Eyemouth Harbour Trust

Eyemouth Harbour Deepening

Dredge Area D – Sediment Contamination Analysis – November 2019

November 2019





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Notice

ABPmer
Quayside Suite, Medina Chambers, Town Quay, Southampton, Hampshire SO14 2AQ
T: +44 (0) 2380 711844 W: http://www.abpmer.co.uk/

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1 Introduction

In 2018 a need for maintenance dredging of Eyemouth Harbour was identified with the primary focus on the entrance channel, Gunsgreen Basin and its' entrance. Applications were made to Marine Scotland's Licensing Operation Team (MS-LOT) for a marine licence to dredge these areas. The chemical sampling indicated that contamination, predominantly hydrocarbons were present, which was above Action Level 1 (AL1) (Marine Scotland, 2017), therefore MS-LOT requested further assessment to be undertaken. That assessment was reported in ABPmer report R.3169 (ABPmer 2019a).

As a result, a Marine Licence for the disposal of dredged material was permitted for the Outer Channel (Area C) and Gunsgreen Basin (Area B). Area A was excluded and subject to a request for further information. A sediment sampling plan for Area A was agreed with MS-LOT and the results were evaluated in ABPmer Technical Note R.3309TN (ABPmer 2019b). See Figure 1 for locations of harbour areas.

Consideration of the existing depths in the Upper Harbour (Area D) has now been undertaken and is the subject of this document. This has identified that maintenance dredging is also required in Area D to restore depths for navigation safety, particularly for the larger fishing vessels and commercial offshore vessels. This note provides information on the Area D dredge requirement (depths, volumes, material types) and analysis of the contamination levels from the September 2019 bed sediment sampling exercise.

1.1 Requirement

Area D was last dredged in September 2014. The total area of Area D is 10,750 m^2 and depths are to be restored to the underlying 'hard' bed level or to 2 m below Chart Datum (CD). At present the exact levels of the 'hard' bed are not known throughout the area and further testing is to be carried out to establish this level.

A detailed bathymetric survey was undertaken in in April 2018, an image of which is provided as Figure 2. A check survey undertaken in October 2019 shows some redistribution of sediment has occurred, but overall the volume of sediment to be removed has remained similar.

To achieve depths of 2 m below CD, thicknesses of sediment up to about 2 m will require to be removed from small areas. The average thickness to be removed is in the range 1 – 1.5 m. Given that some areas are already deeper than 2 m below CD and in others such depths cannot be achieved, the current volume of sediment to be dredged is estimated as 8,630 m^3. However, to allow for uncertainty in the 'hard' bed level a dredge requirement of *circa* 11,000 m^3 should be allowed. Based on the physical properties of the material to be dredged (see Section 2.2) the average *in-situ* density is estimated to be about 1,550 kg/m^3, hence for Marine Licencing purposes the wet tonnage to be dredged would be up to 17,050 wet tonnes.

Arial Imagery from Google Satellite, 2019

Figure 1. Dredge areas and 2019 grab sampling locations Proposed Dredging Activity

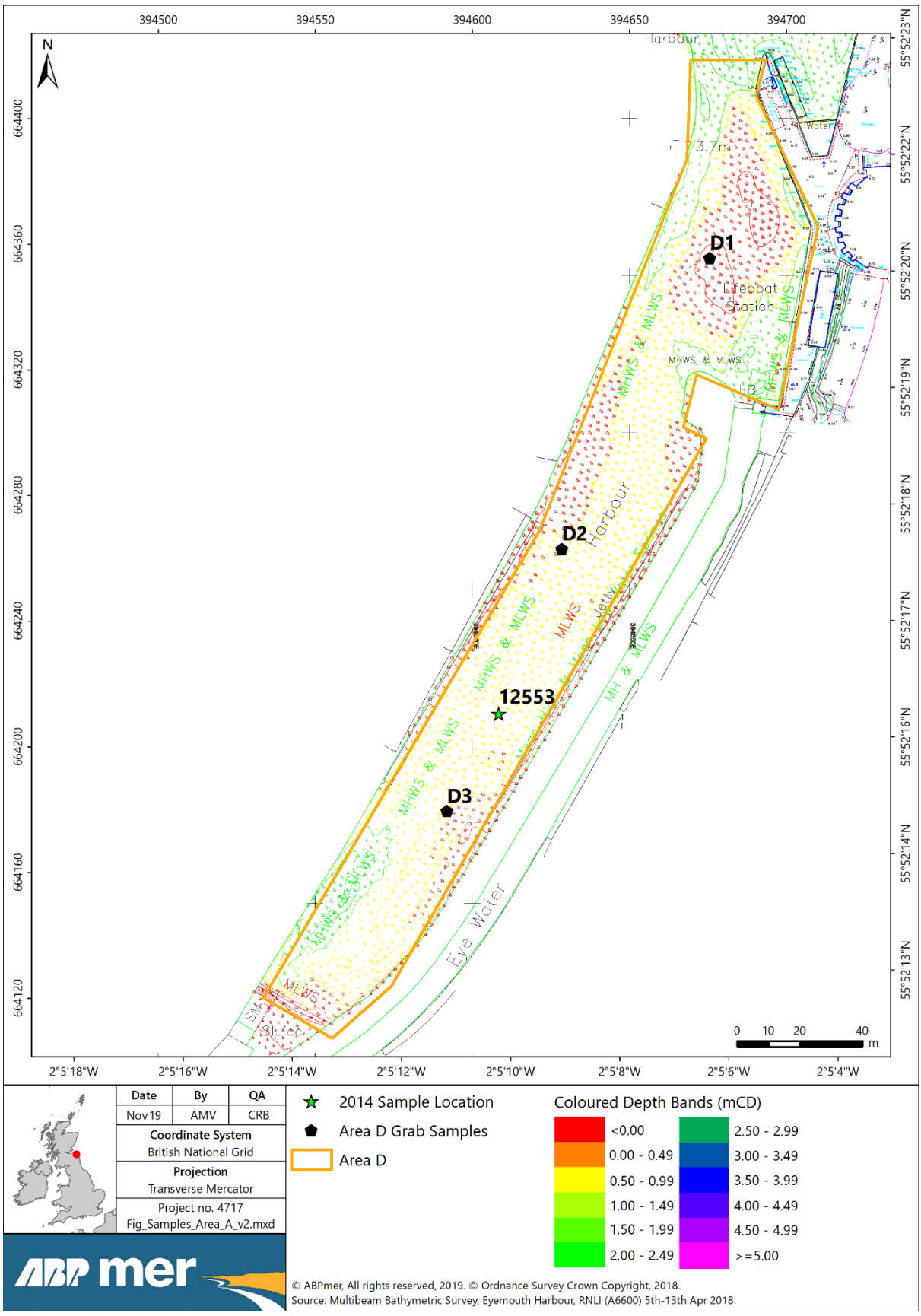

Figure 2. Bathymetry showing 2014 and 2019 sediment sample locations

1.2 Material type

Surface sediment sampling was undertaken on 17 September 2019 with a Van Veen Grab at three locations (see Figure 2) close to where the greatest depths of sediment are to be dredged.

For the purpose of the licensing process and assessment of the physical and chemical analysis, the material grain size is graded into three categories. These are:

- Silt – defined as <63 µm in size;
- Sand – defined as ranging between 63 µm and 2 mm; and
- Gravel – defined as > 2 mm in size.

The results of the laboratory analysis indicate that:

- Grab Location D1 (north) is predominantly sand (74%) and silt (21%) with a small contribution (5%) of gravel. The Total Organic Contents (TOC) of the bed material is general low (<1%). The total solid content is 49% which indicates the material to be relatively free draining and non-cohesive in character. The approximate average in *situ* density (i.e. wet bulk) is estimated to be about 1,700 kg/m^3 or higher;
- Grab Location D2 is predominantly silt (67%) and sand (32%) with a small contribution (1%) of gravel. The bed material contains about 6% TOC and retains a significant volume of water with the solid content being only 28%. This indicates that the bed material is likely to have cohesive properties and the *in-situ* density is likely to be around 1,550 kg/m^3; and
- Grab Location D3 (south) is predominantly silt (80%) and sand (20%) with a TOC content <5%). The total solid content is about 26%, therefore the material is likely to have some cohesive properties but with a an *in-situ* density of around 1,500 kg/m^3.

In summary, the sediment sampling shows the material to be dredged varies from predominantly sand in the north of the area opposite the RNLI berth, currently where the shallowest depths exist. The sediment fines southwards to sandy silt with *circa* 5% organic material. Here the sediment becomes more cohesive and retains more water, lowering the bulk density, hence the mass of sediment per unit volume to be removed.

1.3 Proposed dredge method

Dredging will most likely be undertaken by a small self-propelled hopper barge with backhoe bucket, e.g. MV Sandsend. The dredger will have a maximum carrying capacity of up to 400 tonnes of wet sediment in the hopper. Based on the assumed average density of the bed materials the maximum *in situ* volume removed each load will be about 260 m^3. This means that the total disposal requirement to restore depths would be equivalent to about 43 dredger loads. Assuming a bucket size of about 1.5 m^3 with an average 2 minute cycle time (allowing for vessel manoeuvring) the average loading time would be about 5.5 hours.

The FO080 licensed deposit ground is *circa* 3 nautical miles from the Harbour entrance, therefore with a representative service speed of about 8 knots and time for disposal the overall cycle time will be of the order of 6.5 hours. Given the tidal range in the Harbour and the depths in the entrance channel and the loaded draught of the vessel, dredging will be tidally restricted, particularly on spring tides. This means that realistically only one dredge load will be deposited per tide.

To remove the full volume would take about 22 days (assuming no weather delays). The maximum rate of disposal at FO080 would therefore be a single load of up to 260 m^3 of Harbour dredge material approximately every 12.5 hours for 22 consecutive days per year, assuming all dredging is undertaken in a single campaign.

2 Sediment Contamination Results

The three surface samples (locations D1 to D3 on Figure 2) were analysed for Heavy metals, Tri-Butyl Tin (TBT) Aromatic Hydrocarbons (PAH) and Total Hydrocarbon Content (THC) at the approved Socotec Laboratory.

Contamination information is also provided from the 2014 sample; sample reference 12553 on Figure 2. This information gives an indication of how the contamination may have changed over the 5 years, noting that dredging occurred followed by sedimentation during this time.

2.1 Heavy metals and organotins

Comparison of the contamination levels is shown as Table 1 and for the most part the 2019 Heavy Metal concentrations were for many determinands lower (in some cases by around 50%) than the levels present in 2014 and no determinands exceeded MS-LOT AL2.

Contamination from Copper and TBT are, however, higher particularly in the sandier sediments of the northern part of the area. Comparison with the MS-LOT ALs show that Copper, Nickel and Zinc contamination at most locations still exceeds AL1, albeit most levels except for Copper, being relatively close to the threshold value.

The TBT concentration at the northerly site (D1) has increased significantly from relatively close to AL1 to 75% of the way towards the AL2 threshold concentration. Concentrations are considerably lower at Locations D2 and D3 and below AL1, suggesting that the concentration at Location D1 could be a localised 'hot spot'.

Overall, the Heavy Metal and Organotin contamination in the sediment, whilst some determinands still exceed AL1, will have lower environmental effects than the previous dredging campaign from Area D.

It should be noted the 2014 concentrations were allowed to be disposed at sea in the subsequent dredge.

Table 1. Heavy metal contamination levels against Marine Scotland Action Levels

Sample	Bed Depth (m)	Dry Weight (mg/kg)									
		Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Dibutyltin (DBT)	Tributyltin (TBT)
February 2014 Data											
12553	0.00-0.15	14.9	0.42	57.7	55.5	0.13	34.3	42.0	181	0.013	0.175
Area D Sampling September 2019 Data											
D1	0.00-0.15	6.6	0.21	28.2	106	0.02	27	34.3	108	0.0405	0.738
D2	0.00-0.15	8.8	0.31	37.1	60.2	0.08	28	31.4	154	<0.005	0.0592
D3	0.00-0.15	8.3	0.39	33	63.7	0.1	25.4	28	199	<0.005	0.088
Marine Scotland Guideline Action Levels (mg/kg Dry Weight)											
AL 1		20.0	0.40	40.0	40.0	0.30	20.0	50.0	130.0	0.100	0.10000
AL 2		100.0	5.00	400.0	400.0	3.00	200.0	500.0	800.0	1.000	1.000

2.2 Polycyclic aromatic hydrocarbons and total hydrocarbons

2.2.1 Action levels

Table 2 provides a similar comparative analysis for PAH contamination levels to that for the Heavy Metals. At Location D1, where the bed material is predominantly sand the PAH contamination is substantially lower for all determinands compared to 2014. Most concentrations are reduced below the AL1 threshold with the exceptions of Benzo(b)fluoranthene, Fluoranthene and Pyrene, however, these were at levels of only circa 25% of those that occurred in 2014.

The contamination levels increase southwards as the sediment fines to predominantly silt, with about 5% organic content. In this area, the overall contamination level is lower or similar to that in 2014, however, some individual determinands are marginally higher than previously existed.
Overall, the sediment has lower PAH concentrations than occurred in 2014.

2.2.2 Canadian Sediment Quality Guidelines (CSQG)

As for the previous PAH analyses for the other harbour areas (for example Area A, where MS-LOT had concerns over the concentration) the levels, in some cases considerably exceeded AL1, however as there is no AL2 threshold it is difficult to 'gauge' the significance of likely, environmental effect.

To aid the assessment of potential environmental effect, should disposal at sea be licensed, Table 3 provides a similar comparison against the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CSQG) (CCME, 1999) for some of the PAH determinands. Discussion on the use of the various ALs and CSQG Probable Effects Levels (PEL) is presented in ABPmer 2019a, previously supplied to MS-LOT. The comparison against the PEL provides some guidance in the absence of a MS-LOT AL2 threshold for PAH determinands.

Table 3 shows a similar result to the AL1 assessment above in that contamination exceeds the lower SQG level, however, none of the PAHs analysed exceed the PEL level. Consequently 'probable' effects on the biological environment are considered unlikely. In general, the contamination levels are considerably less than 50% of the concentration difference between the SQG and PEL levels.

Table 4 provides a comparison of the 2019 average PAH contamination levels between Area D, Area A and Area B, where PAH concentrations were generally above AL1. This table shows that for most determinands the average contamination level is lower than both Areas A and B, in a number of cases substantially. For example, the maximum PAH determinand reduction was for C1-phenanthrene at 75%, with an overall average percentage reduction compared to Areas A and B of about 37%. The final column in Table 4 shows that the Total Hydrocarbon Content (THC) was 81% lower in Area D than elsewhere in the harbour.

These data suggest that should disposal at sea be licensed the effect on the marine environment would be small, particularly as the rate of delivery, due to the small dredger size and low frequency of disposal (one load per tide). The overall contamination level is *circa* 37% of the levels in the areas of the harbour already licensed for disposal at sea.

Table 2. PAH levels of contamination against the Marine Scotland Guideline Action Levels

Sample	Bed Depth (m)	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)																					
		Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
February 2014 Data																								
12553	0.00-0.15	22.7	5.9	62.2	296.2	344.9	470.9	279.8	324.9	203.4	163.5	523.2	347.7	910.3	268.1	69.4	646.6	53.5	355.8	77.7	122.0	258.2	545.8	1044
Area D Sampling September 2019 data																								
D1	0.00-0.15 m	8.6	7.0	23.4	73.9	98.3	113.0	90.7	89.0	40.7	46.6	82.3	56.0	85.7	97.4	19.8	148.0	12.3	83.3	22.4	43.3	70.5	132.0	8.6
D2	0.00-0.15 m	23.1	32.2	75.7	247.0	338.0	358.0	288.0	306.0	201.0	170.0	248.0	183.0	274.0	308.0	48.7	461.0	42.6	287.0	96.7	124.0	218.0	430.0	23.1
D3	0.00-0.15 m	18.9	113.0	85.7	306.0	430.0	406.0	337.0	338.0	214.0	166.0	261.0	149.0	236.0	373.0	69.7	587.0	44.1	339.0	222.0	145.0	273.0	535.0	18.9
Marine Scotland Guideline Action Levels (µg/kg Dry Weight)																								
AL1		100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	-
AL2		No AL2 levels defined for PAH																						

Table 3. PAH levels compared to the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

Sample	Bed Depth (m)	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)											
		Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
February 2014 Data													
12553	0.00-0.15 m	22.7	5.9	62.2	296	345	268	69.4	647	53.5	77.7	258	546
Area D Sampling September 2019 Data													
D1	0.00-0.15 m	8.55	7.04	23.4	73.9	98.3	97.4	19.8	148	12.3	22.4	70.5	132
D2	0.00-0.15 m	23.1	32.2	75.7	247	338	308	48.7	461	42.6	96.7	218	430
D3	0.00-0.15 m	18.9	113	85.7	306	430	373	69.7	587	44.1	222	273	535
Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (µg/kg Dry Weight)													
SQG		6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153.0
PEL		88.9	128	245	693	763	846	135	1,494	144	391	544	1,398

Table 4. Comparison of PAH contamination levels between Area A (2019), Area B (2016) and Area D (2019)

Area	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
Area A Ave. Sep 19	23.7	33.8	151.1	391.1	390.1	291.1	256.4	244.6	170.6	250.2	519.7	281.7	386.0	382.5	45.9	712.5	44.9	220.6	84.5	107.8	383.2	671.3	185,400.0
Area B Ave. Sep 16	26.8	21.2	152.7	336.5	304.5	387.4	306.2	268.9	289.6	175.1	788.4	349.3	724.5	434.8	60.3	610.1	110.9	275.1	57.0	148.0	277.5	747.2	2,802,844.9
Area D Ave. Sep 19	16.9	50.7	61.6	209.0	288.8	292.3	238.6	244.3	151.9	127.5	197.1	129.3	198.6	259.5	46.1	398.7	33.0	236.4	113.7	104.1	187.2	365.7	519,333.3
% Diff for Area D**	-37	+50	-60	-47	-26	-25	-22	-9	-48	-49	-75	-63	-73	-40	-24	-44	-70	-14	+35	-30	-51	-51	-81

Shaded area shows minimum concentration from comparison
** Base for % is highest concentration from any area

3 Water Quality Assessment

Should sediment from Area D be licensed for disposal then the sediment PAH concentrations will have the potential to increase the dissolved concentration of each determinand in the water around the disposal site (FO080). Table 5 shows the maximum likely dissolved concentration in the water column of the PAH determinands where partitioning coefficients are readily available and water Environmental Quality Standards (EQS) exist for marine waters. Again, a comparison is made against equivalent calculations for other sediments that have been, or are licensed, for disposal at the site.

This analysis shows that in general the effects on water quality are similar for the contamination levels that would occur from the Area A 2019 contamination levels and considerably lower than for the 2016 levels. The maximum dissolved concentrations would be lower than for the sediment that has been licensed for disposal from Area B.

Overall, six of the eight determinands are below the respective EQS values and one is relatively close (Fluoranthene). Only Benzo(ghi)perylene remains substantially above its EQS, however this is lower than the licensed disposal from Area B.

These data like the sediment PAH concentration analysis against the sediment quality ALs and CSQG values, along with the relatively small volumes and low frequency of disposal, suggest that any environmental effect around the disposal site will be low and unlikely to cause significant impacts on the biological environment.

Table 5. Maximum dissolved PAH concentrations from deposited material

PAH	Sediment Concentration (mg/kg)	Partitioning Coefficient (l/kg)	EQS (µg/l)	Maximum Dissolved Concentration (µg/l)
Dredge Area A – 2019				
Anthracene	151.083	793	0.1	0.191
Benzo(a)pyrene	390.050	20,795	0.027	0.019
Benzo[b]fluoranthene	291.117	20,795	0.017	0.014
Benzo(ghi)perylene	244.567	25,583	0.00082	0.010
Benzo[k]fluoranthene	170.600	19,859	0.017	0.009
Fluoranthene	712.500	2,444	0.12	0.292
Indeno(1,2,3-cd)pyrene	220.550	58,607	0.027	0.004
Naphthalene	84.467	35	130	2.413
Dredge Area D – 2019				
Anthracene	61.600	793	0.1	0.078
Benzo(a)pyrene	288.767	20,795	0.027	0.014
Benzo[b]fluoranthene	292.333	20,795	0.017	0.014
Benzo(ghi)perylene	244.333	25,583	0.00082	0.010
Benzo[k]fluoranthene	151.900	19,859	0.017	0.008
Fluoranthene	398.667	2,444	0.12	0.163
Indeno(1,2,3-cd)pyrene	236.433	58,607	0.027	0.004
Naphthalene	113.700	35	130	3.249
Dredge Area A - 2016				
Anthracene	1,340.963	793	0.1	1.691
Benzo(a)pyrene	1,538.194	20,795	0.027	0.074
Benzo[b]fluoranthene	1,223.526	20,795	0.017	0.059
Benzo(ghi)perylene	882.645	25,583	0.00082	0.035
Benzo[k]fluoranthene	1,286.441	19,859	0.017	0.065
Fluoranthene	4,784.399	2,444	0.12	1.958
Indeno(1,2,3-cd)pyrene	765.185	58,607	0.027	0.013
Naphthalene	1,640.595	35	130	46.874
Dredge Area B - 2016				
Anthracene	152.735	793	0.1	0.193
Benzo(a)pyrene	304.483	20,795	0.027	0.015
Benzo[b]fluoranthene	387.382	20,795	0.017	0.019
Benzo(ghi)perylene	268.928	25,583	0.00082	0.011
Benzo[k]fluoranthene	289.571	19,859	0.017	0.015
Fluoranthene	610.083	2,444	0.12	0.250
Indeno(1,2,3-cd) pyrene	275.144	58,607	0.027	0.005
Naphthalene	57.032	35	130	1.629

4 Conclusion

The chemical analyses of the material to be dredged from Area D shows that contamination levels have generally reduced in the 5 year period between the 2014 and 2019. This may be due to dredging that has occurred following the 2014 sampling. Heavy Metal, Organotin and PAH levels are still in excess of the MS-LOT AL1 threshold and the Canadian SQG levels, particularly in the southern part of Area D where the material is predominantly lower density silt with about a 5% organic content. The sandier material to the north is cleaner with many determinands below the MS-LOT AL1 threshold.

Whilst a large number of individual PAH determinands remain above AL1 and the SQG value, none exceeded the PEL threshold value. Comparison with samples from Areas A and B show the sediment in Area D is generally cleaner.

Calculations of the maximum dissolved concentrations that could occur in the water column around the disposal site, should a Marine Licence be granted, indicate that most determinands assessed would be below their respective EQS values.

Overall, the chemical analysis along with the relatively small volumes to be disposed and low disposal frequency (i.e. one load per tide) suggests environmental effects around the disposal site will be low, short lived and unlikely to cause significant impacts on the biological environment.

5 References

ABPmer, (2019a). Eyemouth Harbour Deepening – Support for Marine Licence Application. ABPmer Report R.3169.

ABPmer, (2019b). Eyemouth Harbour Deepening, Dredge Area A – Sediment Contamination Analysis – September 2019. ABPmer Report No. R.3309TN.

Canadian Council of Ministers of the Environment, CCME 1995, (1999). Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. CCME EPC-98E.

Marine Scotland, (2017) Pre-disposal Sampling Guidance Version 2 (Scottish Government).

6 Abbreviations/Acronyms

AL	Action Level
CCME	Canadian Council of Ministers of the Environment
CD	Chart Datum
CSQG	Canadian Sediment Quality Guidelines
DBT	Dibutyltin
EQS	Environmental Quality Standards
ISQG	Interim Sediment Quality Guideline
MS-LOT	Marine Scotland Licensing Operations Team
MV	Motor/Merchant Vessel
PAH	Polycyclic Aromatic Hydrocarbon
PEL	Probable Effect Level
RNLI	Royal National Lifeboat Institution
SQG	Sediment Quality Guidelines
TBT	Tributyltin
THC	Total Hydrocarbon Content
TOC	Total Organic Contents

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Contact Us

ABPmer

Quayside Suite,
Medina Chambers
Town Quay, Southampton
SO14 2AQ

T +44 (0) 23 8071 1840
F +44 (0) 23 8071 1841
E enquiries@abpmer.co.uk

www.abpmer.co.uk