FORTH PORTS

Port of Leith Maintenance Dredge Disposal: Marine Licence Application

Best Practicable Environmental Option Report

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1. INTRODUCTION

1.1 Background

This report has been prepared by Environmental Resources Management Ltd (ERM) on behalf of Forth Ports Ltd (Forth Ports) in support of a Marine Licence application for disposal of dredged material at sea. It compares various options for the disposal of dredge material from the Port of Leith and identifies the Best Practicable Environmental Option (BPEO).

Under the *Marine (Scotland) Act 2010, Section 21(1),* a Marine Licence issued by Marine Scotland is required for the dredging and the deposit of substances or objects within waters adjacent to Scotland. Under Part 4, Section 27(2), Marine Scotland has an obligation to consider the availability of practical alternatives when considering applications involving disposal of material at sea. Applications for a Marine Licence to dispose of dredged spoil at sea require a BPEO assessment, demonstrating that alternatives to sea disposal have been investigated and that sea disposal does not pose an unacceptable risk to the marine environment and other legitimate users.

Marine Licences for these activities are currently valid in Scotland for up to three years (1). Forth Ports Ltd currently has a maintenance disposal licence (06449/18/1) to maintain a safe navigable depth which expired on 12 February 2021. This application is therefore expected to cover dredge spoil disposal operations from 2021 to 2024.

1.2 The Need for Dredge Spoil Disposal

The Port of Leith, located on the south bank of the Firth of Forth at the north of Edinburgh, provides berthing facilities, primarily for cargo vessels transporting cement, grain and bulk goods; oil industry and renewables service support vessels; and regular passenger vessels using the port during the summer. The port has approximately 350 to 450 vessel movements into and out of the port per annum (2017 to 2020 data) (2).

The entrance to the docks is accessed by a 0.7 nautical mile approach channel with a depth of 6.7 m below Chart Datum (CD). Suspended sediments from the action of waves and tides in the Firth of Forth settle in the slack water of a large eddy existing in the lee of the Eastern Breakwater (3). The main sediment accumulation occurs over approximately 200 m of the inward end of the approach channel and maintenance dredging is required to maintain safe navigation in the channel. Sedimentation is generally less significant within the Leith Dock complex, although sediment material enters from the Water of Leith, entering the complex at the Albert Dock.

Should Forth Ports consider the ‘Do Nothing’ approach, and not undertake the maintenance dredging operations, a navigable depth would not be maintained and the Port of Leith would not be able to continue to service current vessels. Given Forth Port’s statutory duty as the Harbour Authority to ensure safe navigation, there is an ongoing maintenance dredging requirement and the need for disposal of the dredged material, therefore the do nothing option is not considered further in this BPEO.

In line with Section 13 of Scotland’s National Marine Plan (Marine Planning Policy Transport 4), the planned dredging operations will continue to maintain and support the sustainable development of the Port of Leith. Forth Ports plans to continue the previous regime of annually dredging the Port of Leith and the approach channel to the port. It is proposed that the dredged material resulting from the maintenance dredging will be disposed of at sea at the licenced marine disposal site at Narrow Deep.

Figure 1.1 shows the planned dredging areas and the proposed spoil disposal site at Narrow Deep.

(1) Marine (Scotland) Act 2010, Part 4 Marine Licencing. General Guidance for Applicants. Available online http://www.scotland.gov.uk/Resource/0043/00435338.pdf

(2) Forth Ports pers comm February 2021.

(3) HR Wallingford, Forth Ports Siltation and Dredging Study, 1998

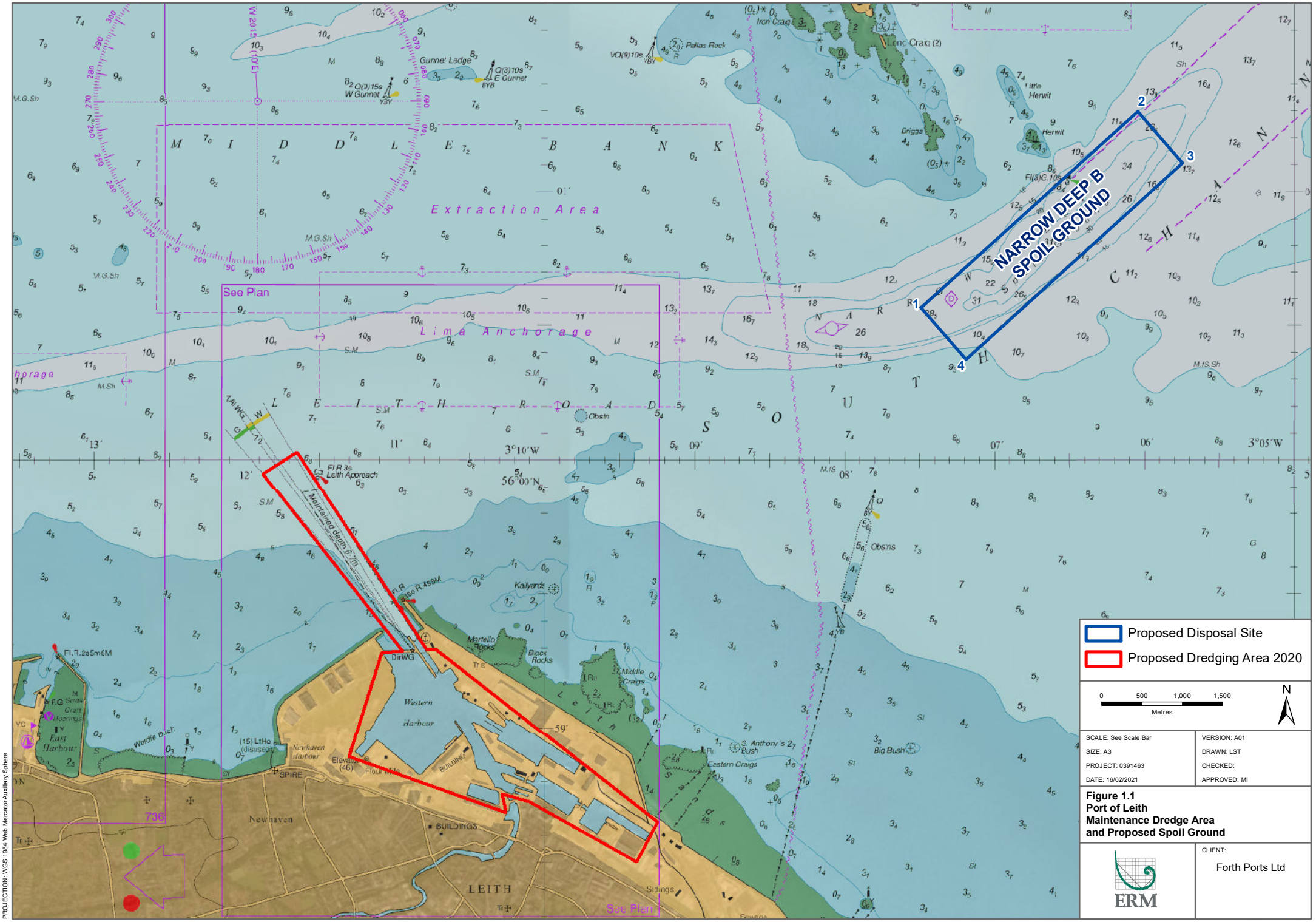

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Figure 1.1
Port of Leith
Maintenance Dredge Area
and Proposed Spoil Ground

CLIENT: Forth Ports Ltd

ERM

PROJECTION: WGS 1984 Web Mercator Auxiliary Sphere

Path: \\UKLONSV04\Data\Edinburgh\Projects\0391463 Forth Ports 2017 BPEO.MI\Ph8 Leith 2020\GIS\MAPS\Fig1_1_0391463_LTH_ProposedDisposalSite_A01_A4.mxd

1.3 Previous Maintenance Dredge Spoil Disposal Activities

To maintain access to the Port of Leith, Forth Ports dredges the approach channel and within docks area. Between 1968 and 2000 dredging was mainly undertaken using the trailing suction dredger *Abbotsgrange* or a chartered suction trailer dredge if the *Abbotsgrange* was not available. Since January 2001, Forth Ports has contracted United Kingdom Dredging (UKD) for the majority of operations within the Forth Estuary and Firth of Forth. The *UKD Marlin* (see ***Error! Reference source not found.***) is a trailing suction dredger, with a hopper capacity of 3,000 m^3, which is double that of the *Abbotsgrange*.

Figure 1.1 Dredge Vessel - UKD Marlin

1.4 Proposed Dredge Spoil Disposal Operations

Forth Ports wishes to apply for a licence from Marine Scotland for the disposal of dredge spoil to a maximum of 100,000 m^3 of dredged material per annum (up to 130,000 wet tonnes based on density of 1.3 (1)). This is required to ensure compliance with safe vessel navigation and berthing and to allow for any fluctuation in sediment deposition or contingencies.

The dredging operations to maintain the approach channel and docks are estimated to occur for up to eight days per annum, subject to siltation and commercial requirements.

The boundary co-ordinates of the planned dredge areas are presented in *Table 1.1*.

(1) Conversion factor used by Forth Ports for maintenance dredge sediments from the Port of Rosyth. Forth Ports pers comm September 2020.

Table 1.1 Co-ordinates of Planned Dredge Sites at the Port of Leith and the Approach Channel

Node	Co-ordinates (WGS84)	
	Latitude	Longitude
A	55° 58.894’ N	003° 11.302’ W
B	55° 59.282’ N	003° 11.085’ W
C	55° 59.287’ N	003° 10.944’ W
D	55° 59.951’ N	003° 11.877’ W
E	56° 00.030’ N	003° 11.650’ W
F	55° 59.293’ N	003° 10.785’ W
G	55° 59.296’ N	003° 10.728’ W
H	55° 58.649’ N	003° 09.248’ W
I	55° 58.503’ N	003° 09.385’ W
J	55° 58.726’ N	003° 10.099’ W
K	55° 58.756’ N	003° 10.280’ W
L	55° 58.684’ N	003° 10.257’ W

Coordinates in WGS84, UTM Zone 30N, degrees decimal minutes

The Narrow Deep B (FO038) spoil disposal ground is situated approximately 2.5 nautical miles east of the Port of Leith and has historically been used by Forth Ports for spoil disposal from the Port of Leith. The water depth within the spoil disposal ground ranges from 10 m below CD at the south-west corner and increases to 31 m below CD through the centre of the site. The boundary co-ordinates of the spoil disposal ground are presented in *Table 1.2.*

Table 1.2 Coordinates of Narrow Deep Spoil Disposal Ground

Node	Coordinates (WGS84)	
1	56°01.298’ N	003°06.038’ W
2	56°01.106’ N	003°05.739’ W
3	56°00.374’ N	003°07.184’ W
4	56°00.566 N	003°07.484’ W

Coordinates in WGS84, UTM Zone 30N, degrees decimal minutes

The volume of dredged material deposited at the Narrow Deep spoil disposal ground from the Port of Leith and approach channel from 2001 to 2016 ranged from 3,173 m^3 to 65,719 m^3 per annum. Annual spoil disposal volumes are presented in Table 1.3. Due to low levels of siltation during some years (2005, 2012, 2013 and 2017) no dredging was necessary and higher volumes are deposited when both the approach channel and the docks are dredged (*e.g.* in 2016 and 2020).

Table 1.3 Volume of Dredge Spoil Disposal at Narrow Deep Spoil Disposal Ground from Leith (2001 to 2020)

Year	Quantity (m^3)	Spoil Disposal Ground
2001	65,719	Narrow Deep
2002	23,820	Narrow Deep
2003	21,689	Narrow Deep
2004	10,162	Narrow Deep
2005	NIL	-
2006	14,096	Narrow Deep
2007	3,173	Narrow Deep
2008	28,412	Narrow Deep
2009	28,241	Narrow Deep
2010	23,574	Narrow Deep
2011	21,597	Narrow Deep
2012	NIL	-
2013	NIL	-
2014	25,930	Narrow Deep
2015	18,966	Narrow Deep
2016	47,957	Narrow Deep
2017	NIL	-
2018	22,426	Narrow Deep
2019	6,780	Narrow Deep
2020	41,802	Narrow Deep

Data source: Forth Ports February 2021

1.5 Description of Sediment to be Dredged and Disposed

In line with Marine Scotland guidelines on pre-dredge sampling protocol (1), a survey programme was undertaken on 30 November and 7 December 2020. Samples were taken at nine stations using a van-Veen grab. For each of the samples the following chemical analysis was undertaken.

- Sediment water content and density.
- Total Organic Carbon (TOC).
- Sediment particle distribution (PSD).
- Metals: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn).
- Tributyl Tin (TBT).
- Polycyclic Aromatic Hydrocarbons (PAHs): US EPA 16.
- Total Hydrocarbon Content (THC).
- Poly Chlorinated Biphenyls (PCB): ICES 7.
- Presence of asbestos.

The location of the sample stations and the results of the physico-chemical analysis are presented in *Appendix A.*

The sediment to be dredged from the channel and docks comprises sandy mud, muddy sand and gravelly mud with most samples being defined as medium to coarse/very coarse silts (using the Folk and Ward classification). There are concentrations of metals, TBT, PAHs and PCBs and above

(1) Guidance for the sampling and analysis of sediment and dredged material to be submitted in support of applications for sea disposal of dredged material. Available online http://www.scotland.gov.uk/Resource/0044/00443832.pdf

Marine Scotland Action Level 1 and in one station above Action Level 2 (1) for copper and in two stations above Action Level 2 for TBT in the sediment samples analysed.

Samples from the Narrow Deep spoil ground and other spoil disposal grounds in the Forth Estuary and Firth of Forth have been analysed by Marine Scotland. A summary of the historical sample analysis is provided in presented in *Appendix A.*

1.6 Scope of the Study

This report provides an appraisal of available disposal options and short-lists those which are considered to be practicable. Options are reviewed according to the Waste Hierarchy, as outlined in the *Waste Management Licensing (Scotland) Regulations 2011*. The options on the short-list are then reviewed against strategic, environmental and cost considerations. The options are then compared and the BPEO identified.

The remainder of this report is structured as follows.

- Section 2 describes the BPEO assessment method.
- Section 3 describes each of the available disposal options and summarises their respective advantages and disadvantages.
- Section 4 compares the disposal options.
- Section 5 identifies the BPEO.

Further supporting information is provided in the three Appendixes.

- *Appendix A:* Sediment Sample Chemical Analysis Results.
- *Appendix B:* Environmental Impacts of Disposal Operations.
- *Appendix C:* Summary of Consultee Responses.

(1) Action Levels for metals, PCBs, TBT and PAHs are used by Marine Scotland to assess the suitability for disposal of sediments at sea.

2. BPEO ASSESSMENT METHOD

2.1 Introduction

The BPEO study was undertaken using the following method.

- Identification of potential disposal options.
- Preliminary appraisal and short-listing of options based on practicability.
- Assessment of the short-listed options based on:
  - strategic considerations;
  - environmental considerations *i.e.* what the environmental impacts would be; and
  - cost, in terms of capital and maintenance/operating costs.
- Comparison of the relative merits and performance of the options and identification of the BPEO.

Informal consultation by emailed letters, outlining the proposals and requesting any comments or relevant information, was undertaken with the following consultees.

- Forth Ports;
- Edinburgh city Council (ECC);
- Forth District Salmon Fisheries Board (FDSFD);
- Marine Scotland;
- Maritime and Coastguard Agency (MCA);
- Northern Lighthouse Board (NLB);
- Scottish Environment Protection Agency (SEPA);
- NatureScot (NS); and
- The Crown Estate.

Responses received by email are included in *Appendix C.*

2.2 Identification of Options

The following seven potential treatment/disposal options for the dredged material were identified:

- beach nourishment;
- coastal reclamation and construction fill;
- spreading on agricultural land;
- sacrificial landfill;
- incineration;
- other disposal options and reuse; and
- sea disposal.

2.3 Preliminary Appraisal

A preliminary appraisal of each of the options identified above was undertaken, including an assessment of the practicability of each option with regard to availability of disposal sites. Following the preliminary appraisal those options that are considered to be practicable were short-listed for further consideration.

2.4 Assessment of Options

The short-listed options were then subject to detailed assessment. The parameters which were used to assess the short-listed options are described below.

2.4.1 Strategic Considerations

Strategic considerations included the following.

- Operational practicability - focusing on whether the option is technically and operationally practicable.
- Availability of sites/facilities - considering whether there are any sites or facilities which can take the dredge spoil.
- Security of option - examining whether Forth Ports will have control over all stages of the disposal.
- Established practice - considering whether technologies and techniques proposed are established and therefore whether the performance and potential difficulties of the technologies and techniques can be anticipated.
- Likely public acceptability - gauging whether the public are likely to object to or support the proposals.
- Likely agency acceptability - gauging whether public agencies are likely to have any major concerns when consulted on the Marine Licence application.
- Legislative implications - assessing compliance with relevant legislation and the potential management control required.

2.4.2 Health, Safety and Environmental Considerations

The factors used to assess the health, safety and environmental performance of the options are summarised below.

- Safety. Considering potential sources of hazard and probability that there would be any risk to the general public or workers.
- Public health. Assessing whether there would be any risk of a detrimental effect on public health, based on predicted pathways and receptors.
- Contamination/Pollution. Evaluating whether there is potential for pollution or contamination that could result in failure to meet Water Framework Directive (WFD) objectives and associated Environmental Quality Standards (EQSs: the amount or concentration of a substance that should not be exceeded in an environmental system). Contamination is defined as the presence of an unwanted constituent in the natural environment whilst pollution is the introduction of contaminants into the natural environment that causes adverse change.
- Ecological impact. Assessing the significance of any potential impact on important habitats or species, including designed sites.
- Interference with other legitimate users. Considering whether there are likely to be impacts on other activities, such as users of the estuary, ports or roads.
- Amenity/aesthetic. Assessing whether there is likely to be a visual, olfactory or noise impact resulting from the disposal or any impact on local amenity.

2.4.3 Cost Considerations

Cost of disposing of dredged material was considered in terms of the following.

- Capital costs (site costs, construction and equipment hire /purchase costs).

- Operational/maintenance costs (transport costs, disposal costs including site operation).

2.4.4 Comparison of Options

The performance of each option was evaluated on a scale from Low to High according to definitions presented in *Table 2.1*. Intermediate grades (Low to Medium and Medium to High) were also used where the assessment was marginal between Low, Medium or High. The results of the assessment process are presented in *Section 3* and *Section 4.*

Table 2.1 Definitions of Performance

Consideration	High	Medium	Low
Strategic Considerations			
Operational Feasibility	Practical, easy to operate and achievable as process is robust and established. Low number of stages and each stage easy to control.	Some practical difficulties. Moderate number of stages with some difficulties.	Major practical difficulties. Large number of steps with some major difficulties.
Availability of Sites/Facilities	Suitable site/facility available within 1 km of the port by road and 10 km by sea.	Suitable site/facility available within 10 km of the port by road and 20 km by sea.	No suitable sites/facilities within the vicinity (over 10 km by road and 20 km by sea).
Security of option	In complete operational control of Forth Ports.	Is mainly in control of Forth Ports with some outside involvement for which there are alternative sources of supply.	Has elements that are out of Forth Ports control for which there are no practical alternative sources of supply.
Established Practice	Technology and techniques are clearly established with no foreseeable significant problems.	Technology and techniques have been tested but not applied to dredge material.	Technologies and techniques are untested and unforeseen problems are likely.
General Public Acceptability	Likely to be generally acceptable to the public based on reaction to similar developments.	Unlikely to provoke a strong negative or positive reaction based on reaction to similar developments.	Likely to provoke a strong negative reaction based on reaction to similar operations.
Likely Agency Acceptability	Likely to be generally acceptable to statutory bodies after consultation.	Statutory bodies may have some concerns that may be overcome through further consultation.	Statutory bodies may have major concerns that may not be overcome through consultation.
Legislative Implications	Would easily comply with legislation with a low level of management and physical control.	Requires some control/intervention to achieve compliance.	Requires a high level of management control and intervention to achieve compliance.
Health, Safety and Environmental Considerations			
Safety	No significant risk to workers and the general public.	Low risk to workers and the general public which is easily controlled.	Moderate to high risk to workers and general public.
Public Health	Will not cause workers or public to be exposed to substances potentially hazardous to health.	May cause some low level intermittent exposure to substances potentially hazardous to health.	Risk of exposing workers and general public to substances potentially hazardous to health.
Pollution/Contamination	Compliant with emission standards and water quality objectives. Low risk of harm from substances released to environment.	Environmental quality standards may be approached or breached occasionally. Some risk of harm to environment.	Environmental quality standards may be breached regularly and there is a moderate or high risk of harm to environment.

Consideration	High	Medium	Low
Ecological Impact	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the Habitats Regulations 2019 (1) will not be affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the Habitats Regulations 2019 may be slightly affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the Habitats Regulations 2019 are likely to be significantly affected.
Interference with other Legitimate Activities	Little potential for interference with other activities.	Some potential for interference with other activities.	High potential for interference with other activities.
Amenity/Aesthetic	No significant impact on local amenity or aesthetic qualities.	Potential for impacts of moderate significance on local amenity or aesthetic qualities.	Potential for impacts of high significance on local amenity or aesthetic qualities.
Cost			
Capital and operational	£1m or less.	Between £1m and £2.5m.	More than £2.5m.

(1) The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019 apply to European sites (formerly Special Protection Areas and Special Areas of Conservation).

3. PRELIMINARY ASSESSMENT OF AVAILABLE DISPOSAL OPTIONS

3.1 Introduction

This section describes the seven identified disposal options, reviewing the steps required for each option, namely:

- beach nourishment;
- coastal reclamation;
- spreading on agricultural land;
- sacrificial landfill;
- incineration;
- other disposal options and reuse; and
- disposal at sea.

A description of the predicted impacts of the disposal operations is presented in *Appendix B* and extracts from significant correspondence are provided in *Appendix C*.

The identified disposal options are described and issues and requirements associated with each option are discussed below. The section concludes by identifying those options that are short-listed for further consideration in the BPEO process.

There are a number of steps that are common to some of the land-based options and these are described in *Section 3.2* to avoid repetition.

3.2 Common Steps to Land-Based Disposal Options

The disposal options that have land-based components include:

- beach nourishment (if material transported by road);
- coastal reclamation and construction fill (if material transported by road);
- spreading on agricultural land;
- sacrificial landfill;
- incineration; and
- other disposal options and reuse (such as brick making/concrete aggregate/top soil production).

The steps that are common to the land-based disposal options are:

- landing the dredge material;
- storage of dredge material;
- dewatering the dredge material; and
- loading and transport for disposal.

These steps are described below along with a discussion of the practicalities of undertaking these steps at the Port of Leith.

3.2.1 Landing the Dredged Material

All of the land based options require transport to on-shore facilities. This could be via a pumped discharge, conveyor or grab. As Forth Ports does not have suitable landing facilities at Leith, or elsewhere within the Firth of Forth area, a new coastal landing facility would be required to enable the materials to be off-loaded.

3.2.2 Storage of Dredged Material

Once the dredged material has been landed, it will require storage prior to onward transport for final disposal. A storage facility may therefore require construction at the site, capable of retaining the dredged material and associated run-off and dust.

3.2.3 Dewatering the Dredged Material

The land disposal options require dewatering of the dredged material either to make transport more feasible or to create a material which is suitable for disposal to land or incineration *i.e.* disposal of a more solid sludge rather than a liquid. Based on previous experience from dredging at this location the hopper contents are likely to average 20% solids (by volume) and range from 30% to 15% solids *i.e.*, solids to liquid ratio will decrease as dredging operations progress and only isolated pockets of sediments remain resulting in an increased uptake of water (1).

There are three approaches that are typically used for drying marine sediments: construction of settling lagoons, use of a mobile centrifuge unit and a filter press, as described below.

Settling Lagoons

Settling lagoons are likely to be large, ring-dammed structures into which the dredged material would be offloaded. These could be built within the intertidal area or on land. The material would be piled up in the lagoon and the water drained out under gravity. The lagoons would have a drainage system to collect the water and watery sludge from the dredged material for further treatment (usually by hydrocyclone, see below) or to be transported offsite for disposal. The lagoons must be of sufficient size to contain the dredged material prior to transport. They must also be accessible by road and must have facilities to load the dredged material into tankers or sealed heavy goods vehicles (HGVs) for movement to the disposal/treatment centre. To minimise the distance the wet dredge material has to be transported from the dredger they must be located near the quayside.

The majority of the intertidal area falls within the Firth of Forth Site of Special Scientific Interest (SSSI) and Outer Firth of Forth and St Andrews Bay Complex Special Protection Area (SPA). The SPA is a large estuarine/marine site consisting of the two adjacent Firths of Forth and Tay. NS has previously expressed the view on similar BPEO assessments that further loss of intertidal habitats is not considered a realistic option.

Setting up settling lagoons would require assessment to ensure that any leachate from them would not contaminate groundwater and a licence would be required from SEPA under the *Water Environment (Controlled Activities) Regulations (2011)*. Forth Ports advise that the potential to be able to find appropriate space to create settling lagoons close to the port is considered to be very low.

As some samples of the material analysed contains metals, TBT, PCBs and PAHs above Marine Scotland Action Level 1 and 2 (see *Appendix A*) it might be additionally necessary to construct the lagoons with special liners to retain the contaminants and consider treatment of the supernatant water draining out of the lagoons.

Centrifuge or Hydrocyclone System

The use of a centrifuge or hydrocyclone system to dewater the material to a level suitable for disposal to landfill (approximately 10% water content) may be required, depending on the final water content of the recovered material. One mobile unit system was reported as being capable of treating up to 150 $m^3 hr^{-1}$ depending on unit size and material solids content. Other systems may be available that can process material at different rates, however, for the purposes of this assessment a rate of 150 $m^3 hr^{-1}$ has been used. If material can be dried at a rate of 150 $m^3 hr^{-1}$, to dewater a total volume of approximately 100,000 m^3 would require approximately 667 hours (28 days assuming working 24

(1) Forth Ports Ltd pers comm.

hours a day, seven days a week, or approximately 83 standard working days). Other units with lower throughputs could take longer (1).

Filter Press

A filter press is a tool used to separate solids and liquids using the principle of pressure. The press is filled with the dredge spoil, building up pressure before the spoil is strained through filter cloths by force. The remaining dried spoil can then be removed from the filter press and taken away for disposal. Processing rates would be similar to that of a centrifuge.

3.2.4 Loading and Transport for Disposal

A loading facility would be required adjacent to the storage or dewatering area to load the material into covered HGVs for transport to disposal/treatment sites. The required infrastructure would include hard standing to allow a fleet of HGVs to be loaded by mechanical excavators. Although hard standing is already available at the Port of Leith, there are no storage or dewatering sites at Leith.

Assuming the materials can be dried to a water content of 10% (by volume) at or adjacent to the Port of Leith, the estimated 93,500 m^3 (2) per annum of dried materials would require transport to a beach nourishment/reclamation project or for disposal to agricultural land, landfill or incinerator. The length of journey required would depend on the location of the re-use or disposal sites.

A volume of 93,500 m^3 of dried (to 10% water content) material equates to approximately 121,550 tonnes (3). Assuming 20 tonne capacity HGVs/tankers are used, this would equate to 6,078 return trips or 12,115 vehicle movements per annum. The levels of HGV movements in the Leith area are already high so this level of movement may be acceptable at the collection end. However, there is more likely to be an issue with regard to increase in traffic flows on rural roads if they are used to reach disposal/treatment sites.

3.2.5 Disposal/Treatment Issues

Neither method of the drying process (*e.g.* lagoons or centrifuge) is likely to reduce the concentration of metals, TBT, PAHs, PCBs and salt present within the dredged material. This will restrict disposal and reuse options and as the material has elevated levels of some contaminants, pre-treatment may be required prior to disposal on land.

Where an option involves disposal on land there is an issue of classification of the dredged material. Once the material has been removed from the docks for disposal on land it will be classed as waste. The waste then requires disposal at a licensed waste management facility and to be transported by a registered waste carrier. In the waste hierarchy set out in the Waste Management Licensing (Scotland) Regulations (2011), dredged spoil is coded as 17 05 05 (Mirror Hazardous) or 17 05 06 (Mirror Non-hazardous), depending on the concentrations of particular contaminants. If landfill is identified as the disposal route for this waste then further analysis may be required to ensure that the material meets the Waste Acceptance Criteria for hazardous landfill.

The saline nature of the sediment also restricts its application on land, as without going through a washing process it will not be able to support any form of terrestrial flora growth.

3.3 Beach Nourishment

3.3.1 Process Description

Beach nourishment involves the disposal of the dredged material on a beach directly from the dredging vessel or, if dewatering was required, the spoil would be brought ashore and dewatered prior to transport or placement on the beach using earth moving plant.

(1) Maximum throughput of 120 m^3hr^{-1} http://www.euroby.com/services/mobilecontract-dewatering-units/
(2) 100,000 m^3 total spoil at 85% solids content equals 85,000 m^3 plus 8,500 m^3 (10% water content) equals 93,500 m^3.
(3) Based on a weight of 1.3 tonnes per m^3 of dredge spoil.

3.3.2 Suitable Sites for Beach Nourishment

Beach nourishment requires materials of a similar composition to the existing beach materials and usually involves clean sand or gravel. The sediment from within the proposed dredge zone generally comprises medium to coarse/very coarse silts. The sediment from the Port of Leith is not suitable for beach recharge due to the particle size distribution and the presence of contaminants such as metals, TBT, PAHs and PCBs.

Due to the risk of direct exposure to contaminated sediment, spoil containing contaminants disposed of at the public recreational sites such as beaches is considered less suitable than if it were disposed of at sea. Action Levels provided by Marine Scotland are specific to the disposal of material to sea where the sediment does not come into direct contact with the public, rather than at recreational areas. Guidance published by NS (then SNH) (1) on managing coastal erosion in beach/dune systems makes reference to use of materials that *are not contaminated in any way* but does not provide equivalent action levels for contaminants. NS has also confirmed during a previous consultations that it would only be appropriate to use material on a beach of similar substrate provided contaminant levels were not of concern

No sites requiring beach nourishment with this grade of material have been identified. Given the conservation status of the Firth of Forth, the lack of available beaches for nourishment, the contamination of the spoil and its particle size composition, beach nourishment is not considered to be a practicable option.

3.4 Coastal Reclamation and Construction Fill

3.4.1 Process Description

This section considers the use of the dredged material in coastal reclamation projects or as fill material inland. Depending on the potential site, reclamation or fill could involve landing, storage, dewatering, transport and possibly desalination. Coastal use directly from the dredging vessel would be preferable as this would involve pumping or spraying the material directly from the dredger or barge to the site where it was needed and would avoid handling and transporting the material on land.

3.4.2 Suitable Sites for Reclamation

Forth Ports, Marine Scotland and the coastal local authorities are the most likely bodies to be responsible for or aware of reclamation projects in the Firth of Forth. No sites for coastal reclamation have been identified through the consultation process as requiring any of the dredged material. In addition, the dredged material would not be suitable for many reclamation sites due to the low compressive strength properties of predominantly muddy sediments. The spoil could be pumped into bunded lagoons at the edge of the Firth of Forth to create land that could be used for development, agricultural or similar purposes. This is unlikely to be acceptable to NS or other stakeholders due to the potential impact on designated areas in the Firth of Forth.

3.4.3 Construction Material

Use as fill in inland construction projects would not be appropriate because of low compressive strength properties of predominantly muddy sediments and the need for landing, drying and transport of the dredged material. If landing, drying and transport were feasible then it may be that the material could be used for quarry/landfill capping. However, the presence of contaminants in the dredged material and its high salt content make this option unattractive.

(1) Scottish Natural Heritage (2000). A Guide to Managing Coastal Erosion in Beach/dune Systems. Summary 7: Beach Nourishment.

3.5 Spreading on Agricultural Land

3.5.1 Process Description

SEPA has previously confirmed that the disposal or recycling of marine dredged material on agricultural land does not fall within the exemptions under Paragraph 7 of Schedule 1 of the *Waste Management Licensing (Scotland) Regulations 2011*, and the activity would therefore require to be licensed. Planning permission may also be required from the local authority. In support of the application to dispose of the dredged material to agricultural land, evidence that the material would not cause pollution of the environment or harm to human health would need to be provided.

The disposal of marine spoil to agricultural land would involve landing, dewatering, storage, desalination and transport for disposal. Dewatering the dredged material in lagoons, centrifugal drier or filter press would remove some of the salt; however it is likely that the desalination would still be required. Desalination could be achieved by placing the spoil in lagoons, layering it with sharp sand, spraying water over the material and allowing leaching of the salt back into the Firth of Forth.

The material sampled at the Port of Leith has contamination from metals, TBT, PAHs and PCB above Action Level 1 and, in two stations, above Action Level 2 for some parameters. The data from the 2020 samples shows that the mean metal concentrations were similar to previous samples (1990-2020) and generally within the range the range of previously collected data from Leith and from other ports within the Forth Estuary and the Firth of Forth (*Table 3.1*) (1).

Table 3.1 Concentrations of Metals in the Port of Leith Sediment (1990-2020) with those from other Firth of Forth and Forth Estuary Ports

Metal Concentration (expressed as mg kg^{-1} on air dried sediment)								
	As	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**
Leith 2020								
Mean	14.72	1.12	68.3	144.7	0.96	48.1	132	306
Range	10.5-19.6	0.25-1.86	52.1-88.7	31.1-362	0.56-1.31	32.4-74.8	65.6-195	126-453
Leith 1990-2017								
Mean	13.1	1.1	61.4	71.1	1.2	39.8	134.5	261.3
Range	4.6-21.6	0.0-3.9	14.1-84.3	12.8-144	0.2-4.4	13.0-59.3	29.0-787	62.6-687
Rosyth 2000-2020								
Mean	17.04	0.23	74.31	38.77	0.95	34.0	70.0	150.1
Range	12.4-21.9	BDL-4.5	46.3-106	22.5-189.9	0.4-2.6	24.6-43.4	43.1-137.5	88.4-1,730
Grangemouth 1988-2019								
Mean	14.5	0.1	73.3	49.6	1.1	32.2	69.9	147.3
Range	0.0-43.6	0.0-1.2	10.7-211	3.0-353	0.0-3.8	7.6-80.6	9.3-209	28.9-743

Key: As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Hg = Mercury, Ni = Nickel, Pb = Lead, Zn = Zinc.

Blue shading indicates concentrations above Marine Scotland Action Level 1.

Approximately 200,000 tonnes of sludge are recycled to agricultural land per annum across Scotland (2). Forth Ports is seeking to dispose of approximately 93,500 m^3 of dewatered material (121,550 tonnes at 1.3 tonnes m^{-3}) of dried material equating to approximately 60.8% of the current volume of annually recycled sludge in Scotland. In addition, the material from Leith has a low organic carbon content (an average of approximately 6% from the sediment sample analysis). For these reasons, spreading dredged material from the Port of Leith on agricultural land is not considered a practicable option.

(1) Data for Grangemouth, Rosyth and Leith provided by Marine Scotland, Aberdeen and NLS, Leeds.

(2) https://www.gov.scot/publications/review-storage-spreading-sewage-sludge-land-scotland-sludge-review-final/

3.6 Sacrificial Landfill

3.6.1 Process Description

The type of landfill site which can take the spoil is dependent upon the classification of the waste. As discussed in Section 3.2.5 above it is understood that the waste would likely be classified as hazardous or non-hazardous rather than inert and therefore a suitably licensed landfill site with sufficient capacity is required.

3.6.2 Available Landfill Sites

Subsequent to implementation of the *Landfill Allowance Scheme (Scotland) Regulations 2005* and re-evaluation of landfill licences, there are currently two sites within an hour's drive from the Port of Leith able to accept such material. A suitable landfill site is located at Avondale Landfill, Polmont, approximately 22 miles west of the Port of Leith. However, the Avondale site is not large enough to accommodate all of the dredged material, and would only consider taking some of the dredged material upon closure of one or all of the phases within the plant. Fife Council Lower Melville Wood landfill site in Cupar, approximately 40 miles north of Leith, also has the capability to accept non-hazardous material, although not the volume required and not on an annual basis. This site was due to close at the end of 2020 (1)

3.6.3 Taxes and Royalties

The material will be exempt from landfill tax under the terms of the *Landfill Tax (Scotland) Act 2014* issued by the Scottish Government that specifies that dredged material from any inland waters, including harbours and their approaches, are not subject to landfill tax. As the Crown Estate Scotland owns part of the seabed in the Firth of Forth, royalties may be due to be paid by Forth Ports or the receiving party. The requirement and value of Royalties would require to be subject of discussions between Forth Ports and the Crown Estate Scotland and are not known at this point.

3.7 Incineration

3.7.1 Process Description

Incineration would involve landing the dredged material, dewatering, possibly storing it and transporting it to either an existing incinerator or a newly constructed incinerator. The ash would then require disposal. Options for disposal of ash include landfill, reclamation and spreading on agricultural land.

The organic content of the dredged material is assumed to be approximately 6% (based on the 2020 samples which had an average percentage of organic carbon of 6.23% and range of 3.6 to 9.07%) and therefore there is only a small combustible component within the material. It is anticipated that incineration would result in a reduction in volume of the dried spoil by less than 16% *i.e.,* less than 6% organics plus 10% water content. Incinerator operators generally require material to have an organic content above 20% to ensure efficient combustion and would most likely reject material with an organic content below this threshold (2).

A further consideration is that the material to be dredged contains metals, TBT, PCB and PAHs. In a typical thermal desorption incineration process it is likely that PCBs, salt and most of the mercury (around 80%) would be removed. In addition, the leaching potential of other metals would be reduced (except for arsenic) and as a result, the ash would still be contaminated. Pre-treatment would be required for the removal of metals. Emissions to atmosphere from the incineration processes would also require to be controlled by SEPA under the *Environmental Protection Act 1990.*

(1) https://www.sepa.org.uk/media/109581/landfill-sites-and-capacity-report-2010.xls
(2) Baldovie Waste to Energy Plant, pers comm, January 2017

3.7.2 Available Incinerator Sites

There are no appropriate waste incinerators in Scotland that could accept the dredged material. The nearest incinerator is at Ellesmere Port, Merseyside (approximately 250 miles km south) and transport would be costly and therefore this option is not considered to be practicable.

3.8 Other Disposal Options and Reuse

The other disposal options are re-injection into the tidal flats via a pipeline and reuse in brick making, concrete aggregate or top soil production processes.

3.8.1 Re-injection

This would involve the construction of a pipeline to take the dredged spoil to a high tide point on the Cramond tidal flats and injecting it at velocity back into the mudflat. The advantage of this is that it effectively keeps the sediment within the sediment cell. The disadvantage of this is that the re-injection at velocity would be likely to have an adverse impact on the protected mudflat habitat through disturbance and erosion and may affect the benthic fauna and associated ornithological interests that feed in the mudflats.

Due to the costs associated with the construction and maintenance of the pipeline and the disturbance during construction and operation of the pipeline on the ornithological interest of the mudflats this option is not considered to be practicable.

3.8.2 Brick Making/Concrete Aggregate/Topsoil Production

There are processes by which marine sediments can be made into bricks or can be used to form concrete aggregate. The advantage is that the materials can be beneficially used and metals are sealed into the bricks or aggregate. Previous consultations between Forth Ports and a brick making factory confirmed that the mineralogy of the material would not be appropriate for brick making and the contamination by salt would be unacceptable for any construction material.

Almost no agricultural species can grow in salty soils and very few in brackish soils. The salinity of the dredged sediment would require to be reduced naturally by rainwater or by a dewatering process before consideration for use as topsoil (see Section 3.2.3). The best topsoil is a mixture of sand, silt, clay and organic matter and must be clean for use in the production of food crops [(1)].

3.9 Disposal to Sea

3.9.1 Process Description

Disposal at sea involves the dredge material being transported to a licensed marine disposal site in a dredging vessel. Disposal to sea is the normal practice for disposal of dredged spoil from Leith and from other ports and harbours in the Forth Estuary and Firth of Forth. This approach takes place at sea and does not require the landing of any materials. It involves the dredger sailing to a licenced disposal site and releasing the materials through bottom doors or by lowering the excavator head into the water. For the current dredger, bottom door disposal is used.

There are seven licenced marine disposal sites in the Forth Estuary and Firth of Forth: Bo'ness, Oxcars, Blae Rock, Kirkcaldy, Methil and two sites designated at Narrow Deep (A and B). For the dredging operations at Leith, Forth Ports would propose to use the Narrow Deep B spoil ground located approximately 2.5 nm east of the Port of Leith within the Firth of Forth. This site has historically been used for the disposal of dredged material from Leith and is the closest site to the port, thus minimising the distance for vessel transport.

(1) Permanent International Association of Navigation Congresses. Permanent Technical Committee II. Working Group 19. 1992. Beneficial Uses of Dredged Material, Issue 19.

Forth Ports have used the *UKD Marlin* since 2001 to dredge the approach and dock areas and propose to continue to do so. The time required for one cycle (dredging - travelling - discharging - travelling) is approximately two hours. A global positioning system (GPS) would be used to position the vessel in the disposal area and records of the spoil discharge locations would be retained.

The baseline environmental conditions and potential environmental impacts at the disposal site are described in *Appendix B*.

3.10 Conclusion

The description of the available options allows options that are evidently impracticable to be ruled out. This is summarised in *Table 3.2.* The assessment of the short-listed options taken forward for further consideration is presented in *Section 4.*

Table 3.2 Short-listing of Options

Option	Assessment	Result
Beach Nourishment	This option does not appear to be practicable. The material is not suited to beach nourishment in the Forth Estuary or the Firth of Forth; in addition there are no beaches within the Forth Estuary or the Firth of Forth, identified by Forth Ports, consultees or in the NCCA (2017) (1) report that require nourishment with this grade of material.	Discard
Coastal Reclamation and Construction Fill	This option may be practical. The salt content, poor load bearing properties and the potential concentration of contaminants limits the available options for reuse of the dredged material.	Short-list
Spreading on Agricultural Land	This option does not appear to be practicable. The material is not desirable for disposal on agricultural land due to potentially containing concentrations of contaminants and having a low organic content (<5%). Furthermore, desalination, storage, dewatering and transport of this material are impractical. Disposal on agricultural land would require a Waste Management Licence and evidence that there would be no harm to human health.	Discard
Sacrificial Landfill	This option may be practicable. There are a large number of steps involved in storage, dewatering and transport. Landfill site operators may be unwilling to accept the material due to the sediment composition and large volumes.	Short-list
Incineration	This option does not appear to be practicable. The material is not suited to incineration due to low organic content (c, 6%) and large volume of spoil involved. If incinerated, volume would only slightly reduce and there are no available incinerators in Scotland that could take this amount of material.	Discard
Other Uses	This option may be practicable in the form of brick making, concrete aggregate and top soil production.	Short-list
Disposal at Sea	This option is practicable and has been the BPEO for previous dredging campaigns at the Port of Leith.	Short-list

(1) Fitton JM, Rennie AF and Hansom JD (2017). Dynamic Coast - National Coastal Change Assessment: Cell 2- Fife Ness to Cairnbulg Point. CRW1014/2.

4. ASSESSMENT OF SHORT-LISTED DISPOSAL OPTIONS

4.1 INTRODUCTION

This section presents an assessment of each option against the assessment definitions of performance listed in *Table 2.1*. A classification of likely performance is provided for each of the criteria and the assessment is then summarised in *Section 5*.

4.2 COASTAL RECLAMATION AND CONSTRUCTION FILL

4.2.1 Strategic Considerations

Operational Feasibility

The reuse of the dredged material for reclamation will involve either direct pumping from the dredger into the disposal site or landing and drying the material and desalination prior to transporting the material for disposal on land. This option would be practical if disposal sites were available adjacent to the Firth of Forth.

Classification: Low to Medium

Availability of Sites

No coastal sites within the Firth of Forth requiring this grade of material for reclamation or construction fill have been identified by Forth Ports, consultees or in the latest Dynamic Coast – National Coastal Change Assessment (2017) (1).

Classification: Low

Security of Option

No sites have been identified as belonging to Forth Ports, so disposal to reclamation sites is outwith their control and could present practical problems, such as scheduling in sediment delivery with proposed dredging programme.

Classification: Low

Established Practice

The use of suitable dredged materials, such as marine aggregates, in coastal reclamation and construction fill is common practice and the technologies and techniques to move such material are well established. However, the use of dredge spoil for such activities is not common.

Classification: Low to Medium

General Public Acceptability

Use of the materials for reclamation is likely to be viewed as an acceptable option by the general public. Depending on the method of transporting the dredged material to the site requiring it will affect acceptability by the general public. Transport by sea is likely to be viewed as more favourable than transport by road, which may be viewed as unacceptable by local residents and road users.

Classification: Medium

Likely Agency Acceptability

Use of the dredged material for reclamation or construction fill is likely to be acceptable to public agencies. There may be some concerns regarding the contamination levels in the dredge spoil and the volume of material to be transported by HGVs for reasons relating to air quality and proximity to residential areas.

(1) Fitton, J.M., Rennie, A.F., and Hansom, J.D. (2017) Dynamic Coast - National Coastal Change Assessment: Cell 2 - Fife Ness to Cairnbulg Point, CRW2014/2

Classification: Medium to High

Legislative Implications

The disposal of dredged material from the Port of Leith directly from the dredger to a reclamation site requires a Marine Licence from Marine Scotland under *Section 20(1) of the Marine (Scotland) Act 2010*.

Once the material has been removed from the harbour for disposal on land it will be classed as waste under the *Waste Management Licensing (Scotland) Regulations (2011)* and the disposal will therefore require a waste management licence and an exemption for reclamation works. As well as a Marine Licence for the construction works, consent will be required from the planning authority and a levy paid to the Crown Estate Scotland.

Classification: Medium to High

4.2.2 Health, Safety and Environmental Considerations

Safety

Pumping the dredged material ashore has risks associated with operational activities, all of which have mitigation measures in place. Should the dredged material be transported by HGV, there may be an increase in safety risks associated with the movement of materials for disposal, particularly if tankers/sealed HGVs travel through populated areas and along minor roads.

Classification: Medium to High

Public Health

Slight risks to public health are anticipated due to intermittent increase in HGV traffic.

Classification: Medium to High

Pollution / Contamination

The material may be classified as hazardous or non-hazardous (*i.e*. not inert) due to the concentration of contaminants with respect to land based disposal, however, further analysis would be required to confirm this and run-off and leaching would need to be controlled. There may be localised and temporary deterioration in air quality as a result of HGV movements.

Classification: Medium

Ecological Impacts

There are unlikely to be any ecological risks resulting from the use of dredged materials for reclamation, assuming any contaminants are contained within the site and there would be no significant impact on national or local priority species or habitats. If the site was to be used for terrestrial habitat creation then the salt levels would limit plant growth.

Classification: Medium to High

Interference with Other Legitimate Activities

The disposal of dredged material is unlikely to interfere with other activities unless the reclamation site is in the port area, in which case the dredger may interfere with other port users, or if the area to be reclaimed was used for recreation. If HGVs are used to transport the dredged material, they may affect other road users.

Classification: Medium to High

Amenity/Aesthetic

If the dredged material is disposed of directly from the dredger there are low risks to amenities/aesthetics. If disposed of by HGV, landing, storage and transport may result in an impact to both amenities and aesthetics of the area.

Classification: Medium to High

4.2.3 Cost Considerations

If the dredged material was pumped directly ashore there would be no further capital costs. If the dredged material was landed, treated and then transported by road, the estimated costs below would apply:

- discharge berth: over £3.5 m;
- pumping material to site – approximately £8.75 per m^3 (1) £875,000; or
- dockside centrifuge facility capable of dewatering and desalinating up to 100,000 m^3 per annum: £20 to £30 m; and
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(2): £607,750.

Total £4.98 m to £34.1 m

Classification: Low

4.3 Sacrificial Landfill

4.3.1 Strategic Considerations

Operational Feasibility

Disposal to landfill would require the landing, storage and drying of the dredged materials prior to transporting to a landfill facility. Approximately 121,550 tonnes of material would require transport. This option has practical difficulties relating to drying the dredged material and transport of large volumes of material to a landfill site.

Classification: Low to Medium

Availability of Sites / Facilities

The nearest suitable site is located at Avondale Landfill, Polmont, approximately 23 km from Leith. Avondale has advised that it may be able to receive some of the material, however would require a more in depth analysis to include pH and total petroleum hydrocarbons before confirming acceptance and cost. In addition, the timing of receipt of material would need to fit in with its operational requirements when closing exiting landfill cells (3).

Classification: Low

Security of Option

Whilst Forth Ports have control over the dredging operations, it would have no control over the continued availability of landfill space for the material or the disposal route.

Classification: Low

Established Practice

Dredged material is sometimes disposed of to landfill for small one-off dredging operations, however it is not established practice to routinely dispose of large quantities of dredged material in this way. Landfill sites require the dredged material to be dried to 10% water content before acceptance. It is unlikely that this is a practice that would be acceptable if there are other viable alternatives.

Classification: Low to Medium

(1) Based on previous consultation with contractors.
(2) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour.
(3) Avondale pers comm, February 2016.

General Public Acceptability

Disposal of the material to landfill is likely to be acceptable to the general public. However, the transport of the dredged material from Leith to potential landfill sites may be unacceptable to residents and other road users.

Classification: Medium

Likely Agency Acceptability

The National Waste Strategy establishes the direction of the Scottish Executive's policies for sustainable waste management to 2020. One such policy is to reduce landfilling of municipal waste from 90% to 30% and as such there may be objection to dredged material routinely requiring space in landfill.

Disposal to nearby landfill sites is likely to be acceptable to SEPA provided the materials are regarded as suitable for landfill, however, the acceptability would depend on the quantities to be disposed of and further assessment and classification of hazardous substances.

Classification: Medium

Legislative Implications

The material would be controlled waste material for the purposes of transport, storage and disposal. As such, Section 34(7) of *The Environmental Protection Act 1990* and Regulation 6 of the *Pollution Prevention and Control (Scotland) Regulations 2012* would apply and compliance is likely to be possible. The disposal of the material will also require a waste management licence under *Waste Management Licensing (Scotland) Regulations 2011*.

Classification: Medium to High

4.3.2 Health, Safety and Environmental Consideration

Safety

There may be an increase in safety risks associated with the movement of materials for disposal, particularly if 12,115 tankers/sealed HGVs travel through populated areas and along minor roads each year.

Classification: Medium to High

Public Health

Slight risks to public health are anticipated due to the intermittent increase in HGV traffic.

Classification: Medium to High

Pollution/Contamination

There may be a small risk of leaching of contaminants that should be contained on site.

Classification: Medium to High

Ecological Impacts

Although there is a small risk of contaminants leaching out from the dredged material, this would be at very low concentrations and is unlikely to cause significant harm to the local ecology. The salt content in the material may prevent plant growth unless covered in a top soil.

Classification: Medium to High.

Interference with Other Legitimate Activities

The increase in HGV movements may interfere with other road users. Baseline traffic data for the A199 in the vicinity of the port indicates that approximately 4% of all road traffic in Leith is HGVs (1). As a result of the proposed disposal to landfill, the proportion of HGVs in the total annual traffic flow would increase by approximately 5.4%(2). Depending on the landing and storage arrangements there may be potential for some interference with other dock and road users.

Classification: Medium

Amenity/Aesthetic

The movement of HGVs through the area will have an impact on local amenity through noise, vibration, visual impacts and road congestion. This risk also applies to the disposal site.

Classification: Medium

4.3.3 Cost Considerations

Capital would be required to purchase new equipment. Estimates of the cost of this equipment are:

- discharge berth: £3.5 m;
- lagoons to settle dredged material - £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 100,000 m^3: £20 m - £30 m;
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(3): £607,750.

Total £6.6 m to £34.1 m

Classification: Low

4.4 OTHER DISPOSAL OPTIONS AND REUSE

4.4.1 Strategic Considerations

Operational Feasibility

Reuse for brick making, concrete aggregate or top soil production would require the landing, storage and drying of the dredged materials prior to transporting to a landfill facility. Approximately 130,000 wet tonnes of material would require transport. There are practical difficulties relating to handling the dredged material at the Port of Leith. The availability of suitable factories/facilities to process the dredged material and markets for the final products are also considerations.

Classification: Low to Medium

Availability of Sites/Facilities

There are no known sites or facilities to receive the dredged material for other uses such as top soil production or brick making.

Classification: Low

(1) UK Traffic Data, A199 Leith 2019 traffic data. Available online https://roadtraffic.dft.gov.uk/manualcountpoints/30872

(2) 2019 data present an average of 222,650 HGVs on the A199 at Leith per annum, which would increase to 234,7465HGV movements (from a total of 6,071,045 to 6,083,160 vehicles recorded per annum on the A199 at Leith) with the transport of dredged material from Leith by road. Based on 7 days a week.

(3) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour.

Security of Option

Although Forth Ports would have control over the dredging and landing, they would not have control over the continued acceptance of the materials for making bricks or aggregate.

Classification: Low to Medium

Established Practice

Use of excavated materials for brick making or concrete aggregate is common practice but use of marine dredged spoil is not and it is generally not feasible due to the level of salinity and the composition of the material. Whilst top soil has been made from dredged material in the past it is not common practice.

Classification: Low to Medium

General Public Acceptability

Making bricks, concrete or top soil is likely to be publicly acceptable depending on the end use. However, the transport of the material over a large distance may not be acceptable to residents and other road users.

Classification: Medium to High

Likely Agency Acceptability

It is likely that brick making, concrete production and top soil production would be acceptable to agencies and considered a positive activity. However, the contaminant levels in the samples would make using the material for top soil unattractive.

Classification: Medium to High

Legislative Implications

SEPA would control emissions from brick making factories under the provisions of the *Environmental Protection Act 1990*. A waste management licence would also be required for their transport and storage under the *Waste Management Licensing (Scotland) Regulations 2011*.

Classification: Medium

4.4.2 Health, Safety and Environmental Considerations

Safety

There are unlikely to be any significant safety risks associated with making bricks, concrete or top soil with the exception that there may be an increase in safety risks associated use of plant and manual handling of materials as well as the movement of materials, particularly if HGVs travel through settlements and along minor roads.

Classification: Medium

Public Health

Slight risks to public health are anticipated due to the intermittent increase in HGV traffic.

Classification: Medium to High

Pollution / Contamination

The contaminant levels in the dredged material would make using the material for top soil unattractive. Pollution from plant emissions is not likely to be an issue provided emissions are controlled in accordance with licences.

Classification: Medium to High

Ecological Impacts

Making bricks or concrete should have no adverse ecological effects, provided the materials were decontaminated and desalinated before use.

Classification: High

Interference with Other Legitimate Activities

There is a slight risk that movement of the material would impact other road users.

Classification: Medium to High

Amenity/Aesthetic

The only impacts on amenity are likely to stem from the impact of HGVs from transporting the material.

Classification: Medium to High

4.4.3 Cost Considerations

An estimate of costs is provided below.

Capital would be required to purchase new equipment. Estimates of the cost of this equipment are:

- a discharge berth for the dredger with a storage facility - £3.5 m;
- lagoons to settle dredged material and possibly desalinate - £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 100,000 m^3 of silt per annum - £20 m - £30 m; and
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(1): £607,750.

Total - £6.6 m to £34.1 m

Classification: Low

4.5 SEA DISPOSAL

4.5.1 Strategic Considerations

Operational Feasibility

Operationally disposal at the Narrow Deep site is comparatively simple as it does not require the landing, storage and drying of the spoil and all the necessary procedures are understood. As this is the present discharge route for the ongoing maintenance dredge operations at the Port of Leith, it has been proven as practicable and all the necessary procedures are understood and logistical arrangements in place.

Classification: High

Availability of Sites / Facilities

The sites/facilities which are required for the sea disposal option are those which are already used. No other disposal sites have been indicated by Forth Ports as available at this time for the dredged material from the Port of Leith.

Classification: High

(1) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour.

Security of Option

Forth Ports will have full control over all stages in the dredging and disposal process assuming they receive a disposal licence.

Classification: Medium to High

Established Practice

Disposal at the Narrow Deep licenced spoil ground is the current practice for the disposal of the dredged spoil from the Port of Leith. It is, therefore, established and proven as effective.

Classification: High

General Public Acceptability

Forth Ports has confirmed that similar disposal operations from other ports and harbours in the Firth of Forth and Forth Estuary have not attracted any appreciable comment. Dredging operations are unlikely to affect members of the general public, with the possible exception of some recreational users in the Firth of Forth when the vessel is transiting to and from the disposal site.

Classification: High

Likely Agency Acceptability

Consultations with the regulatory bodies for previous Marine Licences indicate that there is no objection to sea disposal at Narrow Deep. The Forth District Salmon Fishery Board (FDSFB) has previously highlighted concerns surrounding time of year of disposal coinciding with seaward migration of salmon smolts and requested that disposal is avoided during June and July. Due to the operational requirements at Leith to maintain the navigation channel at all times of the year and the small magnitude of potential effects of disposal operations to migrating salmonids, Forth Ports does not consider that this request is justified. This issue is addressed in *Appendix B*.

Classification: Medium to High

Legislative Implications

A Marine Licence will be required from Marine Scotland and provided that the BPEO is satisfactory, and the statutory consultees do not object, it is established practice that a Marine Licence will be issued. Compliance should not therefore demand significant management control. Permission will be required from The Crown Estate for disposal of spoil to The Crown Estate owned sea bed.

Classification: Medium to High

4.5.2 Health, Safety and Environmental Considerations

Safety

The operations are undertaken at sea, therefore members of the public are not likely to be exposed to risk from the disposal activities. Forth Ports will have oversight of the dredging contractor's operations.

Classification: High

Public Health

The risk of members of the general public being exposed to contamination from the dredged material deposited at the Narrow Deep spoil ground is considered to be low. Commercial species of demersal fish are not taken from the disposal area so no direct food chain links between the disposal site, fish and human consumers leading to impacts on public health are considered likely.

Classification: Medium to High

Pollution/Contamination

The effects on water quality of the disposal operations and the potential for impacts on sediment contamination may cause the occasional exceedance of Environmental Quality Standards, although based on current evidence this would be localised and short-term. The identification and assessment of environmental impacts of dredged material are presented in *Appendix B* and follow the guidance provided in Best (2106) (1).

Classification: Medium

Ecological Impacts

The disposal operations may affect the benthic fauna in proximity to the disposal site due to sediment drifting from the disposal area itself. It is anticipated that there will not be any significant impact on the Forth marine ecosystem as a whole given the scale and duration of effects of continued disposal at this site which has been ongoing for over 20 years. There may be some localised and short-term effects such as displacement on migrating fish due to increased suspended sediments caused by the discharge of dredged material into the water column but these impacts are not predicted to prevent migration, cause mortalities or affect the viability of fish populations. Under the proposed disposal proposals, cumulative impacts with other operations are not predicted to create a significant impact to the Firth of Forth SSSI, SPAs or SACs farther afield or marine ecosystems.

The ecological impacts of disposal of dredged material to sea is addressed in *Appendix B.*

Classification: Medium to High.

Interference with Other Legitimate Activities

The transport and disposal activities may cause some disruption to other users of the Firth of Forth, however as the operations will only be occurring for a limited period of time and are controlled directly by Forth Ports it is not anticipated that there will be any significant interference. In addition, historic operations at Narrow Deep have not resulted in any reported disruption to other Firth of Forth users.

Classification: High

Amenity/Aesthetic

The disposal activities may cause some short-term disruption to other users of the Firth of Forth but the proposals will contribute to the normal functioning of the Port of Leith.

Classification: Medium to High

4.5.3 Cost Considerations

There would be no capital required to purchase new equipment. Operational costs for the operation of the dredger are approximately £500,000 to 750,000 depending on requirements.

Classification: High

(1) Best, M (2016). Clearing the Waters for All: WFD guidance for developers and regulators in estuarine and coastal waters. Environment Agency.

5. SUMMARY OF THE BPEO

5.1 INTRODUCTION

This section summarises the assessment of options against the criteria described in *Chapter 2*: *Table 2.1* and identifies the BPEO.

5.2 COMPARISON OF OPTIONS

Seven options were initially considered for the disposal of the dredged spoil from the Port of Leith. These were reduced to a short-list of four options based on practicality. A summary of the key considerations with regard to each of the four short-listed options is provided below and illustrated in *Table 5.1.*

5.2.1 Coastal Reclamation and Construction Fill

Operationally, coastal reclamation and construction fill would be possible. The process would be expensive and would involve a number of contractors to undertake the transition from vessel to bunded lagoons and drying and fixing of the material in the lagoons. The sediment is primarily mud and sandy mud, with some gravel fractions from samples in access channel, with low compressive strength properties, making it unsuitable for most types of construction. In addition, the presence of some metals, TBT, PCBs and PAHs restricts its suitability for application on land.

Currently there are no significant areas of coastal reclamation planned in the Firth of Forth or Forth Estuary. If the dredged material (where owned by The Crown Estate) is beneficially used for fill or construction purposes this will attract a royalty rate per cubic metre. The specific royalty rates for material beneficially used are dependent on the quality and specific end use, and this is set during commercial negotiations between the developer and The Crown Estate.

5.2.2 Sacrificial Landfill

Operationally, disposal to landfill will be possible. The dredged materials would require landing and drying in specially constructed facilities and would then require transport in sealed HGVs to an appropriate landfill site. There are limited sites available to take the material, and a full analysis of the contaminants in the material would be required by the operators before final acceptance.

Whilst small amounts of dredged material are sometimes disposed of to landfill, it is not common practice and Forth Ports would not have the security of controlling the disposal route. The public and agencies are likely to find this disposal acceptable, but there may be concerns relating to transport and the *National Waste Strategy Scotland (1999)* favours a reduction in the volume of material disposed by landfill.

The requirement for transport will result in some safety and public health risks and interference with legitimate activities and there is low risk of ecological disturbance. There would be an increase in traffic volume due to HGV movements, along with elevated carbon dioxide emissions. The costs of this option would be high due to the requirement for construction of a landing and storage facility, a drying facility and transport costs.

5.2.3 Other Disposal Options and Reuse

Operationally the option to supply the dredged material for other purposes such as brick making would be possible but there would be difficulties associated with the requirement to land, store, dry and transport the material leading to high capital and operational costs. Forth Ports would have limited control over the option and it is not common practice to use marine dredged material for these purposes. It is likely to be viewed as an attractive option by the public and agencies and no legislative issues are anticipated. Environmental and public health and safety concerns associated with this option are linked to transport of the materials, and are anticipated to be minimal. There will be no significant impact on amenity and little interference with other legitimate users other than road users.

The mineralogical composition and salinity of the material limit its suitability for use for brick making, as concrete aggregate or in top soil production as it would require treatment to desalinate and decontaminate the material.

5.2.4 Sea Disposal

Operationally few problems are anticipated with disposal at Narrow Deep and this site is has been historically used for disposal of dredged materials from the Port of Leith. It is anticipated that this option will be acceptable to both public and agencies, with the exception of the FDSFD that is seeking a seasonal restriction in June and July. The assessment presented in Appendix B concludes that there will be no significant impacts on fish and fish passage based on the levels of suspended sediment generated during disposal operations and the intermittent, localised and temporary nature of the effects of dredge spoil disposal, therefore no seasonal restrictions are justified. Forth Ports would have full control over the dredging process through the appointment of contractors and risks to safety and public health are anticipated to be low.

There will be some intermittent, short-term and localised effects on water quality during disposal, such as raised turbidity and suspended sediment levels, which may have short-term and localised ecological effects but these are considered to be not significant. There is unlikely to be interference with other legitimate activities and there is not anticipated to be any impact on local amenity.

5.3 IDENTIFICATION OF THE BPEO

The assessment of options highlights the major operational difficulties associated with the landfill and other use options that primarily relate to lack of available sites and facilities and the nature of the material. There are also major costs associated with the need to construct landing, storage and drying facilities at the Port of Leith.

The proposed disposal of dredged material at sea supports the objectives set out in Scotland's National Marine Plan and will support the planned dredging operations to safeguard the access to the Port of Leith and its navigational safety.

Disposal at sea will keep the dredged material within the ecosystem, maintaining the sediment budget for the area. In line with guidance from Marine Scotland, the Best Practicable Environmental Option is identified as the disposal at a licensed sea disposal site. The preferred site for this is the Narrow Deep licenced spoil site.

Table 5.1 Summary of Assessment of Options

	Coastal Reclamation and Construction Fill	Sacrificial Landfill	Other Uses	Sea Disposal
Operational practicability				
Availability				
Security of option				
Established practice				
General public acceptability				
Agency acceptability				
Legislation				
Safety				
Public health				
Pollution/contamination				
General ecological				
Interference				
Amenity/aesthetic				
Cost				

Key: Performance of Options	
Low	
Low to Medium	
Medium	
Medium to High	
High	

APPENDIX A SEDIMENT SAMPLE CHEMICAL ANALYSIS

A1 PORT OF LEITH SEDIMENT SAMPLE DATA

A1.1 Introduction

The survey plan followed the Marine Scotland guidance and was submitted to Marine Scotland for review and approved on 11 November 2020. Based on the maximum dredge volumes and dredging depths to be applied for and the areas with the docks to be dredged, grab samples from nine stations were required. Sample station locations are presented in *Table A1.1* and shown in *Figure A1.1.*

Table A1.1 Positions of the Port of Leith 2020 Sample Stations

Sample Station	Latitude	Longitude
L1-2020	55°58.897'N	3°9.920'W
L2-2020	55°59.001'N	3°10.192'W
L3-2020	55°58.997'N	3°10.665'W
L4-2020	55°59.157'N	3°10.850'W
L5-2020	55°59.007'N	3°10.985'W
L6-2020	55°59.452'N	3°11.064'W
L7-2020	55°59.784'N	3°11.487'W
L8-2020	55°58.788'N	3°10.285'W
L9-2020	55°58.749'N	3°9.914'W

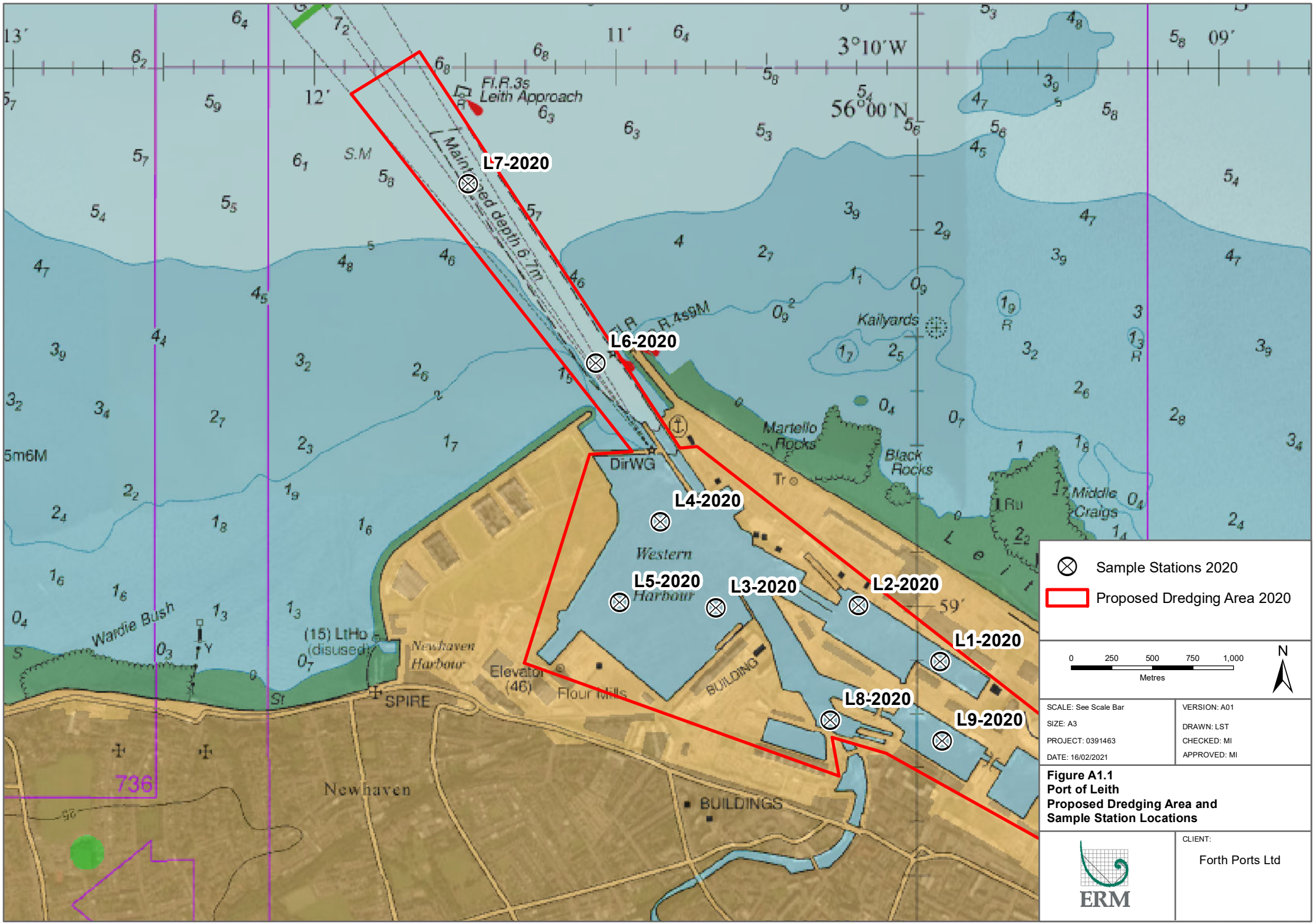
Coordinates in WGS84, UTM Zone 30N, degrees decimal minutes

The grab samples retrieved from each survey station were subsampled on deck and stored in pre-cleaned sample containers provided by SOCOTEC. Each sample was labelled with a unique sample ID and a field log was kept to record the sample location, date and time sample was taken. Samples were kept chilled and sent by overnight courier in coolboxes to the analytical laboratory.

For each of the samples the following chemical analysis was undertaken.

- Metals (As, Cd, Cr, Cu, Hg, Ni, PB, Zn).
- TBT.
- PAHs (US EPA 16).
- Total Hydrocarbon Content.
- PCBs (ICES 7).
- Sediment moisture content and sediment particle density.
- Total Organic Carbon (TOC).
- Sediment particle distribution (PSD).
- Presence of asbestos.

Marine Scotland Action Levels are discussed in Section A1.2 and the sediment sample data are presented in Section A1.3 to Section A1.8.



SCALE: See Scale Bar
SIZE: A3
PROJECT: 0391463
DATE: 16/02/2021

VERSION: A01
DRAWN: LST
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APPROVED: MI

Figure A1.1
Port of Leith
Proposed Dredging Area and Sample Station Locations

CLIENT:
Forth Ports Ltd

ERM

PROJECTION: WGS 1984 Web Mercator Auxiliary Sphere

Path: \\UKLONSV04\Data\Edinburgh\Projects\0391463 Forth Ports 2017 BPEO.MI\Ph8 Leith 2020\GIS\MAPS\FigA1_1_0391463_LTH_DredgeLicenceBoundary_A01_A4.mxd

A1.2 Marine Scotland Action Levels

Table A1.2 and *Table A1.3* set out the Action Levels (AL) for metals, PCBs, TBT and PAHs used by Marine Scotland to assess the suitability for disposal of sediments at sea.

Based on the Marine Scotland guidance, contaminant levels in dredged material below Action Level 1 are generally of low concern and are unlikely to influence the licensing decision. A breach of Action Level 1 does not automatically preclude disposal at sea but usually requires further consideration before a decision can be made. Dredged material with contaminant levels above Action Level 2 is generally considered unsuitable for normal sea disposal, but may be suitable for other management options such as treatment or seabed burial/capping, unless a compelling case can be made for normal sea disposal.

Table A1.2 Marine Scotland Action Levels: Metals

Metal	AL1 (mg kg^{-1} dry weight)	AL2 (mg kg^{-1} dry weight)
Arsenic (As)	20	70
Cadmium (Cd)	0.4	4
Chromium (Cr)	50	370
Copper (Cu)	30	300
Mercury (Hg)	0.25	1.5
Nickel (Ni)	30	150
Lead (Pb)	50	400
Zinc (Zn)	130	600

Table A1.3 Marine Scotland Action Levels: PCBs, TBT and PAHs

Determinand	AL1 (mg kg^{-1} dry weight)	AL2 (mg kg^{-1} dry weight)
ICES 7 PCBs	0.02	0.18
TBT	0.10	0.50
PAHs		
Acenaphthene	0.10	
Acenaphthylene	0.10	
Anthracene	0.10	
Benz[a]anthracene	0.10	
Benzo[a]pyrene	0.10	
Benzofluoranthenes	0.10	
Benzoperylene	0.10	
Chrysene/Triphenylene	0.10	
Dibenz[a,h]anthracene	0.01	
Fluoranthene	0.10	
Fluorene	0.10	
Indenopyrene	0.10	
Naphthalene	0.10	
Phenanthrene	0.10	
Pyrene	0.10	
Total PAHs	100	

A1.3 Metal Results

Concentrations of metals are presented in *Table A1.4*. Levels above Marine Scotland Action Level 1 are highlighted in blue and above Action Level 2 in red (see *Table A1.1* for Action Levels for metals).

Table A1.4 Analysis of Metal Contaminants from the Leith (mg kg^{-1} Dry Weight) 2020

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
L1-2020	12.5	1.86	88.7	167	1.10	66.2	195	372
L2-2020	14.8	1.75	88.0	362	1.31	74.8	152	453
L3-2020	17.2	1.58	72.4	137	1.21	48.7	154	328
L4-2020	15.6	0.84	67.6	150	0.93	43.6	124	297
L5-2020	15.3	0.95	67.5	135	0.96	42.7	123	287
L6-2020	19.6	0.38	62.5	40.2	0.73	36.4	78.2	155
L7-2020	13.8	0.25	58.3	32.1	0.70	32.4	65.6	126
L8-2020	10.5	1.15	52.1	125	0.56	42.2	132	348
L9-2020	13.2	1.35	57.6	154	1.16	45.8	167	395
Mean	14.72	1.12	68.3	144.7	0.96	48.1	132	306
Range	10.5-19.6	0.25-1.86	52.1-88.7	31.1-362	0.56-1.31	32.4-74.8	65.6-195	126-453

As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Hg = Mercury, Ni = Nickel, Pb = Lead and Zn = Zinc.

Table A1.5 provides a comparison of metal data from samples analysed from 1990 to 2020. The ranges in results for all metals over the period for which there is available sample data are large and in the majority of cases most metal concentrations are above Action Level 1 with the mean concentration for Hg being above AL2 in 1990, 2003 and 2004. Mean concentrations of Zn were above Action Level 2 in 1994. Mean concentrations of Pb were above Action Level 1 in 2003 with the upper end of the range being above AL2. Since 2005 all mean concentrations of metals have been below Action Level 2 with the upper end of the range of Cu being above Action Level 2 in 2020.

Table A1.5 Comparison of Metal Concentrations from Leith (mg kg^{-1} Dry Wt) 1990-2000

Year		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
1990	Mean	14.5	1.8	72.5	71.8	1.7	32.7	132.0	219.0
1991	Mean	7.5	1.1	62.3	63.4	1.2	38.7	120.0	178.0
1992	Mean	14.8	0.5	32.1	34.7	1.4	23.6	132.0	94.3
1994	Mean	4.6	0.7	46.9	58.9	1.2	39.9	129.0	687.0
2003	Mean	13.9	1.8	58.4	84.3	1.6	44.1	215.4	280.5
	Range	6.3-17.5	0.0-3.9	14.1-84.3	12.8-121.4	0.2-2.7	13.0-59.3	29.0-787.0	62.6-513.8
2004	Mean	15.5	1.5	67.7	82.9	1.8	46.3	184.8	284.9
	Range	10.9-21.6	0.6-2.3	48.5-77.1	48.4-104.7	1.1-4.4	40.8-52.1	109.5-306.3	173.7-421.2
2005	Mean	14.6	0.6	43.0	52.2	0.8	36.6	92.2	166.7
	Range	11.4-18.4	0.3-0.9	26.4-66.1	32.3-85.9	0.5-1.2	31.9-46.5	62.1-153.4	110.4-252.8
2007	Mean	14.2	0.9	68.3	70.1	0.8	42.7	116.0	207.0
	Range	10.8-16.6	0.3-2.2	55.4-84.1	34.1-144.0	0.5-1.2	33.7-53.7	75.8-163.0	125.0-338.0
2008	Mean	15.1	0.7	75.1	67.1	0.9	43.8	109.6	207.4
	Range	13.0-16.4	0.4-1.1	61.9-83.3	33.8-97.1	0.7-1.1	34.6-51.4	70.1-152.0	125.0-290.0
2017	Mean	16.5	0.99	87.3	126.0	0.8	49.9	113.9	288.1
	Range	14.0-19.3	0.3-2.4	59.9-105.0	26.6-286.0	0.6-1.1	35.9-66.4	65.6-159.0	120.0-528.0
2020	Mean	14.72	1.12	68.3	144.7	0.96	48.1	132	306
	Range	10.5-19.6	0.25-1.86	52.1-88.7	31.1-362	0.56-1.31	32.4-74.8	65.6-195	126-453
1990 - 2020	**Mean**	**13.1**	**1.1**	**61.4**	**71.1**	**1.2**	**39.8**	**134.5**	**261.3**
	Range	**4.6-21.6**	**0.0-3.9**	**14.1-105**	**12.8-362**	**0.2-4.4**	**13.0-74.8**	**29.0-787.0**	**62.6-687.0**

BDL: Below Detection Levels. N/A: Not Applicable. Range data not available from 1990 to 1994.

1.4 Tributyltin

Tributyltin (TBT) is a highly toxic compound historically used as an anti-biofouling agent in paint used to coat the hulls of vessels. It is also toxic to non-target organisms and is linked to immune-suppression and imposex (1) in snails and bivalves. TBT was also used in various industrial processes as a biocide and can enter the marine environmental through effluent discharges. In some cases, TBT can also be persistent in the marine environment.

Mean dry weight concentrations of TBT from the samples collected are presented in *Table A1.6* . Three samples had TBT concentrations above Marine Scotland Action Level 1 (0.1 mg kg^{-1}) and two has concentration above Action Level 2 (0.5 mg kg^{-1}).

Table A1.6 Analysis of TBT from the Port of Leith (mg kg^{-1} Dry Weight)

Station	TBT Concentration
L1-2020	0.388
L2-2020	1.022
L3-2020	0.214
L4-2020	0.119
L5-2020	0.0807
L6-2020	<0.005
L7-2020	<0.005
L8-2020	0.0364
L9-2020	0.591
Mean	**0.274**

Note: DBT was analysed for along with TBT, however there are no Action Levels for DBT. The DBT results are not reported here but have been provided in the Marine Scotland Pre-Disposal Sampling Results Form. To calculate the mean the concentrations below 0.005 mg kg^{-1} were taken as being 0.005 mg kg^{-1}.

A comparison of TBT concentrations from samples collected in 2017 and 2020 (2) are presented in *Table A1.7.* The mean concentrations between the two surveys were similar and above Action Level 1 with some individual samples being above Action Level 2.

Table A1.7 TBT from the Port of Leith in 2017 and 2020 (mg kg^{-1} Dry Weight)

Year		TBT Concentration
2017	Mean	0.221
	Range	0.006-0.716
2020	Mean	0.274
	Range	<0.005-1.022
2017-2020	**Mean**	**0.2475**
	Range	**<0.005-1.022**

(1) The development of male characteristics in females

(2) TBT has only been analysed for in 2017 and 2020

A1.5 Polychlorinated Biphenyls Results

Polychlorinated biphenyls (PCBs) are organic compounds comprising a biphenyl group (composed of two benzene rings) with between one and ten bonded chlorine atoms. PCBs are toxic, persistent pollutants and are readily bioaccumulated in animals.

Although production in the UK ceased in the 1970s, PCBs still enter the marine ecosystem through the disposal of industrial plant, emissions from old electrical equipment and from landfill sites (1).

Dry weight concentrations of ICES 7 PCBs from samples collected in 2020 are presented in *Table A1.8*. Seven of the samples has ICES 7 PCB levels above Action Level 1 (0.02 mg kg^{-1}), none were above Action Level 2 (0.18 mg kg^{-1}).

Table A1.8 Analysis of PCBs (mg kg^{-1} Dry Wt) from the Port of Leith in 2020

Station	Sum of ICES 7 PCB Concentrations
L1-2020	0.07824
L2-2020	0.08953
L3-2020	0.06872
L4-2020	0.05608
L5-2020	0.06087
L6-2020	0.01779
L7-2020	0.01578
L8-2020	0.03836
L9-2020	0.07299
Mean	**0.0537**
Range	**0.01578-0.08953**

ICES 7 PCB congeners (with IUPAC numbers): 28 - 2,4,4' - Trichlorobiphenyl, 52 - 2,2',5,5' - Tetrachlorobiphenyl, 101 - 2, 2', 4, 5, 5' - Pentachlorobiphenyl, 118 - 2, 3', 4, 4', 5 - Pentachlorobiphenyl, 138 - 2, 2', 3, 4, 4', 5' - Hexachlorobiphenyl, 153 - 2, 2', 4, 4', 5, 5' - Hexachlorobiphenyl, 180 - 2, 2', 3, 4, 4', 5, 5' - Heptachlorobiphenyl.

Table A1.9 presents a comparison of mean dry weight concentrations of ICES 7 PCBs from samples collected between 1993 and 2020. Mean concentrations have been similar throughout most of this sampling period, with a peak in the 2003 survey, and all above Action Level 1.

(1) Forth Replacement Crossing: Environmental Statement 2009. Available online from http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j11223-081.htm

Table A1.9 Analysis of PCBs from the Port of Leith (mg kg^{-1} Dry Wt) 1993 – 2020

Year	Mean Sum of ICES 7 PCB Concentrations (rounded to four decimal places)
1993	0.0268
1999	0.0221
2003	0.1597
2004	0.0509
2005	0.0248
2010	0.0296
2017	0.0439
2020	0.0537
Range 1993-2020	**0.0221-0.1597**

ICES 7 PCB congeners (with IUPAC numbers): 28 - 2,4,4' - Trichlorobiphenyl, 52 - 2,2',5,5' - Tetrachlorobiphenyl, 101 - 2, 2', 4, 5, 5' - Pentachlorobiphenyl, 118 - 2, 3', 4, 4', 5 - Pentachlorobiphenyl, 138 - 2, 2', 3, 4, 4', 5' - Hexachlorobiphenyl, 153 - 2, 2', 4, 4', 5, 5' - Hexachlorobiphenyl, 180 - 2, 2', 3, 4, 4', 5, 5' - Heptachlorobiphenyl.

A1.6 Polycyclic Aromatic Hydrocarbons

The analysis undertaken was for the US EPA 16 PAHs which are generally considered to be of environmental concern because of their potential toxicity in humans and other organisms and their prevalence and persistence in the environment.

Concentrations of the EPA16 PAHs are presented in *Table* A1.10. Levels above Marine Scotland Action Level 1 (100 µg kg^{-1}) for individual PAHs are highlighted in blue. Marine Scotland Action Level 1 for Total PAHs is 100 mg kg^{-1}. Station L2-2020, highlighted in blue is above this concentration. There are no Marine Scotland Action Level 2 standards for PAHs.

A comparison of mean dry weight concentrations of PAHs from samples collected between 2003 and 2020 are presented in *Table A1.11* that shows that PAH concentrations of the majority of individual PAHs in most years being above Action Level 1. For most of the individual PAHs, there are higher concentrations in the 2020 samples compared to data from the previous surveys. The reason for this is unknown.

In addition, the total hydrocarbon (THC) concentrations were also analysed and these are presented in *Table A1.10*. There are no Marine Scotland Action Levels for THCs. The dry weight concentration of THCs in the samples ranged from 0.05 to 0.71% which have corresponding wet weights of 0.022 to 0.33%. These wet weights are below the ecotoxic threshold (1%) based on the UK country agency guidance (1), although concentrations above 0.1% may be classified as harmful. It is noted that the guidance is related to Total Petroleum Hydrocarbons (TPH) and not Total Hydrocarbons (THC).

(1) NRW, SEPA, NIA, EA. 2015. Guidance on the Classification and Assessment of Waste. Technical guidance WM3. LIT 10121. Updated January 2021.

Table A1.10 Analysis of PAHs and THC from the Port of Leith (Dry Weight) 2020

PAH	Sample Station								
	L1-2020	L2-2020	L3-2020	L4-2020	L5-2020	L6-2020	L7-2020	L8-2020	L9-2020
LMW (µg kg^{-1})									
Acenaphthene	152	3,810	126	98.9	83.9	131	41.7	101	161
Acenaphthylene	90.7	130	91.3	75.4	62.8	60.3	37.0	63.5	139
Anthracene	502	22,300	516	373	304	514	183	256	566
Fluorene	251	4,850	197	170	132	168	81.1	154	270
Naphthalene	1,190	63,800	1,200	865	753	1,310	429	622	1,360
Phenanthrene	152	3,810	126	98.9	83.9	131	41.7	101	161
HMW (µg kg^{-1})									
Benzo(a)anthracene	1,060	23,100	1,130	897	896	1,050	326	864	1,530
Benzo(a)pyrene	1,530	14,500	1,640	1,250	1,120	1,140	380	1,180	2,540
Benzo(b)fluoranthene	1,700	17,000	1,640	1,370	1,180	1,110	417	1,280	2,770
Benzo(ghi)perylene	1,270	6,500	1,210	1,070	895	873	356	1,060	2,180
Benzo(k)fluoranthene	691	9,550	647	513	518	379	201	560	877
Chrysene	1,200	22,400	1,270	1,010	998	1,070	341	992	1,860
Dibenzo(ah)anthracene	241	1,490	255	215	185	179	66.8	205	445
Fluoranthene	1,930	81,000	2,150	1,650	1,710	2,230	573	1,690	2,840
Indeno(1,2,3-c,d)pyrene	1,120	7,480	1,140	996	852	841	306	1,010	2,100
Pyrene	689	1,660	325	303	235	294	172	162	506
Sum EPA 16 PAH (mg kg^{-1})	16.327	336.67	16.487	12.866	11.865	13.559	4.589	11.980	24.124
Total Hydrocarbons THC (mg kg^{-1})	7,090	3,400	2,120	1,870	2,210	1,190	511	2,840	5,100

LMW = Low Molecular Weight. HML = High Molecular Weight

Table A1.11 Comparison of PAHs from the Port of Leith 2003 to 2020 (mg kg^{-1} Dry Weight)

Year	2003	2004	2005	2007	2010	2017	2020
PAH	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
LMW							
Acenaphthene	ND	ND	ND	ND	ND	0.1107	0.5228
Acenaphthylene	ND	ND	ND	ND	ND	0.0136	0.0833
Anthracene	0.6428	0.7257	0.3255	0.1460	0.1972	0.2657	2.8349
Fluorene	0.3573	0.2955	0.1362	0.0624	0.0815	0.1293	0.6970
Naphthalene	0.4712	0.4417	0.2633	0.1525	0.1484	0.2701	0.4829
Phenanthrene	1.6884	1.7375	0.9237	0.4145	0.5803	0.6069	7.9477
HMW							
Benzo(*a*)anthracene	1.3570	1.7614	0.8292	0.3534	0.4701	0.5804	3.4281
Benzo(*a*)pyrene	1.5604	1.1439	0.7757	0.4083	0.4789	0.6704	2.8089
Benzo fluoranthenes	3.9748	3.2114	1.7999	ND	1.1354	1.3444	4.7114
Benzo(ghi)perylene	1.7876	1.1287	0.576	0.3056	0.3594	0.6564	1.7127
Chrysene/Triphenylene	1.7212	1.6775	0.9561	0.3805	0.4892	0.6177	3.4601
Dibenz(*a,h* anthracene	ND	ND	ND	ND	ND	0.1347	0.3646
Fluoranthene	2.6727	3.0867	1.5324	0.6947	0.9368	1.0301	10.6414
Indeno(1,2,3-c,d)pyrene	1.4114	1.392	0.5187	0.3414	0.3647	0.5570	1.7606
Pyrene	3.0382	2.237	1.7501	0.7388	0.9702	1.1586	8.3731

Action Level 1 is 0.1 mg kg^{-1}

BDL = Below Detection Level

LMW = Low Molecular Weight. HMW = High Molecular Weight

Note only those 15 PAHs for which there are historic data are reported. Benzo fluoranthenes are the sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene

A1.7 Asbestos

No asbestos was reported from any of the samples.

A1.8 Sediment Physical Properties

The physical properties of the dredge sediment was analysed on the 9 sediment samples taken from the Port of Leith in 2020. Sediments were predominantly poorly and very poorly sorted sandy silt (varying from very coarse to medium silt).

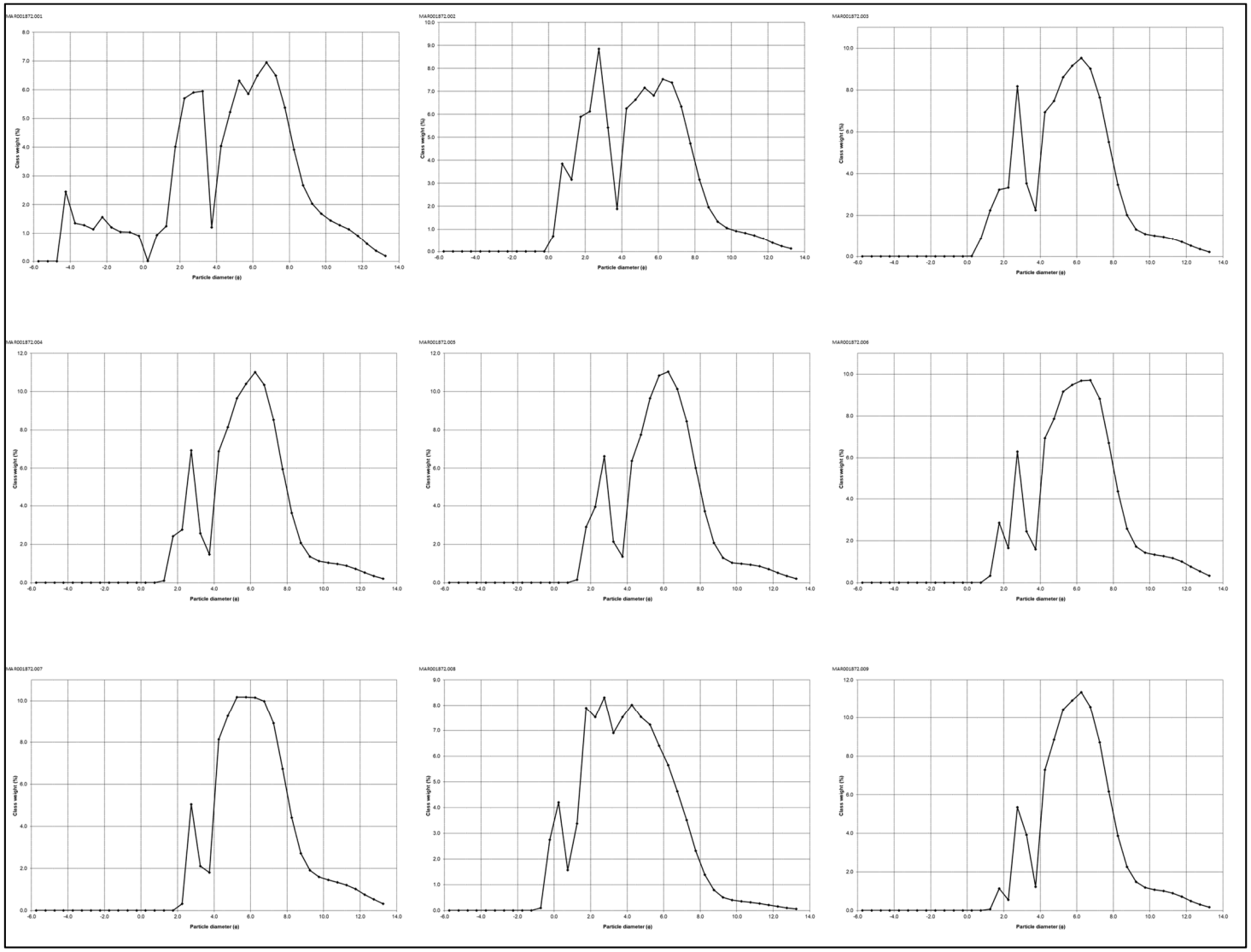
- Gravel is defined as >2 mm,
- Sand is defined as >63 µm<2 mm, and
- Mud (silts and clays) is defined as <63 µm.

Table A1.12 and *Figure A1.2* present the 2020 data. The sediment particle sizes in the sample stations were variable but most comprised more than 50% of silts and clays. Station L8-2020 was muddy sand and only station L1-2020 had a gravel fraction (10%). Stations L2-2020 and L8-2020 had the highest organic carbon content (approximately 9%).

Table A1.12 Port of Leith 2020 Sediment Data Summary

Parameter	Sample Station								
	L1-2020	L2-2020	L3-2020	L4-2020	L5-2020	L6-2020	L7-2020	L8-2020	L9-2020
Textural Group Classification	Gravelly Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Mud	Muddy Sand	Sandy Mud
Folk and Ward Description	Coarse Silt	Very Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Medium Silt	Medium Silt	Very Coarse Silt	Medium Silt
Folk and Ward Sorting	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Poorly Sorted
Mean µm	30.67	32.8	23.35	17.10	18.57	14.90	13.24	60.11	15.39
Mean phi	5.027	4.930	5.421	5.869	5.751	6.068	6.239	4.056	6.022
Sorting Coefficient	3.602	2.598	2.422	2.081	2.179	2.224	2.092	2.323	1.956
Skewness	-0.188	-0.023	-0.065	0.004	-0.048	0.056	0.119	0.032	0.050
Kurtosis	1.178	0.854	1.122	1.209	1.226	1.218	1.236	0.943	1.216
Gravel (%)	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sand (%)	26.9	35.9	23.6	16.2	17.1	15.1	9.3	50.1	12.2
Mud (silts and clays) (%)	63.1	64.1	76.4	83.8	82.9	84.9	90.7	49.9	87.8
Total Organic Carbon (%)	6.32	9.07	5.15	6.58	5.90	5.49	3.60	8.76	5.25
Solids (%) @120°C	46.7	39.1	36.2	28.2	29.7	32.7	43.6	22.8	27.5
Density (mg m^{-3})	2.49	2.53	2.54	2.54	2.54	2.56	2.56	2.41	2.54

Table A1.13 Port of Leith 2020 Sediment PSA (L1 to L9 from top left)



A2 SPOIL GROUND SEDIMENT SAMPLE DATA

Table A1.14 presents metal and PCB concentration data from sediment sampled from spoil ground sites within the Firth of Forth and Forth Estuary. Levels above Marine Scotland Action Level 1 for metals and PCBs are highlighted in blue. Monitoring of spoil grounds is not mandatory therefore, the data presented in *Table A1.14* are the most recent data available. The metal and PCB data indicate that concentrations within sediment samples from the Narrow Deep spoil ground are comparable with those from other Firth of Forth spoil grounds sampled. Concentrations of metals and PCBs in the samples from the Narrow Deep site are lower than the material dredged from Leith (refer to *Tables A1.3* to *A1.7*), which would be expected from a dispersive spoil ground such as Narrow Deep.

Table A1.14 Concentration of Metals and PCBs (mg kg^{-1}) from Forth Spoil Grounds

Site Name/Date	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Sum ICES 7 PCBs
Narrow Deep 2011	9.5	0.2	42.9	21.6	0.49	22.9	53.4	109.4	0.008 (n=3)
(n=6)									
Narrow Deep 2015	11.7	0.2	63.8	24.6	0.6	30.0	58.4	105.9	0.03 (n=3)
(n=4)									
Oxcars 2011	11.2	0.1	42.5	22.2	0.6	22.3	153.5	92.2	0.007 (2007, n=6)
(n=6)									
Oxcars 2015	15.7	0.3	79.6	41.6	1.0	35.8	78.1	141.7	0.008
(n=3)									
Methil 1993	8.2	0.2	9.8	10.7	0.1	19.2	10.5	51.0	
(n=1)									
Methil 2011	6.9	0.07	13.7	7.14	0.07	8.97	20.2	39.8	0.0004 (n=3)
(n=3)									
Methil 2015	8.7	0.1	18.0	9.6	BDL	11.2	14.5	72.8	0.003 (n=1)
(n=1)									
Kirkcaldy 2011	6.24	0.1	21.9	16.2	0.14	16.4	21.7	45.9	-
N=3									
Kirkcaldy 2015	8.9	0.1	43.1	17.0	0.2	22.0	30.6	62.9	0.0025 (n=3)
(n=3)									
Blae Rock 2007	13.4	BDL	59.7	32.4	0.8	28.2	63.9	108.6	0.008 (n=5)
n=3)									
Blae Rock 2011	17.2	0.1	39.6	21.9	0.5	21.4	52.1	80.3	0.01 (n=2)
(n=6)									
Bo'ness 2011	14.5	0.1	50.8	23.3	0.8	23.6	56.9	95.7	0.005 (n=3)
(n=7)									
Bo'ness 2015	18.6	0.1	59.6	26.5	0.7	27.5	54.2	114.0	0.004 (n=3)
(n=5)									

* Data provided by Marine Scotland (2019)

Key: n = the number of samples analysed (where known)

APPENDIX B ENVIRONMENTAL IMPACTS OF DISPOSAL OPERATIONS

B1 INTRODUCTION

This Appendix addresses the environmental impacts of the disposal of dredged material from the planned maintenance dredging work at the Port of Leith at the licenced Narrow Deep licenced spoil ground within the Firth of Forth. Impacts on water quality, sediment quality, and habitats and species are considered. *Table B1.1* presents the impact summary.

Typically, dredging and disposal takes place over a period of approximately 8 days per annum with the scheduling of the dredging and disposal operations will depend on operational requirements. The cycle time from dredging to disposal and back to the dredging site is approximately 2 hours, subject to timing of the locks. Potential impacts on general vessel movements and fishing due to the disposal operations are not considered to be significant as commercial traffic in the main channel is controlled by Forth Ports' standard operating procedures.

As the Marine Licence application is for disposal of the dredged material, impacts of the dredging activities are not addressed, other than in the context of Bathing Waters and cumulative impacts from existing and proposed dredging and disposal activities, and other activities and developments.

B2 DISPOSAL IMPACTS

The identification and assessment of environmental impacts of the disposal of dredged material in this Appendix follows the Clearing the Waters for All guidance (1).

As described in *Section 1.4* it is proposed that up to 100,000 m^3 (comprising approximately 15,000 m^3 water and 85,000 m^3 solids) of material to be dredged from the Port of Leith per annum.

The material to be disposed consists primarily of mud and sandy mud with some gravel fractions. The concentrations of contaminants are presented in *Appendix A*. Samples were taken at 9 stations (L1-2020 to L9-2020) and the results are summarised here.

- The mean concentrations of all metals, except for arsenic, were above Action Level 1 but below Action Level 2. The concertation of copper at one station (L2-2020) was above Action Level 2.
- The mean concentration of TBT was above Action Level 1 but below Action Level 2. Concentrations at two stations (L2-2020 and L9-2020) were above Action Level 2.
- The mean concentration of PCBs (sum of ICES 7 PCBs) was above Action Level 1 but below Action Level 2. Concentrations in seven of the nine samples stations were above Action Level 1.
- The sum of the EPA 16 PAHs were below Action Level 1 for all stations except L2-2020. For individual PAHs, the majority were above Action Level 1 and all below Action Level 2.
- No asbestos was recorded.

Available metal and PCB concentration data from sediments sampled in the Narrow Deep spoil ground are presented in *Appendix A*. This shows the concentration of some metals in the sediment were above Action Level 1 but below Action Level 2, which is similar to other spoil grounds within the Firth of Forth and Forth Estuary.

B2.1 Impacts on Water and Sediment Quality

Coastal water quality in the Firth of Forth is currently Good in the outer Firth, with the exception of the area around Portobello and Musselburgh, which is classified as Poor. It is classified as Good in the lower estuary to Muirhouses and Moderate upstream in the estuary to Kincardine bridge (2).

(1)Best, M (2016). Clearing the Waters for All: WFD guidance for developers and regulators in estuarine and coastal waters. Environment Agency.
(2)Water Framework Directive (WFD) Waterbody Classification 2007-2017 (SEPA)
https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=1110. Consulted 8 February 2020.

The salinity in the Firth of Forth averages 33‰, decreasing into the Forth Estuary under the influence of freshwater inputs. Suspended solids levels in the inner Firth of Forth are usually low compared to levels in the upper estuary (1). In the Firth of Forth, dissolved oxygen concentrations show little variation with depth and are approximately 90-95%, but may be lower during periods of high summer water temperatures (2).

There are no designated bathing waters with 2 km of the dredging or disposal sites. The nearest is Portobello West on the south coast of the Firth of Forth which is approximately 5 km from the dredging and disposal sites.

The material disposed at Narrow Deep will fall to the sea bed by gravity and consists of cohesive lumps of dredged material. Fine sediment will be liberated as it sloughs off the descending material and when the clumps reach the seabed. Field measurements of suspended solids in surface waters following similar disposal operations indicate that less than 5% of the discharged material escapes the descending density jet (3).

There are no data available that indicate the concentration or dispersion of suspended solids from the disposal operations at Narrow Deep. Data available from Middle Bank in the Firth of Forth (approximately 2.1 nm north-west of Narrow Deep) during dredging operations in 2008 (4) recorded the baseline mean suspended solids concentrations between 8.87 mg l^{-1} and 10.3 mg l^{-1} (mean 9.1 mg l^{-1}). Comparison of these mean baseline suspended solids concentrations with those recorded during dredging activities at Middle Bank indicated peak increases were approximately two and half times above background levels (1). These increases were short-lived and dissipated with the outgoing tide. Significant increases in suspended sediments associated with the disposal operations are therefore likely to be confined to the immediate area of the spoil ground and for a short period.

Similar studies were undertaken for the Forth Replacement Crossing (Transport Scotland 2009)(5) which showed that increases in suspended sediment concentrations from dredging works were short-lived and localised.

The natural levels of suspended sediments in the Firth of Forth vary with seasonal weather conditions and this contributes to the natural sedimentation in the Firth of Forth which aids the removal of contaminants from the water column and incorporates them in the seabed sediments.

Increased nutrient levels may stimulate local algal production, although the effects are predicted to be short-term and confined to the immediate area of the disposal operations. Nitrogen is generally regarded to be the limiting nutrient in estuarine and marine systems and in its reduced form (ammoniacal nitrogen) is also toxic to fish. As a consequence of the reduced (oxygen demanding) nature of the seabed sediments, nitrogenous nutrients are likely to be in this form.

The oxidation of anoxic sediments released into the water column has been shown to reduce oxygen concentrations by up to 58% (6). Based on the background levels this may reduce the oxygen saturation to between 40 and 50% (equating to approximately 4 to 5 mg l^{-1}). Therefore, if the disposal operations occurred during a period of 'naturally' low dissolved oxygen it is possible that the water quality standards of oxygen concentration greater than 6 mg l^{-1} would not be met (7). It is predicted that this would be short-lived, due to the limited period over which disposal is intended to occur, and localised based on previous dredge plume studies. The impacts are not considered to be significant given the generally high dissolved oxygen levels anticipated at the spoil ground and the extent of the area potentially affected.

(1) SEPA monitoring buoy data from Gunnet Ledge, Firth of Forth, available online from http://www.sepa.org.uk/environment/environmental-data/monitoring-buoys-network/gunnet-ledge/
(2) SEPA (1998). Winter Nutrient Distribution in the Firth of Forth, 1987 - 1997. Report TW 01/98, January 1998.
(3) Kennish M.J. 1992. Ecology of Estuaries Anthropogenic Effects Dredging and Dredged Spoil Disposal p357-397
(4) ERM, 2008. Middle Bank Aggregate Production Licence: Monitoring Report. A report for Westminster Gravels Ltd.
(5) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.
(6) Brown C. 1968. Observations on Dredging and Dissolved Oxygen in a Tidal Waterway. Water Resources Research Vol 4, No 6, p1381.
(7) UKTAG 2010. Water Framework Directive: An approach to the Revoked Directives:- the Freshwater Fish Directive, the Shellfish Directive and the Dangerous Substances Directive. Available online from: http://www.wfduk.org/resources%20/approach-revoked-directives-%E2%80%93-freshwater-fish-directive-shellfish-directive-and-dangeroussubstances Directive

Although there may be some release of contaminants such as metals, TBT, PCBs and PAHs into the water column during disposal operations the majority of the dredged material will descend to the seabed rapidly. Sediment bound contaminants liberated during the disposal operations will quickly become complexed with particulate matter in the water column and be re-deposited on the sea bed. Previous studies have shown that metal concentrations in the water column remained consistent following sediment disposal (1).

The PAHs in the sediment samples comprised both low molecular weight (LMW) (two and three benzene rings) and high molecular weight (HMW) (more than 3 benzene rings) compounds. The individual PAHs that were in concentrations above Action Level 1 had both LMW and HMW PAHs. PAHs tend not to be volatile and are poorly soluble and therefore readily absorb onto particulate matter in the water column and are incorporated into marine sediments. The HMW PAHs are generally the less water soluble, less acutely toxic and slower to biodegrade (*i.e.* more persistent).

The ratios of individual PAHs have been used to determine the likely anthropogenic source of PAHs in the environment: *e.g.* from combustion sources (pyrolytic) or petroleum hydrocarbons (petrogenic). Petrogenic PAHs are often characterised by phenanthrene to anthracene (Ph/An) values >10, whereas pyrolytic PAH from combustion processes are characterised by Ph/An ratios <10. The ratio of and fluoranthene to pyrene (Fl/Py) greater than 1 generally come from pyrolytic sources while ratios of less than 1 generally indicate petrogenic sources (1). For all the sediment samples analysed from the Port of Leith in 2020 the Ph/An ratios were between 2.32 and 2.86 and the Fl/Py ratios were between 0.71 and 1.42. This suggests that these contaminants are from both combustion and petroleum hydrocarbon sources and are similar to the results from the 2017 sample analysis. This pattern has been identified in other ports in the Firth of Forth and Forth Estuary indicating that these sources of PAHs are in the sediments from the wider Forth Estuary and Firth of Forth sediment circulation system.

There was a large reduction in point source discharges of metals and hydrocarbons within the Forth Estuary and the Firth of Forth between the mid-1980s and 1990s (2). Reduction and improved regulation of point source discharges has improved many aspects of the Forth system: inputs of organic material have declined and there has been an associated rise in dissolved oxygen during summer in the upper Forth Estuary. The rise in dissolved oxygen has led to increasing numbers of smelt caught in the upper estuary and to increasing inputs of nitrate generated by nitrification in the suspended sediment maxima of the estuary during summer. In winter, conservative mixing of nutrients is seen and there has been little change in winter nutrient concentrations in the Forth Estuary and Firth of Forth. Metal and trace organic inputs have been reduced so that aqueous concentrations have fallen rapidly (3). With efforts focussed on improving the water quality of the Firth of Forth in more recent years, point source discharges have continued to decrease and the water quality of the Firth of Forth has continued to improve as a result (4).

It is therefore not anticipated that the disposal operation at Narrow Deep will introduce significant amounts of contamination into the water column. Disposal of the dredged material may result in a localised and short term increase in the levels of some contaminants; however, the deposited sediment will disperse over time. Considering the short term, localised and intermittent increase in the levels of some contaminants in the water column will not affect the overall water body quality statuses of the Firth of Forth.

(1)Y.W. Qiu, G. Zhang, G.Q. Liu, L.L. Guo, X.D. Li, O. Wai. Polycyclic aromatic hydrocarbons (PAHs) in the water column and sediment core of Deep Bay, South China. Estuar. Coast. Shelf Sci., 83 (1) (2009), pp. 60-66.
(2) SEPA, 1998. Trace Metals in the Forth 1986 - 1996. Available online from
http://www.sepa.org.uk/science_and_research/data_and_reports/water/forth_estuary_trace_metals.aspx
(3) Dobson, J., Edwards, A., Hill, A. et al. Senckenbergiana maritima (2001) 31: 187. https://doi.org/10.1007/BF03043028
(4) SEPA, 2014. Scottish bathing waters 2013-2014. Available online http://www.sepa.org.uk/media/39125/scottish-bathing-waters-report-2013-2014.pdf

B2.2 Impacts on Benthic Ecology

The benthic macrofaunal communities recorded in proximity to Narrow Deep spoil ground are expected to be typical for estuarine conditions and not considered to be of high conservation significance due to the wide distribution, low diversity and lack of any rare or notable species (1).

The impact on benthic communities will depend on the comparative rates of natural deposition (currently unknown) and the deposition due to the dredging disposal operations. It is anticipated that the deposition of dredged material at the Narrow Deep spoil ground will result in the loss (burial) of the benthos within and in the immediate vicinity of the 'deposition zone' within the spoil ground. Localised impoverishment of the fauna (in terms of abundance and diversity) is likely along the axis of tidal flow as a result of secondary impacts comprising sediment deposition subsequent to the disposal activities. There is an existing licenced spoil ground therefore the benthic communities in this area will have been impacted by the ongoing spoil deposition activities that have occurred there over the last 20 years.

Given the relatively homogenous nature of benthic communities in this part of the Firth of Forth and the availability of similar habitat within the Firth of Forth, the spatial extent of predicted sediment related impacts to benthos (and resultant impact on prey availability for foraging seabirds) are not considered to be significant.

B2.3 Impacts on Seabirds

The Firth of Forth Special Protection Area (SPA), Forth Islands SPA, Imperial Dock SPA and the Outer Firth of Forth and St Andrews Bay Complex SPA are designated (2) for rare, vulnerable and regularly occurring migratory bird species.

There are three potential effects of the disposal of dredge material at sea on seabirds; increased suspended solids, release of contaminated particulates and physical disturbance of birds by the dredging vessel. These effects could potentially have a significant effect on the qualifying interests of the SPAs by reducing prey availability and disturbing bird behaviour and breeding patterns.

The vessel used for disposal of the material will be travelling to and from the Port of Leith and the disposal site for up to eight days per annum, a round trip of approximately 5 nautical miles (nm).

The SPAs support breeding seabirds which forage over a wide area. The disposal of the dredged material will result in localised increases in suspended sediment which may reduce the ability of fish eating birds to forage around the spoil ground due to impaired visibility. However the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by.

The results of sediment dispersion studies undertaken by HR Wallingford (3) for aggregate extraction activities on Middle Bank (approximately 2.1 nm north-west of Narrow Deep) involving the disposal of 68,000 m^3 sediment overburden (estimated 40% silt, 60% sand content) at the Narrow Deep spoil ground indicated that the maximum levels of dispersion were achieved with disposal during spring tides. The study showed that at peak tidal velocity the plume would extend 7 km west and 5 km northeast of the spoil ground, *i.e.* along the axis of tidal flow with very little movement to the north or south and therefore not impacting coastal or intertidal areas within the SPAs(4).

It is noted that Narrow Deep is an established and long term spoil ground with disposal activities being ongoing at the time that the SPAs were designated. Given that disposal was an existing activity and ongoing disposal is at a similar scale to previous disposal activities, it is considered that the proposals will not have significant effects on the qualifying interest of the SPAs.

(1) Elliot M & Kingston P F (1987). The Sublittoral Benthic Fauna of the Estuary and Firth of Forth, Scotland. Proceedings of the Royal Society of Edinburgh, 93B, pp 449-465
(2) The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019.
(3) HR Wallingford Ltd, 1998. Middle Bank Aggregate Dredging - Dispersion Studies. Report EX 3874.
(4) ERM, 1998. Aggregate Production Licence Application, Middle Bank, Firth of Forth: Environmental Statement. Report to Westminster Gravels Ltd.

B2.4 Impacts on Fish and Marine Mammals

The River Teith Special Conservation Area (SAC), the Isle of May SAC and the Moray Firth SAC are designated (1) for their habitats and fish and mammals species of European importance.

Atlantic salmon, river lamprey and sea lamprey inhabit and migrate up and down the Firth of Forth and Forth Estuary to reach spawning grounds in the River Teith SAC and may therefore pass the Narrow Deep spoil ground. The Forth District Salmon Fishery Board has previously advised that smolts are likely to be passing through the lower Forth Estuary and Firth of Forth during June and July. The river lamprey grows to maturity in estuarine environments and between October and December moves into fresh water to spawn in clean rivers and streams. The sea lamprey spends most of its life at sea, only returning to freshwater to spawn around April and May.

A potential effect of disposal at sea is for increased levels of suspended solids to disturb fish migration routes and areas they occupy. The proposals are not likely to have a significant effect on fish for the following reasons.

- The concentration of suspended sediment at which the passage of salmonid fish is affected has been observed to be approximately 500 mg l^{-1} (2). Studies in the US, looking at a variety of salmonid species, illustrates that fatalities to smolts (50%) can occur at high suspended sediment concentrations over extended periods (*e.g.* exposure of between 488 to 19,364 mg l^{-1} for 96 hrs) (3). The natural suspended sediment maxima in the Forth Estuary is in the upper estuary with mean concentrations over ten times higher than in the Firth of Forth (130 mg l^{-1} at Kincardine (4) and approximately 10 mg l^{-1} ambient levels recorded during the Middle Bank dredging and disposal operations in the Firth of Forth) (5).
- The disposal activities will take place within the Firth of Forth which represents a small area where sea lamprey and salmon smolts may be present or may pass through. It is noted that the width of the Firth of Forth at the Narrow Deep spoil ground is approximately 9.6 km (5.2 nm) wide. The fish species will be able to avoid the area during the short periods of raised suspended sediment during disposal and migrate using an alternative route through the Firth of Forth and therefore short term and intermittent disposal operations are not considered to present a significant barrier to migration. .

A localised, short-term and non-continuous increase in suspended sediment concentration affecting a small proportion of the width of the Firth of Forth is not anticipated to affect the migration of adult salmon, smolts or other fish species, based on the evidence of studies on the effects of suspended sediments on salmonids and the predicted suspended sediments concentrations resulting from the disposal operations. It has been reported that Atlantic salmon numbers have been decreasing in Scotland and farther afield over the last ten years (6). Forth Ports' dredge spoil disposal operations have been ongoing at Narrow Deep for over twenty years covering the periods of much higher salmon numbers indicating that there is no causal link between the ongoing spoil disposal activities and a broad scale decline in salmon numbers. Seasonal restrictions to operational requirements to dispose of dredged material from Leith at Narrow Deep are therefore not considered to be justified.

The Isle of May SAC, in the outer Firth of Forth, is designated for its populations of grey seal. Grey seals forage widely and may forage at the Narrow Deep spoil ground. Potential effects on grey seals resulting from the disposal activities are disturbance and noise due to vessel movements and disposal

(1) The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019.
(2) Redding M.J. and Schreck C.B. 1987, Physiological effects on coho salmon and steelhead of exposure to suspended solids, Transactions of the American Fisheries Society, Vol 116 pp737-747
(3) Bash J, Berman, C and Bolton S. 2001. Effects of Turbidity and Suspended Solids On Salmonids. Prepared for Washington State Transportation Commission, Department of Transportation and U.S. Department of Transportation, Federal Highway Administration
(4) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.
(5) ERM, 1998. Aggregate Production Licence Application, Middle Bank, Firth of Forth: Environmental Statement. Report to Westminster Gravels Ltd.
(6) https://www.britishecologicalsociety.org/understanding-decline-atlantic-salmon-catches-scotland/#:~:text=The%20Scottish%20Government%20has%20collected,the%20previous%205%2Dyear%20average.

activities and displacement of prey species as a result of increased levels of suspended sediment at the spoil ground.

The proposals are not likely to have a significant effect on grey seals for the following reasons.

- The small potential foraging area affected by disposal activities at the Narrow Deep spoil ground in relation to the available foraging area in the Firth of Forth.
- The intermittent and short duration of disposal activities (typically up to eight days a year).
- The small number of vessel movements associated with the disposal activities in relation to total vessel movements within the Firth of Forth.
- The long term existing disposal operations in the area which pre-date the site designation.

Bottlenose dolphins are a Habitats Directive Annex II species and are resident in the Moray Firth SAC. They are infrequent summer visitors to the Firth of Forth, mainly between June and September (1).

Vessel movements and noise have the potential to disturb or displace marine mammals and disposal activities have the potential to displace prey species within and in the vicinity of the spoil ground. The proposals are not likely to have a significant effect on bottlenose dolphins for the following reasons.

- The distance between the spoil ground and the SAC is large and the proportion of the bottlenose dolphin population anticipated to pass through the small area affected by disposal activities is anticipated to be low.
- The intermittent and short duration of disposal activities (typically up to eight days a year).
- The small number of vessel movements associated with the disposal activities in relation to total vessel movements within the Firth of Forth.
- The relatively low speed and direct line of travel of dredge vessel movements to and from the spoil disposal site (*i.e.* no fast moving and erratic vessel movements).
- The long term existing disposal operations in the area which pre-date the site designation.

B2.5 Summary of Impacts

Table B1.15 presents a summary of the impacts and an assessment of significance of the impacts in relation to the sensitivity/importance of the receiving site.

(1) Evans P. G. H. Chapter 5.15 Whales, Dolphins and Porpoises. In Coasts and Areas of the United Kingdom. Region 4 South- east Scotland: Montrose to Eyemouth, ed by J H Barne, C F Robson, S S Kaznowska, J P Doody, N C Davidson and A L Buck, pp 129-132. JNCC (Coastal Directories Series).

Table B1.15 Summary of Significance of Impacts

Receptor	Impact Significance Justification	Impact Significance
Water quality at spoil ground	Disposal will be periodic and sediment will descend to the seabed rapidly. Any impacts will be localised and short-lived.	Not Significant
Sediment quality at spoil ground	Increase in the levels of some contaminants will be localised and short-term and the deposited sediment will disperse within the open water system over time.	Not Significant
Benthic ecology at spoil ground	Narrow Deep is designated as a spoil ground and disposal operations have taken place there for over 20 years. Disposal will occur over a relatively short period of time and similar habitat is available in close proximity to the site.	Not Significant
Seabirds	Proposed disposal operations are over a relatively short period of time each month and the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by. The volume of dredger vessel traffic will not be significant in relation to the existing traffic in the Firth of Forth and Forth Estuary. The SPAs were designated after the Narrow Deep spoil site was designated, and have not been impacted by historic and ongoing disposal operations.	Not Significant
Marine mammals and fish	Proposed disposal operations are over a short period of time and the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by. The volume of dredger vessel traffic will not be significant in relation to the existing traffic in the Firth of Forth and Forth Estuary. The SACs were designated after the Narrow Deep spoil site was designated, and have not been impacted by historic and ongoing disposal operations.	Not Significant

B3 Cumulative Effects within the Firth of Forth

B3.1 Introduction

The potential impacts of the sea disposal option have been assessed within *Section B1.2* in isolation from other activities within the Firth of Forth. The impacts associated with the sea disposal option are not predicted to result in adverse effects on the integrity of the SPAs and SACs, however, it is possible that cumulative impacts with other projects could result in significant impacts.

For the purposes of this report, a working definition of cumulative impacts as ‘impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions, together with the project [(1)] has been adopted. The assessment of potential cumulative impacts has been restricted to activities and proposed activities with the potential to directly impact the water and / or sediment quality or cause disturbance to the qualifying interests of the SPAs and SACs.

(1) European Union. Guidelines for the Assessment of Indirect and Cumulative Impacts, as well as Impact Interactions, DG XI Brussels Downloaded from http://ec.europa.eu/environment/eia/eia-support.htm

B3.2 Past and Current Activities within the Firth of Forth and Forth Estuary

B3.2.1 Introduction

The Firth of Forth and Forth Estuary has previously experienced pollution from a number of industrial sources and sewage discharges, such as the petro-chemical operations at Grangemouth and the sewage works at Seafield. The Imperial Chemical Industries (ICI) chemical plant previously based in Grangemouth is also known to have been a source of mercury into the Forth Estuary. Over the past 35 years, however, most of these pollution sources have been controlled or eliminated altogether.

Additional improvements to sewage works and other effluent treatment plants upstream have improved the condition of the water coming down the estuary.

In addition there are unknown and diffuse sources of discharges into the Forth Estuary, Firth of Forth and riverine inputs to these areas, for example from agricultural run-off and unrecorded drainage outfalls.

Petro-Chemicals and Power Generation

The INEOS refinery and wider petro-chemical complex at Grangemouth are historically a dominant source of oil related PAHs in the Forth Estuary and the Firth of Forth.

The Longannet coal-fired power station on the north bank of the estuary closed in March 2016. The historic release of combustion related PAHs from this source will have contributed to the PAH loading within the Forth Estuary and Firth of Forth (1). Water from the Firth of Forth was abstracted and used as cooling water by the power station before being discharged back into the Firth of Forth.

Cockenzie power station was a coal-fired power station located on the southern shore of the Firth of Forth near to Cockenzie and Port Seaton. It generated electricity between 1967 and 2013, with demolition of the station completed in 2015. Water was abstracted from the Firth of Forth in the same way it was for Longannet.

Methil power station was a small base load coal slurry-fired power station, located on the south side of the mouth of the River Leven, where the river enters the Firth of Forth at Methil. The power station started operations in 1965 and was decommissioned in 2000, finally being demolished in 2011. As with Cockenzie power station, Methil abstracted water from and discharged water to the Firth of Forth for use as cooling water.

B3.2.2 Commercial Fishing Activity

The sandeel fishery on the Wee Bankie, at the mouth of the Firth of Forth, has been closed since 2000 on seabird conservation grounds. The initial five year period was reviewed and extended following the reduction in numbers of some seabird species observed during a 2004 count (reduced sandeel numbers may be linked) within the Firth of Forth (2).

Improved water quality in the Firth of Forth has led to a resumption of cockle fishing, particularly on the Fife coast. Uncontrolled cockling could impact upon wintering bird populations by causing loss of prey species, directly (removal of cockles) and indirectly (damage to non-target species). A Special Nature Conservation Order (SNCO) was implemented under the *Conservation (Natural Habitats) Regulations 1994* to the outer Firth of Forth, including Forth Bridge to Granton Harbour and from Leith Docks to Joppa. This Order, implemented in March 2003, was revoked and reissued in 2006, and still stands (3).

(1) Richardson D.M., Davies I.M., Moffat C.F., Pollard P. and Stagg R.M. 2001. Biliary PAH metabolites and EROD activity in flounder (*Platichthys flesus)* from a contaminated estuarine environment. J. Environ. Monit., **3**, 610-615.
(2) Marine Scotland (2012). The Distribution of Zooplankton Prey of Forage Fish in the Firth of Forth Area, East Coast of Scotland. Available online http://www.scotland.gov.uk/Publications/2012/08/2345/1 .
(3)http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8499

B3.2.3 Other Dredging Disposal Activities

In addition to the intended maintenance dredging activities at Leith with disposal at Narrow Deep, Forth Ports manages five other dredging operations within the Forth Estuary and Firth of Forth. The operations comprise the following.

- Trailer suction dredging in Grangemouth: maximum capacity for maintenance dredging is 1,700,000 m^3 per annum, undertaken over four days every month.
- Grab/backhoe dredging at Newhaven with disposal at Oxcars spoil ground: maximum capacity for maintenance dredging is 15,000 m^3 per annum, undertaken over four weeks, usually in spring.
- Trailer suction dredging in Rosyth: maximum capacity for maintenance dredging is 400,000 m^3 per annum, undertaken over three days per month, every other month with disposal at Oxcars spoil ground.
- Trailer suction or grab dredger Methil approach channel with disposal at Methil spoil ground: maximum quantity of disposed material is 12,500 m^3. This is undertaken annually.
- Grab dredger and plough at Kirkcaldy with disposal at Kirkcaldy spoil ground: maintenance dredging of approximately 5,000 m^3 undertaken annually.

The actual timing of dredging and volumes required to be dredged during each campaign depend on operational requirements and sedimentation rates (for example due to storm events).

Other recent, ongoing or planned licenced dredging activities in the Firth of Forth include the following (note these are based on planned or licenced activities so actual volumes dredged may be lower and dates may have been delayed due to Covid-19).

- Babcock Marine at Rosyth had a Marine Licence for maintenance dredging of up to 100,000 tonnes between March 2019 and March 2020 with disposal at Oxcars B.
- Maintenance dredge of 3,300 tonnes per year using a plough dredger at Port Edgar within the confines of the marina between 2018 and 2021 with disposal to an area immediately adjacent to the marina breakwater on the north east boundary of the marina.
- Trailer suction and backhoe dredging with self-propelled barge at Defence Munitions (DM) Crombie, maximum quantity of disposed material is 22,000 m^3 per annum for maintenance (1) with disposal at Bo'ness spoil ground.
- Capital dredge of 86,980 m^3 at Granton Harbour with disposal at Bo'ness or Narrow Deep spoil ground between August 2019 and July 2022.
- Maintenance dredging at Pittenweem Harbour, with disposal of 27,334 tonnes at Anstruther spoil ground between August 2019 and August 2020.
- Maintenance dredging of 3,600 tonnes over three years at Dysart Harbour, Fife, with disposal on the adjacent foreshore where it is dispersed on the incoming tide (July 2020 to July 2021).

The above maintenance dredging spoil disposal operations require licence renewals every three years by Marine Scotland. Potential impacts are therefore assessed and reviewed every three years prior to granting a Marine Licence. The historical disposal route for spoil from all listed dredging operations has been deposition at sea, and to date, no environmental impacts, other than direct impacts within the spoil ground, have been reported.

Work began on the Forth Replacement Crossing at the end of 2011, and capital dredging works for the bridge support foundations started at the beginning of 2012. The purpose of the dredging was to create access for the construction of the foundations for the structures which will support the new

(1) Rosyth International Container Terminal. Operational In-combination Assessment of Maintenance Dredging and Implications for the River Teith SAC. Jacobs, 2011.

bridge. In total 180,000 m^3 silt and sand was dredged from the seabed to form access channels for bridge foundation works between 2011 and 2016. This spoil was disposed of at Oxcars [(1)].

B3.2.4 Foreseeable Future Activities within and Close to the Firth of Forth

Levenmouth Demonstration Turbine

The Offshore Renewable Energy (ORE) Catapult's seven megawatt wind turbine was completed in 2013 and is located 50 m from the coast connected to the land by a ramp. The tower stands at 110 m and is 195 m to the top of the blade. Samsung had previously owned the wind turbine demonstrator, before selling to ORE Catapult in December 2015. In 2018 the licence to permit the turbine was extended to 2029.

Inch Cape Offshore Wind Farm

Consent was granted for the proposed Inch Cape Offshore Wind Farm in October 2014. Consent was delayed following an objection lodged by the Royal Society for the Protection of Birds and final approval was given in 2017. A revised scope of design was granted by Scottish Ministers in June 2019. This scope reduced the number of wind turbine generators from 110 to 72. The turbines will occupy an area of 150 km^2. Construction is expected to begin in 2021. Once fully operational the wind farm will have an export capacity of approximately 1,000 megawatts. An application to vary the maximum generating capacity, within the overall footprint of the wind farm, was submitted to Marine Scotland in January 2021.

Seagreen Offshore Wind Farm

Scottish and Southern Electric (SSE) and Fluor joint venture partnership Seagreen Wind Energy was awarded the exclusive development rights for the Firth of Forth Zone by The Crown Estate. The zone covers an area of 2,852 km^2 in the outer Firth of Forth. Seagreen was awarded consent by the Scottish Government in October 2014 to develop the northern part of the Firth of Forth Zone to generate up to 1,050 megawatts of power from up to 150 turbines. The design was updated and approved in 2018 to comprise fewer, larger wind turbines. Currently the plan is for 1075 MW from 114 turbines. Onshore cable installation commenced in September 2020. Montrose port is the preferred location for the operations and maintenance base.

Neart na Gaoithe Offshore Wind Farm

NnG Offshore Wind was granted consent by the Scottish Government in 2018 to build a 450 megawatt offshore wind farm in the Outer Firth of Forth comprising up to 54 wind turbines up to 208 m high occupying an area of approximately 105 km^2. Construction commenced in 2020 with seabed preparations being undertaken prior to piling works. An onshore operations and maintenance base at Eyemouth received planning permission in September 2020. The wind farm is expected to be operational in 2023.

B3.3 Conclusions

Potential cumulative impacts associated with the above activities can be broadly categorised as comprising re-suspension of sediments resulting in loss or smothering of benthos, the discharge of contaminants with the potential to impact both water and sediment quality, or disturbance to seabirds and mammals from vessel movements. The dredge spoil disposal operations at Narrow Deep pre-date the SPA and SAC designations and there is no available evidence to suggest that the past and current disposal operations at Narrow Deep managed by Forth Ports have impacted the integrity of designated sites or resulted in other significant environmental impacts either alone or cumulatively with other activities in the area. Any significant future developments within the Firth of Forth are likely to be subject to assessment of significant environmental effects through the appropriate consenting processes.

(1) Hochtief (UK) Construction (2016). Forth Road Bridge Replacement - Queensferry Crossing. Available online http://www.hochtief-construction.co.uk/bridges_Forth_Road.shtml

APPENDIX C CONSULTEE RESPONSES (EXTRACTS FROM LETTERS/EMAILS RECEIVED)

1 Marine Scotland

As you know as part of the application a BPEO would need to be completed to take into consideration possible ways of disposal and provide evidence for the best option available. As per our guidance, to consider how to gain maximal beneficial use of the material is good, but this option has to be evidenced from chemical and particle size analysis. Detailed consideration of how material can be used beneficially must be in agreement with Scotland's National Marine Plan, and you should also be mindful of the OSPAR Guidelines for the Management of Dredged Material at Sea.

As you may know any pre-sampling for this application must be approved by Marine Scotland. The locations of sampling must be agreed on and once this is proposed we can advise on what else may be required. Selection on the dredge deposit site must be provided in the BPEO. Contingency should be planned for a backup plan if for any reason this site cannot be used. Marine Scotland will advise on this when assessing the BPEO and pre-sampling.

Jack Versiani Holt Marine Licensing Casework Officer, Marine Scotland - Marine Planning & Policy

2 NS

Thank you for contacting us to request information relevant to the BPEO study for Leith Docks. As per our previous advice – the Narrow Deep spoil grounds are well established and continue to be the most appropriate places for disposal. The only beneficial reuse project that we are aware of continues to be Dunbar East Beach. However this project requires clean sandy sediment and it's unlikely that the spoil from Leith is suitable.

Malcolm Fraser, Area Officer – Forth

3 NLB

Thank you for contacting Northern Lighthouse Board with regard to this consultation. NLB have no objection to the proposed disposal sites for the dredging operations at Leith.

Adam Lewis, Coastal Inspector

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