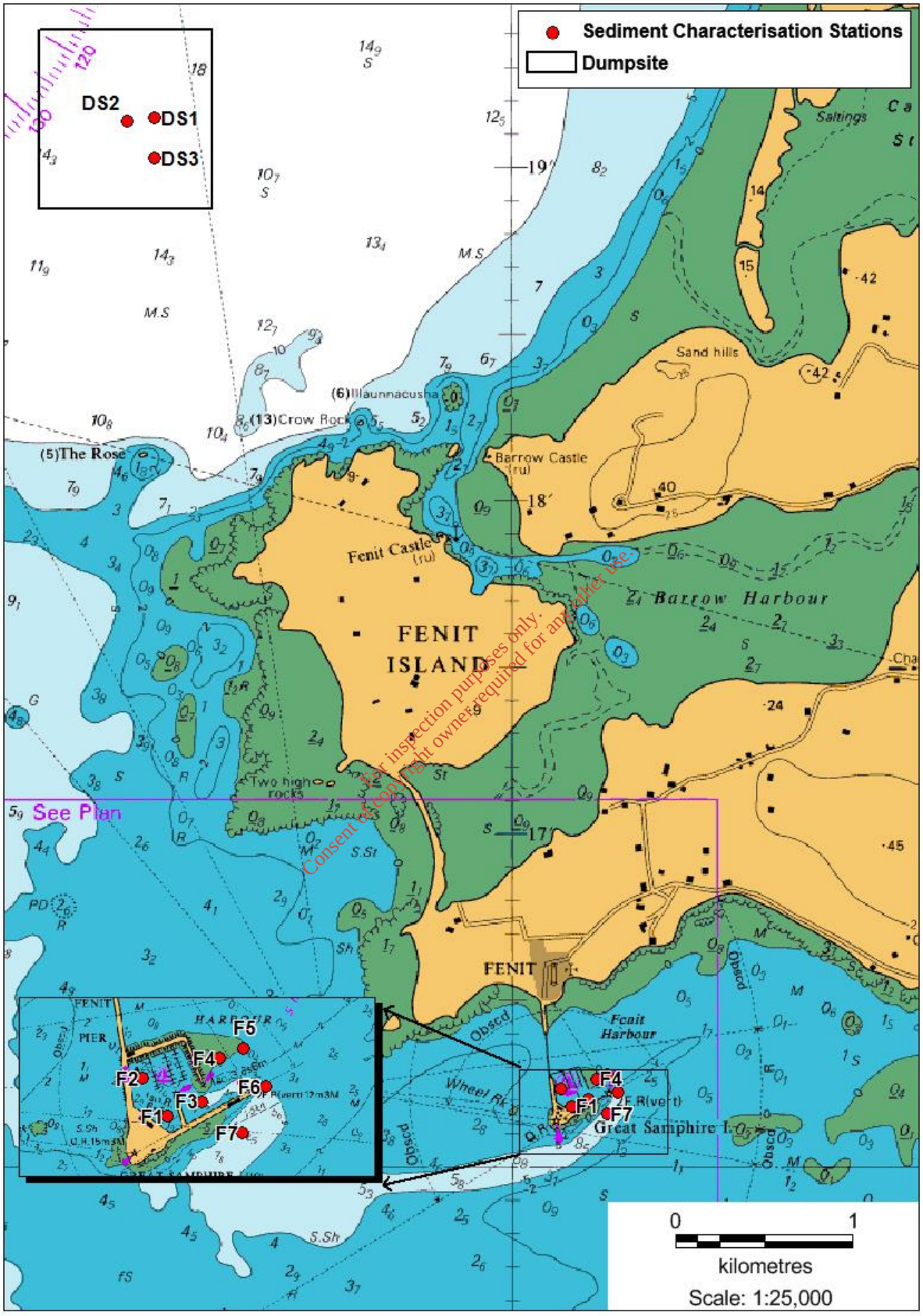

Figure 3.2: Sediment characterisation station locations

Table 3.2: Coordinates of the sediment characterisation station locations

Station	Longitude	Latitude	Depth (m)	Determinand Required
F1	-9.86234	52.27003	4.1	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F2	-9.86327	52.27092	4.6	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F3	-9.86103	52.27037	7.5	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F4	-9.86035	52.27139	2.1	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F5	-9.85943	52.2716	2.7	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F6	-9.85859	52.27071	7.9	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
F7	-9.85949	52.26964	6.0	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
DS1	-9.89643	52.31958	17.8	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs, Hydrocarbons, TBT, DBT, PAHs
DS2	-9.89866	52.31941	17.6	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, TBT, DBT
DS3	-9.89639	52.31756	17.7	Visuals, Water Content, Density, Granulometry, TOC, Carbonate, Metals, OCLs & PCBs

3.2. Sample Processing

3.2.1. Fauna

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.

3.2.2. Sediment

Once back in the lab, all sediment samples for the analysis of organics and contaminants were sent to the RPS Mountainheath laboratory in Hertfordshire. Organic carbon by Loss on Ignition for the faunal samples was carried out by ALS Labs in Loughrea. AQUAFACT carried out the particle size analysis and moisture and density content as described below.

3.2.2.1. Particle Size Analysis (PSA)

AQUAFACT carried out the PSA analysis in-house using the following methodology:

1. Approximately 100g of dried sediment (previously washed in distilled water and dried) was weighed out and placed in a labelled 1L glass beaker to which 100ml of a 6 percent hydrogen peroxide solution was added. This was allowed to stand overnight in a fume hood.
2. The beaker was placed on a hot plate and heated gently. Small quantities of hydrogen peroxide were added to the beaker until there was no further reaction. This peroxide treatment removed any organic material from the sediment which can interfere with grain size determination.
3. The beaker was then emptied of sediment and rinsed into a 63µm sieve. This was then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve was then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution was added to the beaker and this solution was stirred for ten minutes and then allowed to stand overnight. This treatment helped to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution was washed and rinsed into a 63µm sieve. The retained sample was carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.

6. The dried sediment was then passed through a Wentworth series of analytical sieves (>8,000 to 63µm; single phi units). The weight of material retained in each sieve was weighed and recorded. The material which passed through the 63µm sieve was also weighed and the value added to the value measured in Point 5 (above).
7. The total silt/clay fraction was 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.
8. The following range of particle sizes: <63µm, 63<125µm, 125<250µm, 250<500µm, 500<1000µm, 1000<2000µm, 2000<4000µm and 4000<8000µm were reported.

3.2.2.2. Moisture Content & Density

Moisture content was taken as the percentage weight difference between the wet and dried sediment. Sediment density was calculated by placing a fixed volume (100 ml) of sediment in a volumetric cylinder and weighing the contents.

3.2.2.3. Organic Matter

All organic matter samples from the faunal survey were sent to ALS Labs for analysis. The following methodology was used:

1. The collected sediments were transferred to aluminium trays, homogenised by hand and dried in an oven at 100º C for 24 hours.
2. A sample of dried sediment was placed in a mortar and pestle and ground down to a fine powder.
3. 1g of this ground sediment was weighed into a pre-weighed crucible and placed in a muffle furnace at 450ºC for a period of 6 hours.
4. The sediment samples were then allowed to cool in a desiccator for 1 hour before being weighed again.

The organic content of the sample was determined by expressing as a percentage of the weight of the sediment after ignition over the initial weight of the sediment.

3.2.2.4. Chemical Analysis

The following methodologies were employed by RPS Mountainheath:

- Total Organic Carbon analysis: Combustion and infrared analysis following carbonate removal with hydrochloric acid.
- Carbonate content analysis: Gravimetric analysis of a dry portion of the sediment following carbonate removal with hydrochloric acid.

- Total Hydrocarbons: GCFID analysis following extraction of the wet sediment with dichloromethane:methanol by ultrasonic extraction and subsequent portioning with water. Extract cleaned-up with silica and activated copper.
- Organotins: GCMS analysis following the extraction of the wet sediment and subsequent derivatisation.
- Metal analysis: ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
- PAH & PCB analysis: GCMS analysis following extraction of the wet sediment with hexane:acetone by ultrasonic and equilibrium extraction. Extract cleaned-up with alumina and activated copper.
- Dry solids at 30°C analysis: A portion of the wet sediment is dried in a temperature controlled and heap filtered cabinet at 30°C.

All testes were carried out on the <2mm fraction.

The Limits of detection can be seen in Table 3.3.

Table 3.3: Limits of Detection

Parameter	Unit	LOD
Hydrocarbons	mg/kg	0.01
Mercury	mg/kg	0.03
Aluminium	mg/kg	1.0
Arsenic	mg/kg	0.15
Cadmium	mg/kg	0.05
Chromium	mg/kg	0.15
Copper	mg/kg	0.06
Lead	mg/kg	0.08
Lithium	mg/kg	0.1
Nickel	mg/kg	0.15
Zinc	mg/kg	0.15
OCP	µg/kg	1
PAH	µg/kg	0.01-1
PCBs	µg/kg	0.2
DBT/TBT	mg/kg	0.01

3.3. 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)

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

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.

4. Results

4.1. Fauna

4.1.1. Community Analysis

The taxonomic identification of the benthic infauna across all 8 faunal stations sampled in and around the dumpsite yielded a total count of 135 taxa ascribed to 7 phyla. Of the 135 taxa identified, 80 were identified to species level. The remaining 55 could not be identified to species level for the following reasons: 22 were juveniles, 27 were partial/damaged and 6 were indeterminate. Appendix 1 shows the faunal abundances from the dumpsite stations.

Of the 135 taxa present, 56 were annelids (segmented worms including sipunculids), 40 were molluscs (mussels, cockles, snails etc.), 34 was a crustacean (crabs, shrimps, prawns), 2 were echinoderms (sea urchins), 1 was a chelicerata (sea spiders), 1 was a nemertean (ribbon worm) and 1 was a nematode (round worm).

4.1.1.1. Univariate 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 4.1; taxon numbers, number of individuals, richness, evenness, Shannon-Weiner diversity and Simpson's diversity. Taxon numbers ranged from 17 (DS1) to 53 (S5). Number of individuals ranged from 47 (S4) to 482 (S5). Richness

ranged from 3.62 (DS1) to 8.42 (S5). Evenness ranged from 0.55 (S5) to 0.95 (S4). Shannon-Weiner diversity ranged from 2.78 (DS1) to 4.65 (S4 and S6). Simpson's diversity ranged from 0.78 (DS1) to 0.97 (S4).

Table 4.1: Univariate measures of community structure.

Station	No. Taxa	No. Individuals	Richness	Evenness	Shannon-Weiner Diversity	Simpsons's Diversity
DS1	17	83	3.62	0.68	2.78	0.78
DS2	30	76	6.70	0.78	3.82	0.85
DS3	30	120	6.06	0.82	4.01	0.91
S4	30	47	7.53	0.95	4.65	0.97
S5	53	482	8.42	0.55	3.17	0.79
S6	41	144	8.05	0.87	4.65	0.95
S7	25	97	5.25	0.73	3.40	0.82
S8	37	145	7.23	0.84	4.37	0.93

4.1.1.2. Multivariate Analysis

The dendrogram and the MDS plot can be seen in Figures 4.1 and 4.2 respectively. SIMPROF analysis revealed 4 statistically significant groupings between the 8 stations (the samples connected by red lines cannot be significantly differentiated). The stress level on the MDS plot indicates an excellent representation of the data.

Group a contained stations DS1, S5 and S7 and had a within group similarity level of 35.67%. **Group a** separated from all other stations at a 13.43% similarity level. This group contained 71 taxa comprising 662 individuals. Of the 71 species, 54 were present twice or less. Three species accounted for 70% of the faunal abundance: the gastropod mollusc *Caecum trachea* (197 individuals; 29.76% abundance), Nematoda (172 individuals; 25.98% abundance) and the bivalve mollusc *Goodalia triangularis* (96 individuals; 14.5% abundance). *Goodalia triangularis,* the bivalves Mactridae (juv), *Caecum trachea* and the polychaete *Syllis pontxioi* were identified by SIMPER analysis as the characterising species of the group. Table 3.2 shows the full SIMPER results. *Caecum trachea* and Mactridae are species very sensitive to organic enrichment and present under unpolluted conditions. *Goodallia triangularis* and *Syllis pontxioi* are species indifferent to enrichment, always present in low densities with non-significant variations over time. Nematoda are species tolerant to excess organic matter enrichment and these species may occur under normal conditions but their populations are stimulated by organic enrichment. Species richness ranged from low to high and diversity was moderate at these stations. Organic matter levels for this group ranged between 0.79% to 3.94% and sediment type varied from

fine sand at DS1 to gravelly sand at stations S5 and S7. Station S7 had the highest organic matter levels of all stations.

Group d contained stations DS3, S6 and S8 and had a within group similarity level of 55.55%. **Group d** contained 62 taxa comprising 409 individuals. Of the 62 species, 29 were present twice or less. Seven species accounted for over 53% of the faunal abundance: the bivalve molluscs Pharidae (juv) (47 individuals; 11.49% abundance) and *Angulus fabula* (45 individuals; 11.00% abundance), the polychaetes Cirratulidae (partial/damaged) (34 individuals; 8.31% abundance), *Chaetozone christiei* (32 individuals; 7.82% abundance) and *Spiophanes bombyx* (24 individuals; 5.87% abundance), the bivalve Tellinidae (juv) (20 individuals; 4.89% abundance) and the polychaete Pectinariidae (juv) (17 individuals; 4.16% abundance). The amphipod crustacean *Bathyporeia* tunipes, the polychaete *Owenia* fusiformis, the bivalve *Angulus fabula* and the polychaete Spionidae (partial/damaged) were identified by SIMPER analysis as the main characterising species of the group. Table 3.2 shows the full SIMPER results.

Pectinariidae, Pharidae, *Bathyporeia tunipes* and Tellinidae including *Angulus fabula* are species very sensitive to organic enrichment and present under unpolluted conditions. *Owenia fusiformis* is a species indifferent to enrichment, always present in low densities with non-significant variations over time. Spionidae including *Spiophanes bombyx* are species tolerant to excess organic matter enrichment and these species may occur under normal conditions but their populations are stimulated by organic enrichment. Cirratulidae including *Chaetozone christiei* are second order opportunistic deposit feeders which proliferate in reduced sediments. Species richness and diversity were relatively high at these stations. Organic matter levels ranged from 0.71% to 1.64%. Station DS3 had the lowest organic matter levels and sediment type varied from a very fine sand at S8 to fine sand at S6 to gravelly sand at DS3.

Group c separated from **Group d** at a 34.25% similarity level. **Group c** consisted of station S4 and contained 30 taxa comprising 47 individuals. Of the 30 species, 26 were present twice or less. Four species accounted for over 34% of the faunal abundance: the copepod crustacean *Longipedia scotti* (5 individuals; 10.64% abundance), the bivalve mollusc Pharidae (juv) (5 individuals; 10.64% abundance), the polychaete *Spiophanes bombyx* (3 individuals; 6.38% abundance) and the bivalve *Chamelea striatula* (3 individuals; 6.38% abundance). As only one station made up this group SIMPER analysis could not be carried out for this group. *Chamelea striatula* and Pharidae are species very sensitive to organic enrichment and present under unpolluted conditions. *Spiophanes bombyx* are species tolerant

to excess organic matter enrichment and these species may occur under normal conditions but their populations are stimulated by organic enrichment. Species richness was relatively high at this station and species diversity was highest at this station. Organic matter levels for this station were 2.71% and fine-medium sand dominated at this station.

Group b separated from **Groups c** and **d** at a 28.68% similarity level. **Group b** consisted of stations DS2 and contained 30 taxa comprising 76 individuals. Of the 30 species, 26 were present twice or less. Four species accounted for over 56.6% of the faunal abundance: Nematoda (26 individuals; 36.84% abundance), the bivalve mollusc Pharidae (juv) (7 individuals; 9.21% abundance), the chelicerate crustacean Acarina (4 individuals; 5.26% abundance) and the bivalve Veneridae (juv) (4 individuals; 5.26% abundance). As only one station made up this group SIMPER analysis could not be carried out for this group. Veneridae and Pharidae are species very sensitive to organic enrichment and present under unpolluted conditions. Acarina are a species indifferent to enrichment, always present in low densities with non-significant variations over time. Species richness was relatively high at this station and species diversity was moderate at this station. Organic matter levels at this station were 0.81% and gravelly sand dominated at this station.

The habitat in the area of the dumpsite can be described (according to Fossitt, 2000) as SS1 *Infralittoral gravels and sands*. All species recorded are typical of the sandy/gravelly sediments found in the area.

Table 4.2: SIMPER Results

Group a Average similarity: 35.67%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Caecum trachea	2.52	5.25	3.05	14.73	14.73
Goodallia triangularis	2.29	5.24	3.8	14.68	29.41
Syllis pontxioi	1.72	3.9	2.92	10.94	40.35
Nematoda (indet)	2.27	3.77	2.24	10.58	50.93
Gari tellinella	1.43	3.24	2.76	9.07	60
Mactridae (juv)	1.17	2.85	3.27	7.99	67.99
Glycera lapidum	1.14	2.72	2.76	7.63	75.61
Hippomedon denticulatus	0.67	1.28	0.58	3.6	79.21
Gastrosaccus spinifer	1.08	1.07	0.58	3	82.21
Pisione remota	1	0.99	0.58	2.78	84.99
Protodorvillea kefersteini	1.02	0.9	0.58	2.52	87.51
Veneridae (juv)	0.94	0.9	0.58	2.52	90.03
Group b Less than 2 samples in group					
Group c Less than 2 samples in group					

Group d Average similarity: 55.55%					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Pharidae (juv)	1.95	3.92	5.99	7.06	7.06
Cirratulidae (partial/damaged)	1.79	3.55	6.86	6.39	13.44
Angulus fabula	1.87	3.5	25.4	6.3	19.74
Chaetozone christiei	1.75	3.45	9.37	6.2	25.94
Spionidae (partial/damaged)	1.49	3.18	21.77	5.73	31.67
Spiophanes bombyx	1.59	2.93	8.59	5.27	36.94
Bathyporeia tenuipes	1.31	2.72	35.08	4.89	41.83
Magelona filiformis	1.33	2.63	13.55	4.73	46.56
Tellinidae (juv)	1.48	2.55	5.87	4.58	51.14
Chamelea striatula	1.31	2.45	5.29	4.4	55.55
Magelona johnstoni	1.13	2.36	5.92	4.25	59.8
Pariambus typicus	1.13	2.35	7.5	4.23	64.03
Owenia fusiformis	1.17	2.34	25.4	4.21	68.24
Sigalionidae (partial/damaged)	1	2.21	13.55	3.98	72.22
Perioculodes longimanus	1.19	2.21	13.55	3.98	76.2
Abra sp. (juv)	1	2.21	13.55	3.98	80.18
Pectinariidae (juv)	1.08	0.89	0.58	1.61	81.79
Ensis sp. (juv)	0.79	0.89	0.58	1.6	83.39
Glycera tridactyla	0.79	0.81	0.58	1.45	84.84
Nephtys sp. (partial/damaged)	0.84	0.81	0.58	1.45	86.29
Nassarius sp. (juv)	0.79	0.81	0.58	1.45	87.74
Glycera sp. (partial/damaged)	0.67	0.79	0.58	1.41	89.16
Nephtys sp. (juv)	0.89	0.79	0.58	1.41	90.57

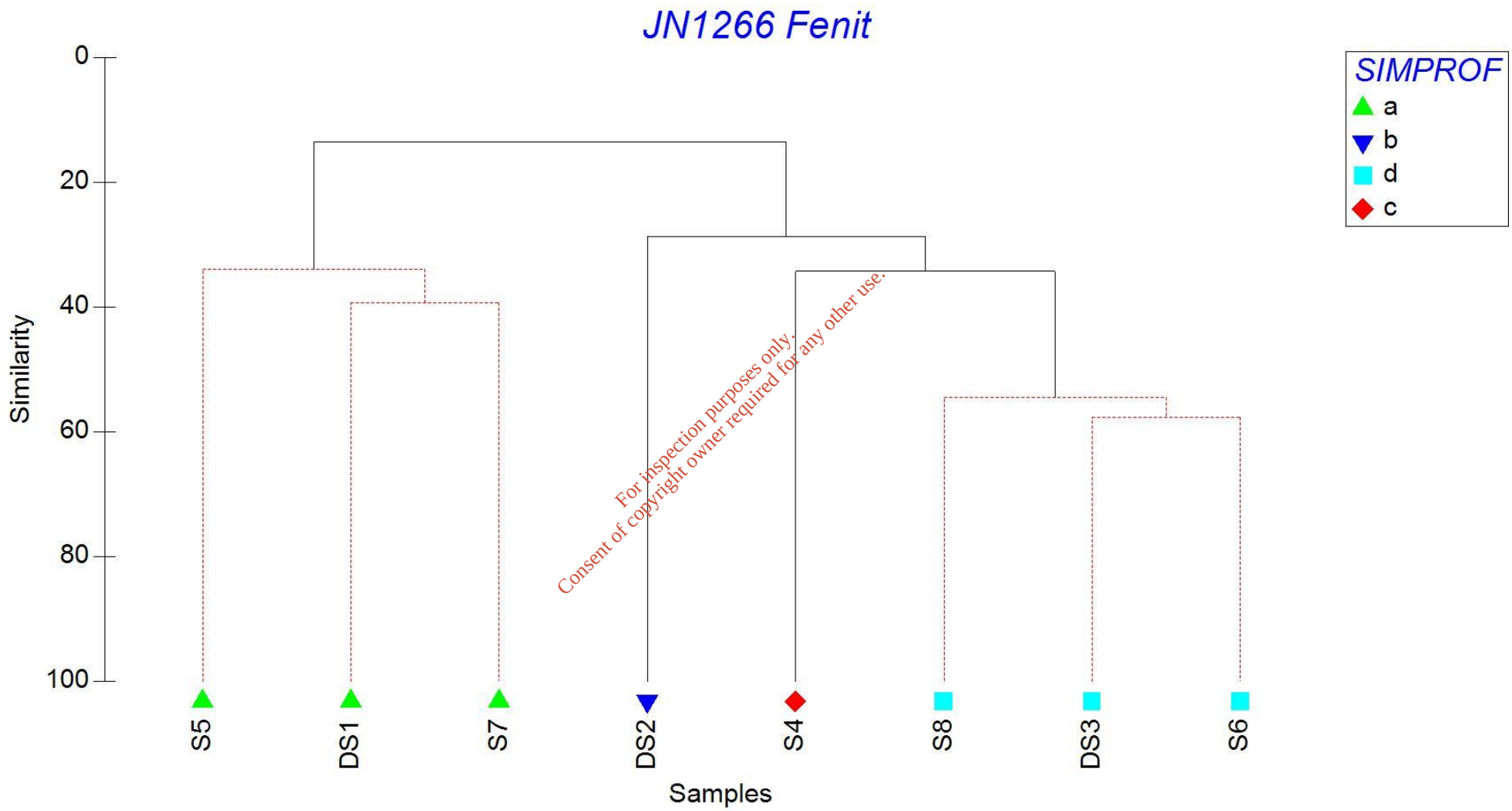

Figure 4.1: Dendrogram produced by Cluster analysis

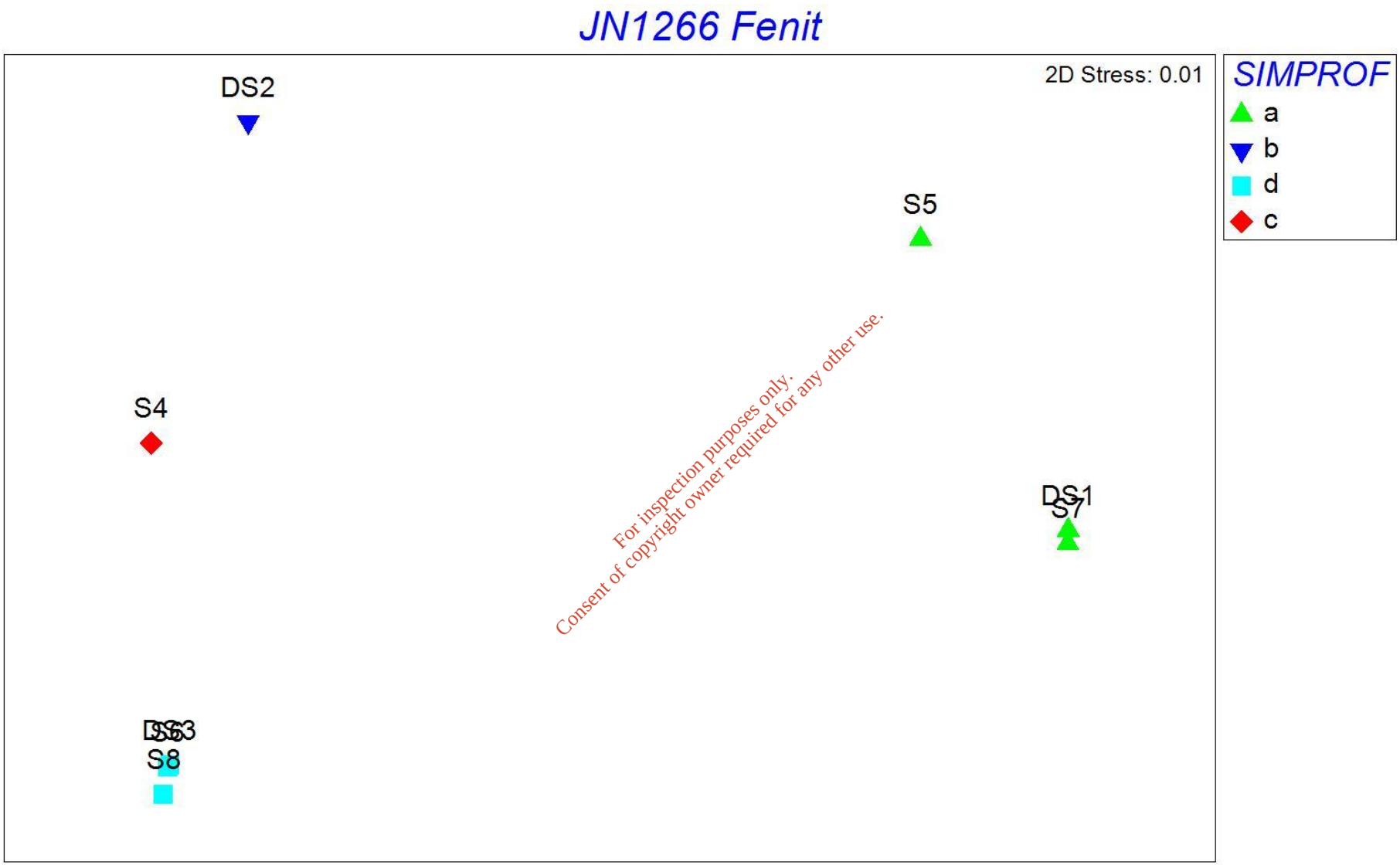

Figure 4.2: MDS plot

4.1. Sediment

4.1.1. Faunal Survey

4.1.1.1. Granulometry

Table 4.3 shows the granulometric data from the 8 stations sampled as part of the faunal survey. Fine gravel ranged from 0 (DS1 and S6) to 20% (S7). Very fine gravel ranged from 0 (DS1) to 14% (DS3). Very coarse sand ranged from 0.4 (DS1) to 22.1% (S5). Coarse sand ranged from 3.4 (DS1) to 46.9% (DS2). Medium sand ranged from 11.7 (DS3) to 38.3% (S4). Fine sand ranged from 0.3 (S7) to 56% (DS1). Very coarse sand ranged from 0.1 (S7) to 61.5 (S8) and Silt-clay ranged from 0 (S7) to 5.1 (S8). Sediment classification according to Folk (1954) consisted of sand and gravelly sand.

Table 4.3: Granulometric data from the faunal survey.

Station	Fine Gravel (4-8mm)	Very Fine Gravel (2-4mm)	Very Coarse Sand (1-2mm)	Coarse Sand (0.5-1mm)	Medium Sand (0.25-0.5mm)	Fine Sand (125-250mm)	Very Fine Sand (62.5-125mm)	Silt-Clay (<63mm)	Folk (1954)
DS1	0	0	0.4	3.4	28.7	56	10.8	0.6	Sand
DS2	2.8	4	17	46.9	23.4	4.7	1	0.2	Gravelly sand
DS3	15.2	14	18.9	38.3	11.7	1.2	0.6	0.1	Gravelly sand
S4	0	0.2	0.8	5.1	38.3	42.6	12.4	0.6	Sand
S5	4.6	6.9	22.1	46.7	18.9	0.6	0.2	0.1	Gravelly sand
S6	0	0.1	0.5	3.7	20.5	45.7	28.3	1.3	Sand
S7	20	6.2	15.3	31.7	26.5	0.3	0.1	0	Gravelly sand
S8	0.3	0.2	0.8	4	12.5	15.6	61.5	5.1	Sand

4.1.1.2. Organic Carbon

Table 4.4 shows the organic carbon results for the 8 stations sampled during the faunal survey. Organic matter values by Loss on Ignition ranged from 0.71 at Station DS3 to 3.94% and Station S7.

Table 4.4: Organic carbon results for the faunal stations

Station	Organic Carbon
DS1	0.79
DS2	0.81
DS3	0.71
S4	2.71
S5	2.73
S6	1.64
S7	3.94
S8	1.19

4.1.2. Sediment Characterisation Survey

4.1.2.1. Physical Properties

Table 4.5 shows the particle size analysis results (a detailed breakdown of all fractions can be seen in Appendix 2). Gravel content ranged from 0 (Station DS1) to 29.2% (Station DS3). Sand content ranged from 51.7% (Station F3) to 99.3% (Station DS1). Silt-clay content ranged from 0.1% (Station DS3) to 48.1% (Station F3). Moisture content ranged from 18.23% (Station DS3) to 63.16 (Station F1). Density ranged from 1.41 g/ml (Stations F1 and F2) to 2.17 g/ml (Station DS2).

Table 4.5: Physical properties of sediment

Station	% Gravel (>2mm)	% Sand (63-2mm)	Silt-Clay (<63mm)	Moisture %	Density (g/ml)	Description
F1	0.4	60.8	38.7	63.16	1.41	Black/grey mud, weak H_2S smell
F2	0.9	66.5	32.6	61.47	1.41	Black/grey mud, weak H2S smell
F3	0.2	51.7	48.1	55.47	1.42	Black/grey mud, no smell
F4	0.3	56.6	43.1	47.58	1.57	Grey/brown mud, no smell
F5	0.3	58.5	41.3	40.31	1.68	Brown mud, no smell
F6	1.1	73.4	25.6	53.91	1.48	Brown/grey mud, no smell
F7	0.2	57.1	42.7	59.84	1.42	Grey/brown mud, no smell
DS1	0	99.3	0.6	25.86	2.04	Yellow medium sand, no smell
DS2	6.8	93	0.2	25.14	2.17	Yellow medium sand, no smell
DS3	29.2	70.7	0.1	18.23	1.89	Yellow medium sand, no smell

4.1.3. Chemical Properties

Table 4.6 shows the results from the chemical analysis. Appendix 3 contains the laboratory report. Table 4.7 shows the results with relevance to Irish Action Levels.

Arsenic exceeded the lower Irish Action Limit at all but 2 stations (F5 and DS2) and nickel exceed the lower Irish Action Limit at Stations F1 to F4, F5 and F6. Lindane and HCB exceed the upper Irish Action Limit at stations F1 to F4 and F7 and exceed the lower Irish Action Limit at all other station (please note the use of < in the reporting of the results prevents an accurate indication of the exceedances). PAHs exceed the lower Irish Action Limits at all stations except DS1.

Table 4.6: Chemical properties of sediment

Determinand	Unit	F1	F2	F3	F4	F5	F6	F7	DS1	DS2	DS3
dry solids (at 105°C)	%	32.6	45.3	38.9	44.8	53.0	56.7	40.2	77.5	71.9	79.2
carbonate % dry matter	%	37.0	36.0	36.8	35.9	35.2	36.9	34.2	61.5	73.6	63.1
total organic carbon	%	2.77	2.81	2.55	1.74	1.37	1.84	2.36	0.46	0.47	0.41
total petroleum hydrocarbons by GCFID (C10 - C40)	mg/kg	165	108	174	162	58.4	78.4	240	7.56		
dibutyltin (DBT)	mg/kg	<0.03	< 0.02	<0.03	< 0.02	< 0.01	< 0.01	<0.03	< 0.01	< 0.01	
tributyltin (TBT)	mg/kg	<0.03	< 0.02	<0.03	< 0.02	< 0.01	< 0.01	<0.03	< 0.01	< 0.01	
aluminium	mg/kg	38500	40300	41900	27800	28100	32400	38800	7320	4040	4120
arsenic	mg/kg	19.5	19.6	18.8	11.2	8.98	15.1	18.5	7.67	14.0	15.5
cadmium	mg/kg	0.52	0.52	0.65	0.53	0.44	0.44	0.61	0.35	0.32	0.32
chromium	mg/kg	60.1	65.1	62.1	44.7	40.0	50.0	61.5	13.3	10.0	9.50
copper	mg/kg	20.7	21.8	20.0	14.6	12.0	13.9	21.1	3.23	3.78	3.17
lead	mg/kg	24.8	25.3	23.7	17.3	14.5	18.6	25.1	5.32	5.96	5.66
lithium	mg/kg	19.5	22.9	20.2	7.73	< 6.00	12.3	22.1	< 6.00	< 6.00	< 6.00
mercury	mg/kg	0.09	0.08	0.06	0.06	0.05	0.07	0.07	< 0.03	< 0.03	< 0.03
nickel	mg/kg	29.2	31.8	30.3	21.3	19.1	24.5	29.7	6.93	7.13	5.95
zinc	mg/kg	80.8	83.5	85.5	59.0	50.8	59.2	77.2	16.7	20.2	16.6
naphthalene	ug/kg	1030	1100	1670	1010	2000	1360	1220	732		
acenaphthylene	ug/kg	76.8	97.0	100	64.7	396	84.7	97.1	5.16		
acenaphthene	ug/kg	67.6	83.8	87.4	60.3	204	93.5	67.2	18.1		
fluorene	ug/kg	218	221	239	138	746	228	144	14.2		
phenanthrene	ug/kg	826	1090	1340	821	4420	1030	784	33.6		
anthracene	ug/kg	178	390	468	344	2210	296	284	< 0.100		
fluoranthene	ug/kg	2010	3180	4590	2600	12400	2460	2420	65.8		
pyrene	ug/kg	1530	2470	3610	2070	9470	1850	2090	41.3		
benzo(a)anthracene	ug/kg	768	1130	1940	942	4330	796	1150	21.9		
chrysene	ug/kg	786	1570	2400	1410	6390	923	1380	16.8		
benzo(b)fluoranthene	ug/kg	1630	2700	3660	2320	6810	1910	2030	49.1		
benzo(k)fluoranthene	ug/kg	439	812	1080	676	2500	545	674	76.2		

Determinand	Unit	F1	F2	F3	F4	F5	F6	F7	DS1	DS2	DS3
benzo(a)pyrene	ug/kg	768	1560	2230	1320	5210	926	1280	18.1		
indeno(1,2,3-c,d)pyrene	ug/kg	700	1080	1450	734	2040	785	722	96.8		
dibenzo(a,h)anthracene	ug/kg	1110	373	473	263	855	238	266	3.23		
benzo(g,h,i)perylene	ug/kg	792	1290	1620	835	2520	872	861	23.2		
aldrin	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
alpha-hexachlorocyclohexane (alpha-HCH)	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
beta-hexachlorocyclohexane (beta-HCH, beta-BHC)	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
delta-hexachlorocyclohexane (delta-HCH)	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
gamma-hexachlorocyclohexane (lindane)	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
hexachlorobenzene (HCB)	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
cis-chlordane	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
trans-chlordane	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
dieldrin	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
endrin	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
endosulfan A	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
endosulfan B	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
heptachlor	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
heptachlor epoxide	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
methoxychlor	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
o,p'-DDD	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
p,p'-DDD	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
o,p'-DDT	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
p,p'-DDT	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
o,p'-DDE	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
p,p'-DDE	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00
trifluralin	ug/kg	< 3.07	< 2.21	< 2.57	< 2.23	< 1.00	< 1.00	< 2.49	< 1.00		< 1.00

Determinand	Unit	F1	F2	F3	F4	F5	F6	F7	DS1	DS2	DS3
2,4,4'-trichlorobiphenyl (PCB congener 28)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,2',5,5'-tetrachlorobiphenyl (PCB congener 52)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,2',4,5,5'-pentachlorobiphenyl (PCB congener 101)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,3',4,4',5-pentachlorobiphenyl (PCB congener 118)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,2',3,4,4',5-hexachlorobiphenyl (PCB 138)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,2',4,4',5,5'-hexachlorobiphenyl (PCB 153)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10
2,2',3,4,4',5,5'-heptachlorobiphenyl (PCB 180)	ug/kg	< 0.31	< 0.22	< 0.26	< 0.22	< 0.10	< 0.10	< 0.25	< 0.10		< 0.10

Table 4.7: Results with reference to Irish Action Limits

Parameter	Units (dry wt) Note 2	Sampling points									
		F1	F2	F3	F4	F5	F6	F7	DS1	DS2	DS3
Arsenic	mg kg^{-1}	19.5	19.6	18.8	11.2	8.98	15.1	18.5	7.67	14.0	15.5
Cadmium	mg kg^{-1}	0.52	0.52	0.65	0.53	0.44	0.44	0.61	0.35	0.32	0.32
Chromium	mg kg^{-1}	60.1	65.1	62.1	44.7	40	50	61.5	13.3	10	9.5
Copper	mg kg^{-1}	20.7	21.8	20	14.6	12	13.9	21.1	3.23	3.78	3.17
Lead	mg kg^{-1}	24.8	25.3	23.7	17.3	14.5	18.6	25.1	5.32	5.96	5.66
Mercury	mg kg^{-1}	0.09	0.08	0.06	0.06	0.05	0.07	0.07	<0.03	<0.03	<0.03
Nickel	mg kg^{-1}	29.2	31.8	30.3	21.3	19.1	24.5	29.7	6.93	7.13	5.95
Zinc	mg kg^{-1}	80.8	83.5	85.5	59	50.8	59.2	77.2	16.7	20.2	16.6
Σ TBT & DBT Note 3	mg kg^{-1}	<0.06	<0.04	<0.06	<0.04	<0.02	<0.02	<0.06	<0.02	<0.02	
γ-HCH (Lindane) Note 4	µg kg^{-1}	<3.07	<2.21	<2.57	<2.23	<1.00	<1.00	<2.49	<1.00		<1.00
HCB Note 5	µg kg^{-1}	<3.07	<2.21	<2.57	<2.23	<1.00	<1.00	<2.49	<1.00		<1.00
PCB (individual congeners of ICES 7) Note 6 PCB 028	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 052	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 101	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 138	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 153	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 180	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB 118	µg kg^{-1}	<0.31	<0.22	<0.26	<0.22	<0.1	<0.1	<0.25	<0.1		<0.1
PCB (Σ ICES 7) Note 6	µg kg^{-1}	2.17	1.54	1.4	1.54	0.7	0.7	1.75	0.7		0.7
PAH (Σ 16) Note 7	µg kg^{-1}	12929.4	19146.8	26957.4	15608	62501	14397.2	15469.3	1215.49	12929.4	19146.8
Total Extractable Hydrocarbons	g kg^{-1}	0.165	0.108	0.174	0.162	0.0584	0.0784	0.24	0.00756	-	-

	Exceed Lower Irish Action Limit
	Exceeds Upper Irish Action Limit

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: *Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.*

Note 2: Total sediment <2 mm

Note 3: Sum of tributyl tin and dibutyl tin

Note 4: 1α,2α,3β,4α,5α,6β-hexachlorocyclohexane

Note 5: Hexachlorobenzene

Note 6: ICES 7 polychlorinated biphenyls: PCB 28, 52, 101, 118, 138, 153, 180.

Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Acenaphthene, Fluorene,Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

5. Discussion

The sediment type in the eastern half of the dumpsite consisted of fine/medium sand, coarse/medium sand and coarse/very coarse sand. Areas of hard ground were encountered in the western half. Immediately south of the dumpsite coarse/medium sand dominated and very fine sand dominated just over 1km south of the dumpsite. Fine/very fine sand dominated to the east of the dumpsite and coarse/very coarse sand dominated to the north. All sediments were classified as sand or gravelly sand by Folk (1954). Silt-clay fractions were extremely low throughout. Depths within the dumpsite ranged between 17.6 and 19.5m and outside the dumpsite they ranged from 15.9 to 20.5m.

The faunal assemblage of the dumpsite and surrounding areas can be classified by Fossitt (2000) as SS1 *Infralittoral gravels and sands*. Variations in the community type and dominating species between the stations was evident. These local variations are common in the natural environment. All species observed are typically of the gravelly/sandy habitat in the area and the species present represent a balanced mix of longer lived deeper burrowing equilibrium species and smaller shorter lived opportunistic species. Some of the main dominants of the assemblage include the gastropod mollusc *Caecum trachea*, bivalve molluscs *Goodalia triangularis*, *Angulus fabula, Chamelea striatula* and Pharidae, Nematoda, the polychaete *Chaetozone christiei* and *Spiophanes bombyx* and the copepod crustacean *Longipedia scotti.*

The sediments from the harbour area were classified as muddy sand throughout by Folk (1954), being dominated by silt-clay and very fine sand for the most part. Depths in the harbour area ranged from 2.1 to 7.9m. A number of determinands exceed the lower and upper Irish Action limits and the final approval for suitability to dispose of at sea lies with the EPA (under advice from the Marine Institute).

6. References

Clarke, K.R. & R.M. Warwick. 2001. Changes in marine communities: An approach to statistical analysis and interpretation. 2nd Edition. *Primer-E Ltd.*

Cronin, M., McGovern, E., McMahon, T. & R. Boelens. 2006. Guidelines for the assessment of dredge material for disposal in Irish waters. Marine Environmental and Health Series, No. 24, 2006.

Folk, R.L. (1954). The distinction between grain size and mineral composition in sedimentary rock nomenclature. *Journal of Geology* **62 (4):** 344-359.

Fossitt, J. 2000. A guide to habitats in Ireland. The Heritage Council.

Margalef, D.R. 1958. Information theory in ecology. *General Systems* **3:** 36-71.

Pielou, E.C. (1977). Mathematical ecology. Wiley-Water science Publication, John Wiley and Sons. pp.385.

Shannon, C.E. & W. Weaver. 1949. The mathematical throry of communication. University of Illinois Press, Urbana.

Simpson, E.H. 1949. Measurement of diversity. *Nature* **163:** 688.

Appendix 1

Infaunal Species List

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
NEMATODA	HD	1																
Nematoda (indet)	HD	1		33	28						55	83				1		
NEMERTEA	G	1																
Nemertea (indet)	G	1			1		2	4	1	1				1				
SIPUNCULA	N	1																
SIPUNCULIDEA	N	2																
GOLFINGIIFORMES	N	10																
Golfingiidae	N	11																
Golfingiidae (juv)	N	11									1							
Phascolionidae	N	29																
Phascolion (Phascolion) strombus strombus	N	34									1							
ANNELIDA	P	1																
POLYCHAETA	P	2																
PHYLLODOCIDA	P	3																
Pisionidae	P	13																
Pisione remota	P	15		3							5	3						
Polynoidae	P	25																
Polynoidae (partial/damaged)	P	25										1			1			
Harmothoe sp. (partial/damaged)	P	50			1						1							
Sigalionidae	P	96																
Sigalionidae (partial/damaged)	P	96					1			1			1				1	
Sigalion mathildae	P	104												1				
Sthenelais limicola	P	109												1				
Phyllodocidae	P	114																
Phyllodocidae (partial/damaged)	P	114				1						1						
Eteone longa aggregate	P	118										1						
Pseudomystides limbata	P	136										1						
Phyllodoce sp. (partial/damaged)	P	178					2	1										
Glyceridae	P	254																
Glyceridae (partial/damaged)	P	254								1								
Glycera sp. (partial/damaged)	P	255		1			1										1	
Glycera sp. (juv)	P	255											1					
Glycera lapidum	P	260		1								4			1			

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Glycera tridactyla	P	265								1			1	1			1	1
Hesionidae	P	293																
Psamthe fusca	P	305									1							
Microphthalmus sp. (partial/damaged)	P	326									1							
Syllidae	P	346																
Syllidae (partial/damaged)	P	346				1												
Syllis sp. (partial/damaged)	P	358														1		
Syllis pontxioi	P			4							15	11			1	4		
Syllis garciai	P			2		2					1							
Streptodonta pterochaeta	P	391									1							
Exogoninae	P	410																
Sphaerosyllis sp. (partial/damaged)	P	424														1		
Sphaerosyllis bulbosa	P	425										1						
Sphaerosyllis hystrix	P	427			1													
Nephtyidae	P	490																
Nephtys sp. (juv)	P	494		1			1		1	1							4	4
Nephtys sp. (partial/damaged)	P	494			2								3					2
Nephtys cirrosa	P	498				1												
Nephtys kersivalensis	P	502											2					
EUNICIDA	P	536																
Onuphidae	P	537																
Onuphidae (juv)	P	537				1			1	1		1						
Dorvilleidae	P	598																
Protodorvillea kefersteini	P	638									7	2			1	2		
Schistomeringos rudolphi	P	643										1						
SPIONIDA	P	707																
Spionidae	P	720																
Spionidae (partial/damaged)	P	720			1	1	3	1	1	1	1		3	3			1	4
Spionidae (juv)	P	720									1							
Prionospio sp. (partial/damaged)	P	763															7	4
Spio sp. (indet)	P	787										1						
Spio sp. (partial/damaged)	P	787									1							
Spiophanes bombyx	P	794						2		3			13	2			5	2

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Magelonidae	P	802																
Magelona filiformis	P	805					2			1			1	1			5	2
Magelona johnstoni	P						1	1						1			1	1
Cirratulidae	P	822																
Cirratulidae (partial/damaged)	P	822				1	17	1	1				7	4			4	1
Cirratulidae (juv)	P	822								2								
Chaetozone christiei	P						19						8				5	
CAPITELLIDA	P	902																
Capitellidae	P	903																
Mediomastus fragilis	P	919									1							
Notomastus latericeus	P	921				2						1						
Maldanidae	P	938																
Euclymene oerstedii	P	964															1	
POLYGORDIIDA	P	1060																
Polygordiidae	P	1061																
Polygordius sp. (partial/damaged)	P	1062									2	3						
OWENIIDA	P	1089																
Oweniidae	P	1090																
Galathowenia oculata	P	1093												1				
Owenia fusiformis	P	1098						1					1	2			1	1
TEREBELLIDA	P	1099																
Pectinariidae	P	1100																
Pectinariidae (juv)	P	1100											1	13			2	1
Lagis koreni	P	1107			1									2				
Sabellariidae	P	1112																
Sabellaria spinulosa	P	1117			1													
Terebellidae	P	1179																
Polycirrus sp. (partial/damaged)	P	1235									1							
OLIGOCHAETA	P	1402																
TUBIFICIDA	P	1403																
Naididae	P	1405																
Tubificidae	P	1425																
Tubificoides pseudogaster aggregate	P	1498				1												

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
CHELICERATA	Q	1																
PYCNOGONIDA	Q	2																
Acarina	Q	53																
Acarina (indet)	Q	53			4													
CRUSTACEA	R	1																
COPEPODA	R	142																
HARPACTICOIDA	R	785																
Longipediidae	R	787																
Longipedia scotti	R	792							5		1							
Canuellidae	R	793																
Canuella perplexa	R	798							1									
Thalestridae	R	1061																
Thalestris longimana	R	1079										1						
Miraciidae	R	1144																
Miraciidae (indet)	R	1144									2	2						
Cylindropsyllidae	R	1525																
Evansula incerta	R	1534										1						
Laophonitdae	R	1667																
Asellopsis hispida	R	1669								1								
OSTRACODA	R	2412																
Ostracoda (indet)	R	2412					1											
EUMALACOSTRACA	S	23																
MYSIDACEA	S	25																
Mysidae	S	31																
Gastrosaccus sp. (juv)	S	40												1				
Gastrosaccus sp. (partial/damaged)	S	40														2		
Gastrosaccus spinifer	S	44				1					3	5	2		2	4		
AMPHIPODA	S	97																
Eusiridae	S	100																
Apherusa bispinosa	S	102										1						
Oedicerotidae	S	118																
Perioculodes longimanus	S	131			1	1	5	1						1			1	
Pontocrates arcticus	S	134		1	1				1									

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Synchelidium maculatum	S	138			1		1			1		1		2		4		
Phoxocephalidae	S	252																
Metaphoxus fultoni	S	265					1											
Lysianassidae	S	271																
Hippomedon denticulatus	S	296		1											1			
Lepidepecreum longicornis	S	301									1			1				
Synopioidea	S	348																
Argissa hamatipes	S	360		1			1											
Atylidae	S																	
Nototropis falcatus	S	410														1		
Ampeliscidae	S	422																
Ampelisca brevicornis	S	427															1	1
Ampelisca typica	S	442									1							
Pontoporeiidae	S	450																
Bathyporeia sp. (partial/damaged)	S	451		1						1								
Bathyporeia sp. (juv)	S	451								1								
Bathyporeia tenuipes	S	459						2					3				2	2
Melphidippidae	S	487																
Megaluropus agilis	S	489											1					
Melitidae	S	495																
Melitidae (partial/damaged)	S	495				1												
Cheirocratus sp. (partial/damaged)	S	503														1		
Isaeidae	S	537																
Gammaropsis sp. (partial/damaged)	S	537														1		
Caprellidae	S	639																
Pariambus typicus	S	651					2							2			1	
ISOPODA	S	790																
Gnathiidae	S	792																
Gnathia sp. (praniza)	S	793				1												
CUMACEA	S	1183																
Bodotriidae	S	1184																
Vaunthompsonia cristata	S	1191				1			1								1	
Iphinoe trispinosa	S	1203															1	

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Pseudocumatidae	S	1231																
Pseudocuma longicornis	S	1236					3										1	
Diastylidae	S	1244																
Diastylis bradyi	S	1248							1									
MOLLUSCA	W	1																
CHAETODERMATIDA	W	3																
POLYPLACOPHORA	W	46																
NEOLORICATA	W	47																
Leptochitonidae	W	48																
Leptochiton cancellatus	W	54							1									
GASTROPODA	W	88																
Gastropoda (partial/damaged)	W	88							1			1		1				
MESOGASTROPODA	W	256																
Cerithiidae	W	258																
Bittium reticulatum	W	263		1							1							
Iravadiidae	W	406																
Hyala vitrea	W	410									1							
Caecidae	W	411																
Caecum trachea	W	414		20							52	113		1	12			
Naticidae	W	482																
Euspira nitida	W	491										2						
NEOGASTROPODA	W	670																
Buccinidae	W	702																
Nassarius sp. (juv)	W	743		1										2				2
Nassarius pygmaeus	W	748																1
Mangeliidae	W	771																
Bela brachystoma	W													1				
HETEROSTROPHA	W	878																
Pyramidellidae	W	906																
Chrysallida sp. (juv)	W	931																1
Turbonilla lactea	W	971												2				1
OPISTHOBRANCHIA	W																	
CEPHALASPIDEA	W	1002																

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Cylichnidae	W	1024																
Cylichna cylindracea	W	1028							1		1		1	2				
Retusidae	W	1073																
Retusa truncatula	W	1080									4	1				1		
SCAPHOPODA	W	1513																
Dentallidae	W	1515																
Antalis entalis	W	1519													1			
PELECYPODA	W	1560																
Bivalvia (partial/damaged)	W	1560					1						1					
NUCULOIDA	W	1561																
Nuculidae	W	1563																
Nucula sp. (juv)	W	1565																1
Nucula nitidosa	W	1569															4	4
Nucula nucleus	W	1570									1							
VENEROIDA	W	1815																
Astartidae	W	1921																
Goodallia triangularis	W	1929		9					1		16	32			3	36		
Cardiidae	W	1938																
Parvicardium pinnulatum	W	1951									2							
Mactridae	W	1967																
Mactridae (juv)	W	1967		1			1		1		2	1		2		2		
Mactridae (partial/damaged)	W	1967															1	
Mactra stultorum	W	1972					1											
Spisula elliptica	W	1975										1						
Pharidae	W	1995																
Pharidae (juv)	W	1995			4	3	19	3	2	3		1	2	16			3	4
Pharidae (partial/damaged)	W	1995															1	
Ensis sp. (juv)	W	1996					2							2	2			
Tellinidae	W	2008																
Tellinidae (juv)	W	2008					1						2	3			9	5
Angulus fabula	W	2019					3	2					1	9			13	17
Angulus pygmaeus	W	2023										3						
Donacidae	W	2036																

Station			1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B
Donax variegatus	W	2039														2		
Psammobiidae	W	2042																
Gari sp. (juv)	W	2044														1		
Gari tellinella	W	2049		2							4	9				2		
Semelidae	W	2057																
Abra sp. (juv)	W	2058			1		1							1			1	
Abra alba	W	2059															1	1
Abra nitida	W	2061							1									
Veneridae	W	2086																
Veneridae (juv)	W	2086			2	2	1	1	1		2	1			1	4	1	
Chamelea striatula	W					2	3	4	3					3				1
Dosinia sp. (juv)	W	2126			1	1						1						
MYOIDA	W	2140																
Hiatellidae	W	2164																
Saxicavella jeffreysi	W	2172			1													
ECHINODERMATA	ZB	1																
ECHINOIDEA	ZB	181																
ECHINOIDA	ZB	190																
Echinidae	ZB	194																
Echinocyamus pusillus	ZB	212							1									
SPATANGOIDA	ZB	213																
Loveniidae	ZB	221																
Echinocardium sp. (juv)	ZB	222											1	3		1		

Appendix 2

Breakdown of Granulometric results Stations F1 to F7

Station	Fine Gravel (4-8mm)	Very Fine Gravel (2-4mm)	Very Coarse Sand (1-2mm)	Coarse Sand (0.5-1mm)	Medium Sand (0.25-0.5mm)	Fine Sand (125-250mm)	Very Fine Sand (62.5-125mm)	Silt-Clay (<63mm)
F1	0	0.4	2.6	12.2	17.2	15	13.8	38.7
F2	0.2	0.7	3.4	13.1	17.3	15	17.7	32.6
F3	0	0.2	0.9	5.1	10.4	13.1	22.2	48.1
F4	0	0.3	1.8	4.9	7.6	10.6	31.7	43.1
F5	0.1	0.2	2.2	9.3	11.9	11.7	23.4	41.3
F6	0.4	0.7	2.2	3.4	4.4	12.8	50.6	25.6
F7	0	0.2	1.3	7.1	12.6	14.5	21.6	42.7

Appendix 3

Results from RPS Mountainheath