Tarbert Ferry Terminal Upgrade Capital Dredge Best Practicable Environmental Option Report

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Document Control

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1 Introduction

This Best Practicable Environmental Option (BPEO) report has been produced to support the dredge and disposal marine licence application under the Marine Works (Scotland) Act 2010 for the proposed Tarbert Ferry Terminal Upgrade.

1.1 Reports Aims and Objectives

The purpose of this report is to identify and assess the available options for the disposal of dredged materials, arising from the upgrade of the Tarbert Ferry Terminal.

The objectives are:

- To provide an overview of the required dredging works;
- Describe the proposed areas for which a dredging campaign is required, including estimated quantity of dredged material likely to be removed;
- Describe the BPEO methodology employed to complete the assessment; and
- To identify and assess options for disposal of dredged material to determine the BPEO for disposal of dredge spoil.

2 Background

A new dual fuel ferry is planned for introduction to the Skye Triangle Ferry Route (Uig (Skye) - Tarbert (Harris) and Uig – Lochmaddy (North Uist)) to replace the current vessel, MV Hebrides. The new vessel has greater pedestrian and vehicle capacity than the current vessel and as such it is larger and has a greater draught.

The existing terminal facilities at Tarbert, owned by Caledonian Maritime Assets Ltd (CMAL), require to be upgraded to accommodate the new larger vessel. Dredging of the ferry berth to accommodate the increased draught of the vessel needs to be carried out as part of these works.

With increased pedestrian and vehicle capacity, improvement to the marshalling and landside areas is also required, hence the proposal is to reclaim land to facilitate these improvements. Following geophysical surveys completed in 2017, the area identified for the reclamation works was identified as having poor quality soft, silty seabed deposits of up to 7m deep. Therefore, it was identified as being unsuitable for founding of the proposed works, construction on top of the unsuitable material likely to result in excessive settlement and slip failure (Wallace Stone, 2018). This area requires dredging to remove the unsuitable material to provide a suitable foundation for the proposed reclamation.

For further project details please see Volume 2, Chapter 2 of the Tarbert Ferry Terminal Upgrade Environmental Impact Assessment Report (EIAR) (Affric Limited, 2018).

2.1 Dredge Areas and Volumes

As shown in Drawing 1973-904 there are three areas that need to be dredged:

- Operational Dredge Area – Existing seabed excavated to achieve a dredge level of -5.0mCD at pier berth. Area of the dredge is approximately 4,000m^2 and the estimated dredge volume is approximately 4,500m^3;
- Marshalling Area - Existing seabed excavated to remove soft, poor quality seabed material. Depths vary across the area, with a maximum depth of approximately -

7.85m CD. The area of the dredge is approximately 8,500m^2 and the estimated dredge volume is approximately 31,300m^3; and

- Access Dredge (Pontoon) Area – an area adjacent to the Marshalling Area where the pontoons are located that needs to be dredged to facilitate access by vessels to dredge the Marshalling Area. Dredged to reduce seabed from -1mCD to -3mCD. Area of this dredge is approximately 4,800m^2 with an estimated dredge volume of 5,000m^3.

An estimated total of 40,800m^3 of spoil material will arise from the combined dredge. However, to allow for insitu changes, a dredge licence for 44,000m^3 is sought. A range of specific gravities has been identified across the total proposed dredge area of between 1.2 and 2 (RPS Mountainheath, 2018). To be conservative a specific gravity of 1.8 has been assumed, therefore the mass of the combined dredged materials would be approximately 80,000 tonnes.

2.2 Description of Material

Sampling was conducted by Aspect Land and Hydrographic Ltd and Causeway Geotech Ltd conforming to Marine Scotland Guidance notes on Pre-Disposal Sampling Guidance (Marine Scotland, 2017). Marine Scotland Guidance requires, as a minimum, five sample stations in relation to the proposed volume of the dredge. As the proposed dredge depth will be more than 1m, core samples were needed at each of these stations.

In accordance with the guidance, seven sample stations were completed within the Operational Dredge and Access Dredge areas. Station sampling was completed using vibrocore equipment to achieve core depths up to 2m. This methodology was appropriate for this area as the proposed dredge depth requirement is between 1m to 2m.

Borehole sampling was undertaken across the proposed development in order to provide geotechnical information to support the design and construction of the proposed ferry terminal upgrade. In total 12 boreholes were completed across the development footprint. Of these 12 boreholes, six were selected for chemical analysis due to requirement for core samples to be completed to the total dredge depth as outlined within the guidance (Marine Scotland, 2017). These six cores were taken to a maximum depth of -8.24 CD using light cable percussion boring. All sample station locations can be seen in Appendix 2. The selected borehole sample stations for chemical analyses are as follows:

- BH01;
- BH02;
- BH03;
- BH04;
- BH05; and
- BH07.

A further nine surface grab samples were also undertaken by Aspect Land and Hydrographic Ltd in order to provide information on the benthic habitat within the proposed dredge areas. As part of this assessment Particle Size Distribution (PSD) was analysed to inform the habitat survey. These results and details on the benthic habitat can be found within Chapter 8 of the EIAR (Affric Limited, 2018). The location of these samples can be seen in Figures 2.1 and 2.2.

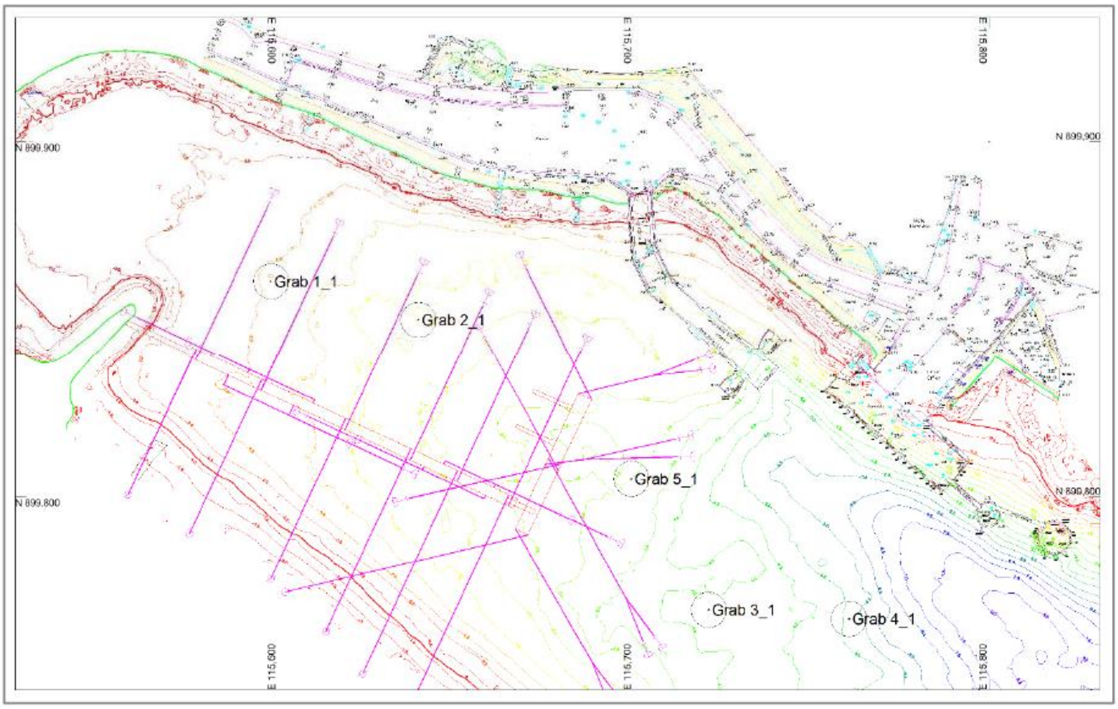

Figure 2.1: Location of Grab Samples 1 to 5 (Aspect, 2017)

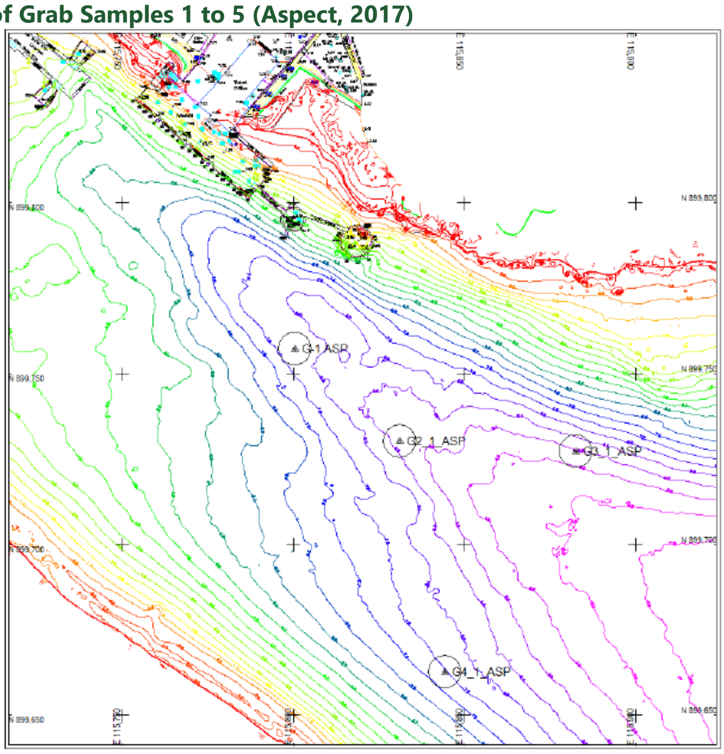

Figure 2.2: Location of Grab Samples 6 to 9 (Aspect, 2017)

All vibrocore samples were analysed by the Laboratory SOCOTEC who are accredited to ISO17025. In line with Marine Scotland Guidelines (Marine Scotland, 2017) each core had samples taken at the following intervals:

- 0.0m to 0.25m;
- 0.5m to 1.0m; and
- 1.5m to 2.0m.

Borehole samples were analysed by RPS laboratory who are accredited to ISO10725. Each borehole sample station had cores of up to -8.24m CD with samples taken at the 0.15m level and then every 50cm as per guidance (Marine Scotland, 2017) with every second sample being analysed. Further information on the Ground Investigation works completed and sampling process can be seen in the Tarbert (Harris) – Ground Investigation Factual Report (Causeway Geotech, 2018).

The results of the sample analysis have been summarised in this section. The full sample results are available in the spreadsheets entitled 'Tarbert Ferry Terminal Upgrade - Vibrocore Pre-disposal Sampling Results Form' (SOCOTEC, 2018) , and 'Tarbert Ferry Terminal Upgrade - Borehole Pre-disposal Sampling Results Form' (RPS Mountainheath, 2018) both of which have been supplied with the dredge licence application.

The Operational and Access dredge areas samples contained a total of 57% solids of which 80.9% was silt, 13.1% was sand and 6% was Gravel. Within the proposed Marshalling dredge area, a total of 61% of material sampled was classified as solid made up of 67% silt, 18% sand and 15% gravel. Hence overall the dredge material compromise 76% silt, 14% sand and 10% gravel.

All samples were tested for a suite of chemical parameters analysed against the Action Levels (AL) prescribed by Marine Scotland in the Pre-disposal Sampling Guidance (Marine Scotland, 2017). Table 2.1 shows the sample results which returned results with exceedances above AL1 but below AL2 as prescribed by Marine Scotland for metal and organotins. All other parameters analysed from the samples returned results for trace metals and organotins below the prescribed AL1s. Table 2.2 provides the average metal concentrations across the three dredge area samples and the full dredge area for metals where AL1 exceedances were observed in individual samples.

Mercury (Hg), Lead (Pb), and Copper (Cu) have been identified at VB3_1_1 within the access dredge area and BH01, BH03 and BH04 within the marshalling dredge area where Zn has also been identified (Table 2.1). All these results are above AL1 but below AL2 as prescribed by Marine Scotland (Marine Scotland, 2017). All results are within 0.65m of the surface with no further occurrences at depth which suggests that contamination is associated with the upper sediments only. Cadmium (Cd) has been detected above AL1 at a range of depths in the marshalling area samples. Table 2.2 however shows that the average concentrations of these metals are below AL1 in all three areas and as an average across the whole area.

Table 2.1: Review of Sample Action Level Exceedances – Metal and Organotin

Sample Point	Sample Depth	Cadmium (Cd) mg/kg (dry weight).	Chromium (Cr) mg/kg (dry weight)	Copper (Cu) mg/kg (dry weight)	Mercury (Hg) mg/kg (dry weight)	Nickel (Ni) mg/kg (dry weight)	Lead (Pb) mg/kg (dry weight)	Zinc (Zn) mg/kg (dry weight)
AL1		0.4	50	30	0.25	30	50	130
AL2		4	370	300	1.5	150	400	600
Sample Results – Marshalling Area								
BH01 0.15	0.15m	0.4	87.7	62.3	0.42	48.5	99.6	166
BH01 1.15	1.15m	0.28	120	13.4	0.03	42.8	25.2	55.1
BH01 2.15	2.15m	0.37	103	11.6	0.04	40.4	13.7	70.3
BH01 3.15	3.15m	0.59	115	14.8	0.05	45.9	13.4	69.6
BH02 0.15	0.15m	0.49	93.4	10.1	0.03	34.6	12.5	62.2
BH02 1.15	1.15m	0.4	91	10.9	0.03	33.2	11.4	55.9
BH02 2.15	2.15m	0.43	97	9.5	0.04	33.7	12.3	57.2
BH02 3.15	3.15m	0.43	98.1	11.2	0.03	34.3	11.6	58.6
BH03 0.15	0.15m	0.37	84.4	56.7	0.21	33	75.7	177
BH03 1.15	1.15m	0.37	83.8	9.48	0.03	30.4	11.1	52.3
BH03 2.15	2.15m	0.41	89.8	9.87	0.06	33	12.7	59.6
BH03 3.15	3.15m	0.29	85.6	8.64	0.03	31.1	11.1	53.8
BH04 0.15	0.15m	0.33	92.9	30.2	0.42	32.8	53.7	108
BH04 0.65	0.65m	0.36	95.6	30	0.26	34.7	60	122
BH04 1.65	1.65m	0.29	73	7.81	0.05	26	8.68	45.7
BH04 2.65	2.65m	0.47	74.5	12.2	0.06	28	11.5	54
Sample Results – Operational Dredge Area								
BH05 0.15	0.15m	0.29	75.4	17.3	0.05	29.8	22.7	72.3
BH05 0.65	0.65m	0.3	84.3	17.6	0.03	31.9	13.4	62.5
BH05 1.15	0.15m	0.35	87.1	10.1	0.03	34.8	12.2	61.6
BH05 1.65	1.65m	0.35	81.5	9.2	0.03	31.8	11.7	56.2
BH07 0.15	0.15m	0.23	75.9	9.79	0.05	28.4	19.2	49.4
BH07 0.65	0.65m	0.35	84.9	10.3	0.06	32	14.8	57.3
VB6_1_1	0.0m to 0.5m	34	48.2	19.5	0.06	33.3	29.9	61.6
VB6_1_2	0.5m to 1m	0.3	49.5	14.6	<0.01	32.4	9.9	52.3
VB6_1_4	1.5m – 2.07m	0.11	43.9	16.3	<0.01	36.8	11.5	64.8
Sampling Results – Access Dredge Area								
VB3_1_1	0.0m - 0.25m	0.33	28.6	37.1	0.25	21.9	257.3	103.7
VB4_1_1	0.0m – 0.25m	0.39	26	27.6	0.82	19.6	46.5	90

Table 2.2: Average Metals Concentration Across Dredge Area

Location	Cadmium (Cd) mg/kg (dry weight)	Chromium (Cr) mg/kg (dry weight)	Copper (Cu) mg/kg (dry weight)	Mercury (Hg) mg/kg (dry weight)	Nickel (Ni) mg/kg (dry weight)	Lead (Pb) mg/kg (dry weight)	Zinc (Zn) mg/kg (dry weight)
Average Across Marshalling Dredge Area	0.39	92.78	19.29	0.11	35.15	27.76	79.21
Average Across Operational Dredge Area	0.26	50.91	12.45	0.03	28.21	13.42	53.16
Average Across Access Dredge Area	0.29	29.88	15.59	0.15	23.20	40.82	57.46
Average Across Total Dredge Area	0.32	62.09	15.65	0.09	29.74	24.49	63.75

Levels of Nickel (Ni) and Chromium (Cr) above AL1 are found in both the proposed marshalling area and operational dredge areas, which are close to the village. The presence of Ni and Cr within the harbour area is not unusual as they can be utilised in sacrificial anodes. As the harbour has been used by both commercial and leisure craft since 1779 (Undiscovered Scotland, 2018) it is likely the source of this material is from vessels and marine infrastructure. The location of the sample point VB6, where Ni was found at all depths, is at the end of the linkspan in close proximity to the sacrificial anodes installed on the infrastructure in 2012. No increased levels of Ni or Cr are found in the access dredge area. This may be due to the pontoons being a new feature and as such vessels haven't historically been moored in this location.

Table 2.2 shows that, when an average of all samples is taken, Ni is below AL1. It is however 17% higher than AL1 in the average of the marshalling area dredge, but is only 23.4% of AL2. Cr is 85% above the AL1 of 50mg/kg dry weight in the marshalling area, but less than 2% above it in the operational dredge area. For the full dredge area Cr is 24% above AL1, equating to 17% of AL2.

Environment Canada has identified Probable Effect Levels (PEL) for a range of chemicals to protect aquatic life in the freshwater and marine environment (CCME, 2002). The PEL for Cr is identified as 160 mg/kg (dry weight) and for Ni is 42.8 mg/kg (dry weight). The averages identified across the proposed dredge areas have dry weight results below the PEL's in all instances. Only 3 individual Ni samples exceed the PEL and no samples exceed the Cr PEL.

Having reviewed the results against the prescribed Marine Scotland ALs and the PELs as identified by Environment Canada the potential dredge material is not predicted to have an effect on the marine environment due to the metal or organotin content.

A range of Polyaromatic Hydrocarbons (PAH) have been identified that exceed AL1 at 9 of the 13 sample station locations. These can be seen in detail in the Borehole and Vibrocore Pre-disposal Sampling Results (RPS Mountainheath, 2018; SOCOTEC, 2018). When the results are combined as an average across the dredge area 15 PAH's have exceedances of above AL1 as shown in Table 2.3.

PAHs are formed during the combustion of carbonaceous material at high temperatures and typically occur in complex mixtures and not as individual compounds. The identified PAHs within the dredge area are present in the chemical composition of coal tar, a product which historically has been used in the protection of wooden marine vessels. As Tarbert was founded as a fishing settlement in 1779 (Undiscovered Scotland, 2018) the presence of these PAHs within this area could be explained by the use of coal tar in the protection of wooden hulled vessels at this time. The settlement would also have been heavily reliant of the use of peat and coal as a source of fuel. The burning of these fuels is likely to release the PAHs that have been identified within the samples.

High Total Hydro Carbon (THC) results as reported in the Borehole Pre-disposal Sampling Results (RPS Mountainheath, 2018) suggest high organic material within the samples ranging from 0.47% to 16%. High THC results would indicate the presence of soils, as the basic components of soil consist of approximately 5% organic matter (University of Hawai'i at Mãnoa, 2018). As identified in Figure 2.3, the surrounding valley has a high organic profile (>35%) with a general soil type of Peaty Podzols (Scottish Government, 2018). These soils are likely to be high in naturally occurring PAHs produced by the decomposition process with the biotransformation of organic material found typically within peat, along with the "biochemical transformations of precursors of aromatic substances during the early diagenesis of sedimentary rocks"(Malawska, 2006). Research completed in Poland suggests that PAHs in deep peat layers may be from natural biomass fires. With perylene, and the possibility of phenanthrene and benzo(ghi)perylene, being products of the biochemical transformation process of aromatic compounds (Malawska, 2006).

The high results of THC are likely due to sediment transportation from a number of streams and outfalls which currently discharge surface water run-off from the village into the harbour. Sample station BH03 within the marshalling dredge area and close to the shoreline identified 16% THC whereas VB7 located further offshore within the operational dredge area identified 0.01% THC which aligns with this theory. It is noted that there are currently no silt interceptors in the surface water drains from the village.

Table 2.3: Average PAH compared to Marine Scotland AL1

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(e)pyrene	Benzo(b)Fluoranthene	Benzo(k)Fluoranthene	Benzo(ghi)perylene	Fluorene	Indeno(1,2,3-cd) pyrene	C1-naphthalenes	C1- phenanthrene	C2-naphthalenes	C3- naphthalene	Chrysene	Diben(ah)anthracence	Fluoranthene	Naphthalene	Perylene	Phenanthrene	Pyrene
Marine Scotland AL1 (mg/kg Dry Weight)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01	0.1	0.1	0.1	0.1	0.1
Average Across Marshalling Dredge Area (mg/kg Dry Weight)	0.068	0.028	0.095	0.201	0.195	-	0.225	0.079	0.117	0.076	0.083	-	-	-	-	0.118	0.028	0.409	0.136	-	-	-
Average Across Operational Dredge Area (mg/kg Dry Weight)	0.007	0.006	0.020	0.036	0.033	0.032	0.036	0.016	0.033	0.013	0.021	0.276	0.135	0.204	0.174	0.036	0.005	0.070	0.144	0.054	0.111	0.069
Average Across Access Dredge Area (mg/kg Dry Weight)	0.058	0.033	0.103	0.309	0.326	0.230	0.286	0.142	0.212	0.063	0.231	0.136	0.284	0.161	0.143	0.341	0.039	0.666	0.068	0.125	0.469	0.613
Average Across Total Dredge Area (mg/kg Dry Weight)	0.040	0.020	0.065	0.154	0.155	0.117	0.159	0.068	0.102	0.047	0.088	0.216	0.199	0.186	0.161	0.130	0.021	0.321	0.125	0.084	0.269	0.307

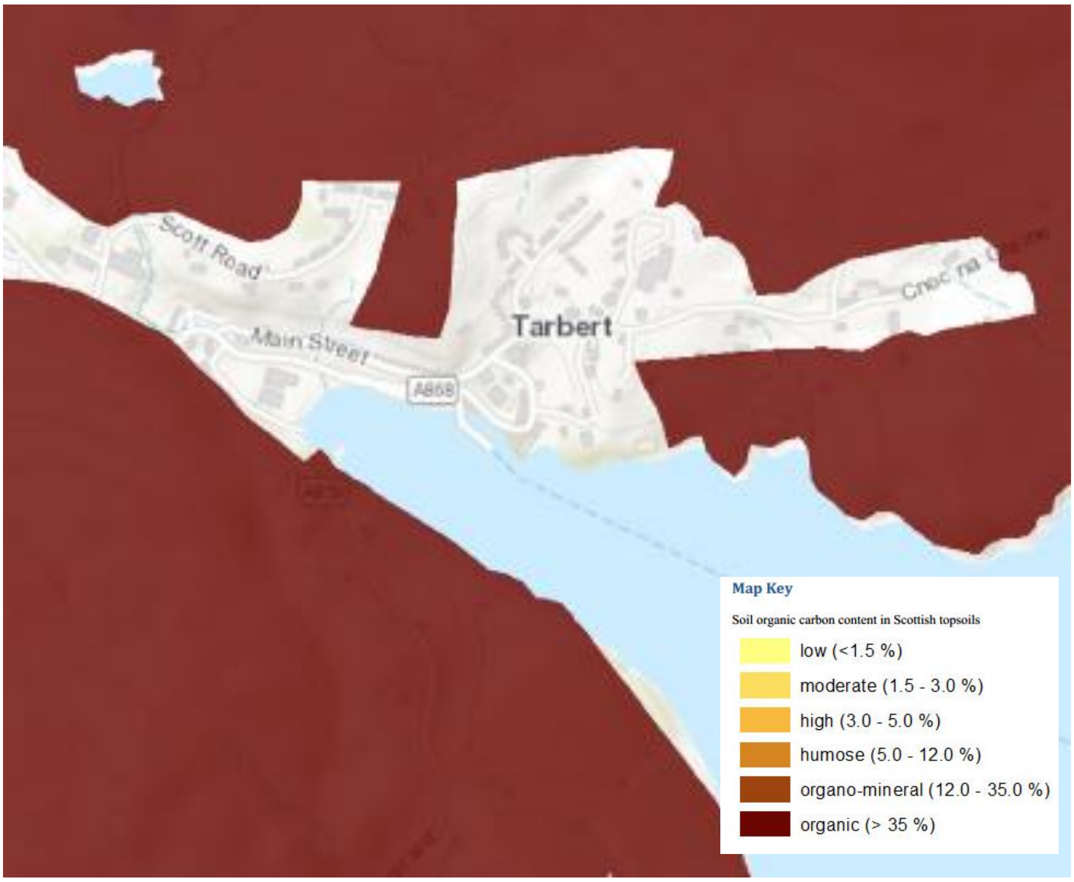

Figure 2.3 Tarbert Organic Soil Content (UK Soil Observatory, 2017)

Research conducted by Environment Canada has identified Interim Sediment Quality Guideline (ISQG) and PEL for a range of chemicals to protect aquatic life in the freshwater and marine environments which include PAHs. Table 2.4 shows the average dry weight for PAH's across all the proposed dredge area against the ISQG and PEL as identified by Environment Canada (CCME, 2002). All PAHs that have PEL assigned are at least 50% below the PEL, thus no effects are predicted on marine life from the presence of these PAHs.

Of those PAH's with no PEL, defined C1-naphthalenes has the highest average concentration at 0.216mg/kg, 2.1 times the relevant AL1. It is noted that PEL's, where they are available, are on average 6.73 times higher than the AL1 for the relevant compound, it is surmised that if a PEL was derived for C1-naphthalenes it would be in the region of 0.6mg/kg. Hence it is likely that all PAH's are at levels too low to have a probable effect on the environment.

Table 2.4: Average Dry Weight PAH Over Proposed Dredge Area

Dry Weights mg/kg	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(e)pyrene	Benzo(b)Fluoranthene	Benzo(k)Fluoranthene	Benzo(ghi)perylene	Fluorene	Indeno(1,2,3-cd) pyrene	C1-naphthalenes	C1- phenanthrene	C2-naphthalenes	C3- naphthalenes	Chrysene	Diben(ah)anthracence	Fluoranthene	Naphthalene	Perylene	Phenanthrene	Pyrene
ISQG mg/kg dry weight (CCME,2002)	0.00671	0.00587	0.0469	0.0748	0.0888					0.0212						0.108	0.00622	0.113	0.0346		0.0867	0.153
PEL mg/kg dry weight (CCME,2002)	0.0889	0.128	0.245	0.693	0.763					0.144						0.846	0.135	1.494	0.391		0.544	1.398
No. of Samples above the PEL	5	1	5	4	4					4						2	2	4	3		6	4
Highest recorded level mg/kg	0.589	0.217	0.802	1.129	1.273	0.887	1.087	0.58	0.811	0.521	0.927	3.098	1.263	1.999	1.833	1.262	0.165	2.790	2.417	0.344	2.790	2.970
Dry Weight Average for all dredge samples	0.0445	0.020	0.065	0.154	0.154	0.117	0.159	0.0685	0.102	0.047	0.088	0.216	0.199	0.186	0.161	0.130	0.021	0.321	0.125	0.084	0.269	0.307
Dry Weight Average as a percentage of PEL	45.50%	15.49%	26.64%	22.27%	20.26%					32.43%						15.42%	15.43%	21.48%	31.97%		49.40%	21.93%

Studies have shown that PAHs accumulate in species which cannot metabolise them, including algae, molluscs and primitive invertebrates. Bioconcentration is less of an issue for fish and higher invertebrates as they can metabolise PAH (UK Marine SAC Project, 2018). Hence increase PAH levels in shellfish areas can cause concern. A review of the proposed dredge area and the immediate areas adjacent to the proposed dredge has not identified any active shellfish farms, or Shellfish waters protected areas, that could be of concern from the proposed operation (Marine Scotland, 2018).

As previously identified in this section, the material from the proposed dredge would be classed as suitable with regards trace metals and organotins for the disposal at sea option as outlined in Marine Scotland Guidelines (Marine Scotland, 2017) and compared to PELs (CCME,2018). The PAHs identified have been assessed against the AL1 as prescribed by Marine Scotland and the PELs as issued by Environment Canada and as such these would be deemed as appropriate for disposal as no effects are predicted on marine life from the concentrations identified.

As stated in this section, THC ranges from 0.47% to 16%. These results are likely to be high due to the surrounding geology of Tarbert (>35% Organic Peaty Podzols)and are discussed further in the options assessment.

3 BPEO Method

3.1 Introduction

In identifying the BPEO for this proposed dredge campaign the following methodology has been employed:

- Identification of options available for the disposal of material;
- Screening to eliminate unsuitable options;
- Assessment of remaining options; and
- Comparison of options and identification of the BPEO.

3.1.1 *Option Identification*

Options for disposal of the material were identified through discussion with CMAL and their engineers.

3.1.2 *Screening to Eliminate Unsuitable Options*

All options have been screened against minimum criteria which each option had to meet in order to be taken forward for detailed consideration. Any option which failed to meet one or more of the criteria was not taken forward to the detailed assessment. The criteria used are outlined below:

- The proposed option must be suitable for the characteristics of the dredge material;
- It must be technically viable; and
- It must allow for continued operation and development of Tarbert Ferry Terminal.

3.1.3 *Attribute Identification and Scoring*
Attributes were scored out of 5 with 1 being the worst performing and 5 being the best. Each score has been designated a colour to aid visual comparison. The attributes are outlined in Appendix 3.

Options meeting the minimum criteria were scored against each of the attributes (Appendix 4) and reasoning for this scoring provided (Appendix 5).

3.1.4 *Comparison of Options and Identification of the BPEO*
Following the scoring of the options detailed comparison was undertaken to identify the BPEO.

4 Assessment of Options

4.1 Identification of Options Available
Several options were initially identified for the disposal of the proposed dredge material including both terrestrial and marine based options. The options identified are outlined below. A "do nothing" scenario is included for consideration.

- Do Nothing;
- Disposal to Landfill;
- Spreading on Agricultural Land;
- Beneficial Re-use;
- Disposal at Sea to an Existing Disposal Site;
- Disposal at Sea to a New Disposal Site; and
- Plough Dredging.

4.2 Screening of Options
Options were initially screened against the minimum criteria as outlined in Section 3.1.2. This initial assessment eliminated four of the options as they do not meet one or more of the screening criteria. The reasons why the four options have been discounted are discussed below.

4.2.1 *Do Nothing*
To not complete dredging would have a significant impact on the proposed upgrade of Tarbert Ferry Terminal. The new larger ferry would not be able to manoeuvre effectively and would likely be subject to operational restrictions including tidal limits. In addition, it would not be possible to complete the land reclamation, which would lead to a lack of marshalling space with the resulting potential for back-up of traffic onto the local road network. Hence to do nothing would compromise the operations of the ferry terminal and the ferry service which is a vital link for the islands.

4.2.2 *Spreading on Agricultural Land*
This option has not been considered further due to the inappropriateness of the material. The high saline content makes the material unsuitable for spreading onto agricultural land without significant further treatment. Salinity is a key environmental limiting factor for the productivity of plant growth and many crops are salt sensitive, making excess salinity a threat to agriculture (Flowers, 2005).

The Marine Scotland AL are set with regard to marine sediments, and as such may not be appropriate for consideration of land uses of the material as the pathways to receptors, including humans, are very different. Hence, the sample results were compared against the Dutch Target and Intervention Values (the New Dutch List) (Ministerie van Volkshuisvesting, 2000) for soil, utilised for the assessment of contaminated land. A comparison of the metals average dry weight of the dredge samples (detailed in Table 2.2) against the New Dutch List identifies that no trace metals are in exceedance of the target levels. With regard to PAH, the New Dutch List combines 10 PAH's into one value (PAH(sum10)). The ten relevant PAH analysis results for the samples have been combined and averaged, the average PAH(sum10) for the Tarbert Ferry Development samples being 1.5mg/kg. This is slightly above the target level for PAH(sum10) of 1mg/kg.

The salinity issues, plus the fact that the dredge spoil is likely to be above the target values for PAH(sum10) make the option unsuitable due to the characteristic of the dredge material.

4.2.3 *Disposal to Landfill*

This option has been discounted as the process of disposing of the dredged material to landfill is not technically feasible for the quantities of dredged material associated with the development. The disposal of material to landfill sites would take up valuable landfill space when space within the UK landfill network is at a premium.

There are several logistical steps associated with the disposal to landfill option that would require completion before removal of the material to a designated site. Dredged material would need to be landed, dewatered, stored and transported to a disposal site. This process would require CMAL to set aside space to process material, space which is not available to them in Tarbert. The disposal would also be subject to landfill tax at £88.95 per tonne of material. (Based on the estimated dredge amount of 80,000tonnes this would equate to £7,116,000 in tax).

Further to the financial impact and lack of infrastructure available to complete the drying process, no suitable landfill site has been identified as being technically feasible for the disposal of material. The landfill site closest to the dredge site, Bennadrove on the Isle of Lewis, does not have the capacity to accept the quantity of dredged arising. The use of a landfill on the mainland is impractical due to the logistics associated with moving and dewatering the material. Table 4.1 shows the landfill options in further detail for comparison.

Table 4.1: Landfill Information (SEPA, 2017)

Landfill Site	Distance from Tarbert and Approximate travel distance and time	Operator	Local Authority Area	Description	Estimated % Dredged material as a Percentage of Remaining Landfill Capacity (2017)
Bennadrove L/F Site, Marybank, Isle of Lewis	34.6 miles by road	Comhairle Nan Eilean Siar	Eilean Siar	Permitted to accept Non-Hazardous Waste Until May 2020. Remaining Capacity as 31 Dec 2017: 58,107 tonnes.	140%
Duisky Landfill Site, Fort William (Site5) (Mainland)	190miles by sea then 12miles by road	Lochiel Logistics LTD	Highland	Permitted to Accept Non-Hazardous Waste. Until December 2040. Remaining Capacity as 31 Dec 2017: 482,000 tonnes.	17%
Highland Council, Seater L/F, Bower, Caithness. (Mainland)	137 miles by sea and 12 miles by road	The Highland Council	Highland	Permitted to Accept Non-Hazardous Waste Until May 2024. Remaining Capacity as 31 Dec 2017: 192,000 tonnes.	42%

In addition to the financial and logistical implications, the Scottish Government launched a Zero Waste Plan for Scotland in 2010 with a vision for a zero-waste society. The plan has a target to recycle 70% of material and a maximum of 5% to landfill by 2025 for all Scotland's waste (Scottish Government, 2010). The disposal of dredged material to existing landfill sites therefore does not align with the Scottish Government Policy where the onus is on reducing the amount of material being sent to a landfill site.

4.2.4 *Beneficial Re-use*

The reuse of material is near the top of the waste hierarchy and is therefore consistent with the Scottish Government's policy of a Zero Waste Scotland by 2025. However, as discussed in Section 2.2 the material is primarily silt (80.9% in the access and operational dredge areas and 67% in the marshalling dredge area), which is not suitable for construction use. The marshalling area is being dredged due to the inability to construct on top of the high silt content material. If any of the material was suitable for reuse, which is not the case, then it would be utilised within the land reclamation. It is highly unlikely that any other project would require material with such a high silt content, hence the option has been discounted.

4.3 Assessment of Feasible Options

Following the screening process, the options taken forward for further analysis are:

- Disposal at Sea to existing Disposal Site;
- Disposal at Sea to a new Disposal Site; and
- Plough Dredging.

Each of these options have been further analysed against the attributes identified in Appendix 3. The options scoring is provided in Appendix 4 with the reasoning for attribute scoring provided in Appendix 5. Where referred to, scores are provided in brackets below.

4.3.1 *Disposal at Sea to an Existing Disposal Site*

There are numerous open dredge and disposal sites located within Scottish Waters for deposition of dredged material. The closest to the proposed dredge is the Stornoway (HE035) disposal site.

The dredge material as outlined within Section 2.2 has high THC's ranging from 0.42% to 16%, likely to be due to transportation of organic materials from surface water run-off from the surrounding area (Figure 2.3). As shown in Figure 4.1, the area around the disposal site HE035, has the same high organic levels (UK Soil Observatory, 2017). It is therefore anticipated that the material located at this site will have naturally occurring high THC levels, similar to Tarbert.

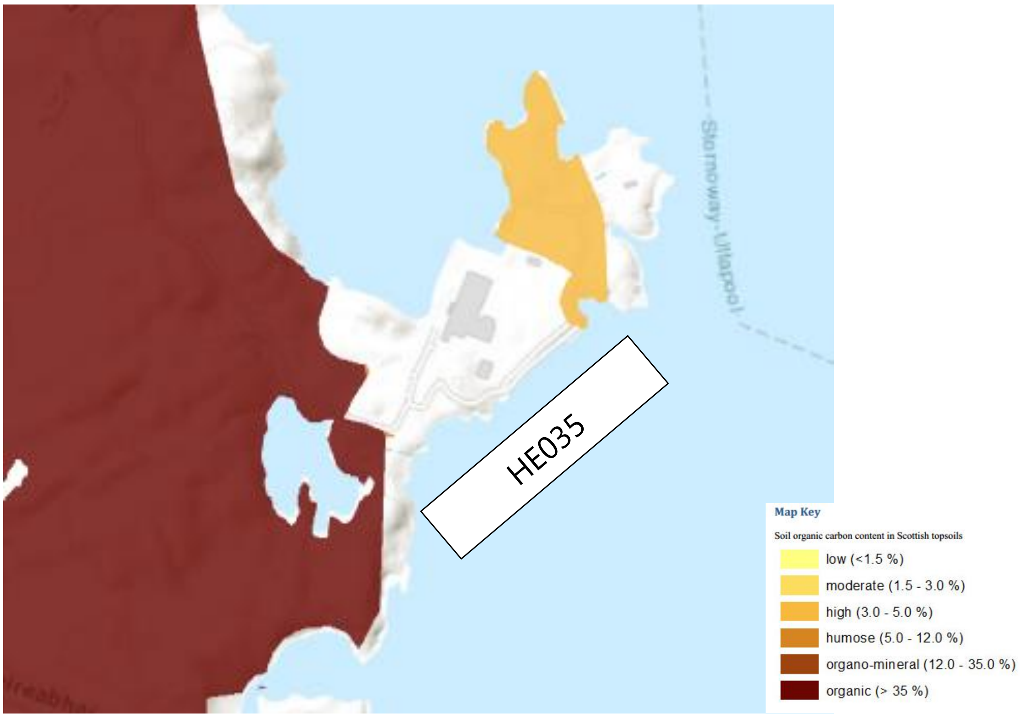

Figure: 4.1: Stornoway Organic Soil Content (UK Soil Observatory, 2017)

As discussed in Section 2.2 the material to be dredged has Cr and Ni present in concentrations in exceedance of AL1 as set by Marine Scotland (Marine Scotland, 2018) but under the PEL for these trace metals (CCME,2018). Under the Pre-disposal Sampling Guidance this material is still able to be disposed of at sea with possible restrictions.

PAHs have been identified across the dredge area in exceedance of the AL as discussed in Section 2.2. Though there have been instances identified where the PAH has exceeded the PEL, these have all been identified as occurring within the top layer of the proposed dredge (0.25m). Having reviewed these PAHs further it is likely that these high results identified are associated with organic material and are naturally formed during the decomposition process with the biotransformation of organic material (Malawska, 2006). Dredging in the areas showing PAH contamination is to be up to 6m in depth and as a consequence mixing will occur with the top layer and lower layers during dredging. Therefore, considering the volume of material and that as an average across the dredge the material is below the prescribed PELs, it is not predicted that there will be an effect on marine life from this material and as such it would be appropriate to be disposed of at HE035.

It is likely that HE035 will have similar PAH values associated with the area due the surrounding ecology and its existing history of material being disposed of at this site. As PAHs can accumulate in Shellfish (UK Marine SAC Project, 2018), a review of the area surrounding the proposed disposal site HE035 has been undertaken. This review has not identified any active Shellfish Farms or Shellfish protected waters within proximity of this site that could be of concern (Marine Scotland, 2018).

HE035 has been identified as the most appropriate disposal site due to its geographical location to the development. The site is located approximately 60km north of the proposed dredge (4).

Dredging operations would be carried out using a Backhoe Dredger (BHD) and/or Trailer Suction Hopper Dredger (TSHD) with the support of Split Hopper Barges. This would require approximately 30 to 35 round trips to dispose of the material at HE035. The disposal of material to sea disposal sites is an established industry practice and as such this option scores highly (5) on the technically feasible attribute.

4.3.2 *Disposal at Sea to a New Disposal Site*

A further option has been identified to designate a new disposal site at Tarbert. Marine Scotland Guidance - Dredging and Sea Disposal Sites: Guidance on Creating a New Sea Disposal Site (Marine Scotland, 2013) outlines the process for this option. The legislative process is a complex (1) and costly (2) exercise requiring baseline surveys to be completed and a period of monitoring before a site can be designated. This includes the assessment of the nature of the seabed, understanding the water column, type of disposal site and the biological, ecological effects of the dredged material upon the new site. The requirement for characterisation of the candidate disposal site and Marine Scotland – Licensing Operations Team (MS-LOT) consultation with stakeholders can take up to a year to process dependent on existing information (Marine Scotland, 2013), hence this option scored (1) under the time attribute.

4.3.3 *Plough Dredging*

Plough dredging was identified as a possible option for the operational dredge area prior to the need to dredge the marshalling and access areas being identified. Figure 4.2 shows the proposed dredge area disposal site highlighted in pink.

The process of plough dredging the operational area is technically feasible and is an established industry practice. However not all of the access and marshalling area dredge would be accessible by the plough dredger. It is also unlikely that the potential receiver site would have the capacity to receive all the material from the three dredge areas. As such this option would need to be coupled with a second technique to make it viable.

Timescales associated with the initial mobilisation are minimal. However, in order to reach the required depths at some points, multiple passes of the dredger would be required which would increase the amount of time spent on this operation (3). This in turn could have a consequential effect on the proposed developments timescales.

Grab samples previously completed to ascertain the benthic habitat identified that the area to receive the plough material is similar in PSD and did not identify any sensitive receptors that would be of concern from this operation. As with the disposal of material to a sea disposal site, the material would be considered appropriate for disposal.

The mobilisation of different vessels to complete dredging in multiple ways would increase the costs to CMAL and as such this option has scored (3) on cost attribute.

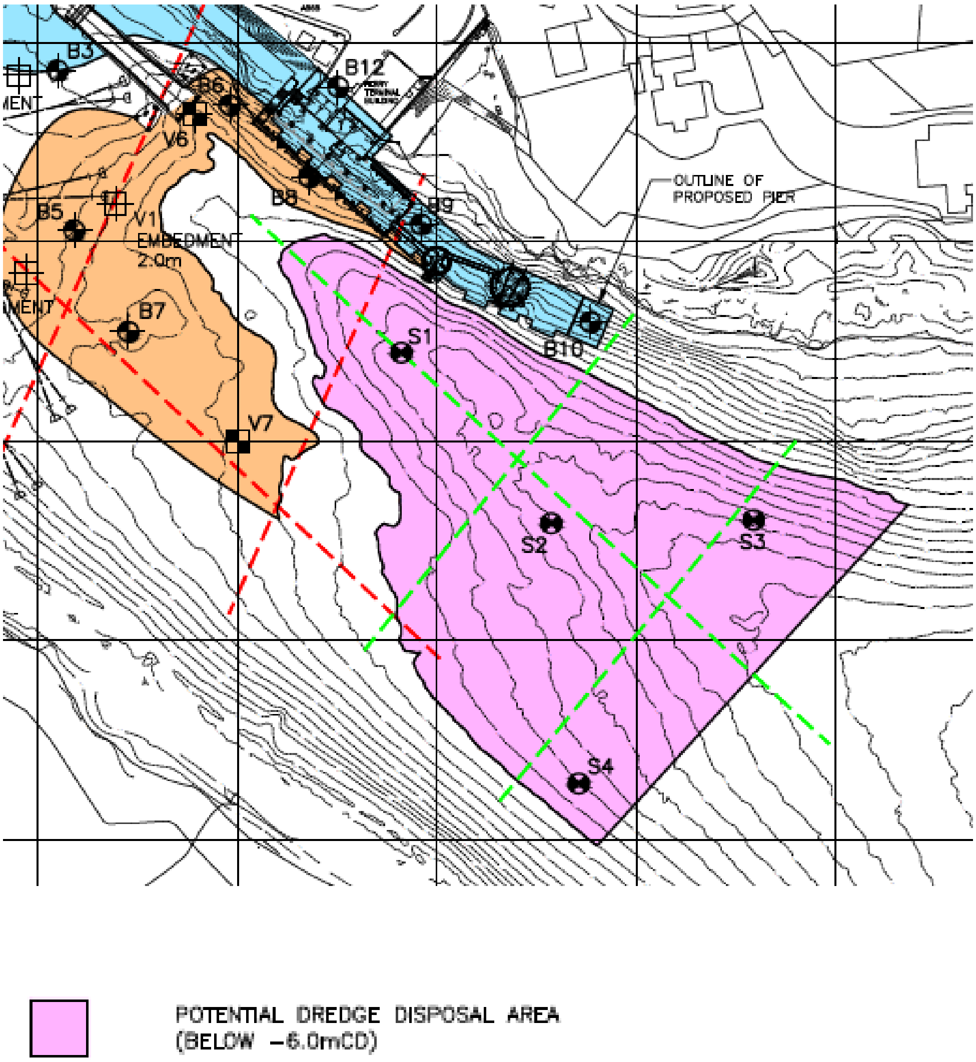

Figure 4.2 Showing Proposed Plough Dredge Disposal

4.4 Comparison of Options

The disposal at sea to an existing disposal site (Stornoway - HE035) option scored 36 out of a possible 45, the highest scoring option. It scored well, 4 or higher on all but one category. A score of 2 for Alignment to Policy attribute was awarded as the disposing of material to sea is not in alignment with Scottish Government's Zero Waste Policies (Scottish Government, 2010).

Designation of new disposal site scored 28 out of a possible 45 with distance scoring higher (5) then HE035. However, this option scored poorly in the Timescale (1), Cost (2), Alignment with Policy (2) and Legislative Complexity (1).

Plough Dredging scored 31 out of a possible 45. As with the previous options, plough dredging only scored (2) on Alignment with Policy due to the material being disposed of at sea not being in line with Scottish Government Policy on Zero Waste Scotland (Scottish Government, 2010). The option scored highly against the distance attribute (5) as the proposed disposal site is located less than 1 mile from the proposed dredge area. However, the option scored poorly (3) for timescale due to the requirement for several passes to complete to the required dredge depth. The option also scores poorly (3) on the technically feasible attribute as the option couldn't be implemented for all of the areas to be dredged. The use of multiple techniques would potentially increase overall cost of the dredge works.

Although plough dredging may have provided a suitable solution for the operational dredge area, when taken in the context of the full project, disposal at sea to the Stornoway disposal site is the preferred option.

5 Conclusion

The pre-disposal sample results have informed this assessment in terms of providing an understanding of both the chemical and physical status of the sediments to be dredged. Due to a high silt content the material was deemed unsuitable for reuse. The detailed assessment of the chemical analysis results identified that the material is unlikely to have an effect on the marine environment, and as such, was suitable for a range of marine disposal options. Multiple options were considered, a number of which were screened out early in the process. Of those taken forward for full assessment the option for 'Disposal at Sea to an Existing Disposal Site', namely Stornoway HE035, scored the highest against a range of attributes. Therefore, the BPEO for the management of dredged material is to take it to the Stornoway dredge disposal site HE035 for disposal.

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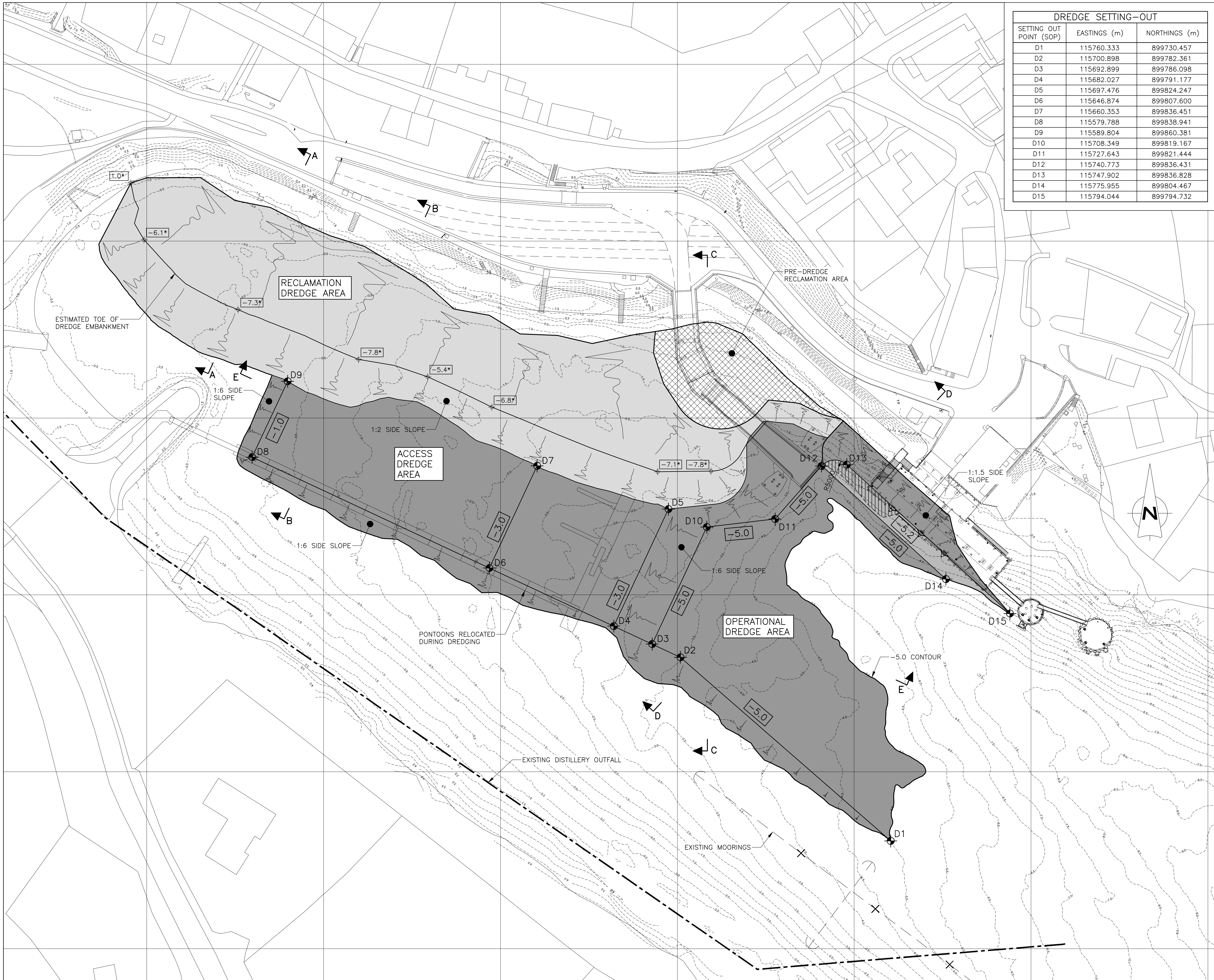
7 Glossary

Acronym	Definition
AL1	Action Level 1
AL2	Action Level 2
BPEO	Best Practicable Environmental Option
CD	Chart Datum
CMAL	Caledonian Maritime Assets Ltd.
CnES	Comhairle nan Eilean Siar
EIAR	Environmental Impact Assessment Report
ISQG	Interim Sediment Quality Guideline
km	kilometres
m	metres
PAH	Polyaromatic Hydrocarbons
PEL	Probable Effect Level
PSD	Particle Size Distribution
SEPA	Scottish Environment Protection Agency
THC	Total Hydro Carbons

Appendix 1: Map of Proposed Dredge Areas



DREDGE SETTING-OUT		
SETTING OUT POINT (SOP)	EASTINGS (m)	NORTHINGS (m)
D1	115760.333	899730.457
D2	115700.898	899782.361
D3	115692.899	899786.098
D4	115682.027	899791.177
D5	115697.476	899824.247
D6	115646.874	899807.600
D7	115660.353	899836.451
D8	115579.788	899838.941
D9	115589.804	899860.381
D10	115708.349	899819.167
D11	115727.643	899821.444
D12	115740.773	899836.431
D13	115747.902	899836.828
D14	115775.955	899804.467
D15	115794.044	899794.732

GENERAL NOTES

1. ALL LEVELS ARE IN METRES AND RELATE TO CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
3. TIDE LEVELS ARE AS FOLLOWS

   HAT +5.9mCD
   MHWS +5.0mCD
   MLWS +0.8mCD
   LAT +0.1mCD
4. CHART DATUM IS 2.74m BELOW ORDNANCE DATUM.
5. FOR DREDGE SECTIONS, REFER TO DRAWINGS 1973/202-203

LEGEND

- 6.31 PROPOSED DREDGE LEVELS
- -7.1* ESTIMATED LEVELS
- ACCESS & OPERATIONAL DREDGE AREAS
- RECLAMATION DREDGE AREA- SOFT SILTY SEABED MATERIAL DREDGED TO EXPOSE UNDERLYING FIRM CLAY/HARD GRAVEL OR ROCKHEAD
- POSSIBLE AREA OF ROCK TO BE BROKEN OUR DURING DREDGING
- AREA OF SEABED INFILLED WITH 1 LAYER OF 0.5t to 1.0t ROCK ARMOUR

REV	DATE	DETAILS	DRAWN	CHK'D	APP'D
A	15.11.18	MINOR REVISIONS	AB	BP	TR

AMENDMENTS

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DRAWING TITLE

DREDGE LAYOUT

DR Redacted

DATE	DATE	DATE
02/18	10/18	10/18

SCALE (A1) 1:500

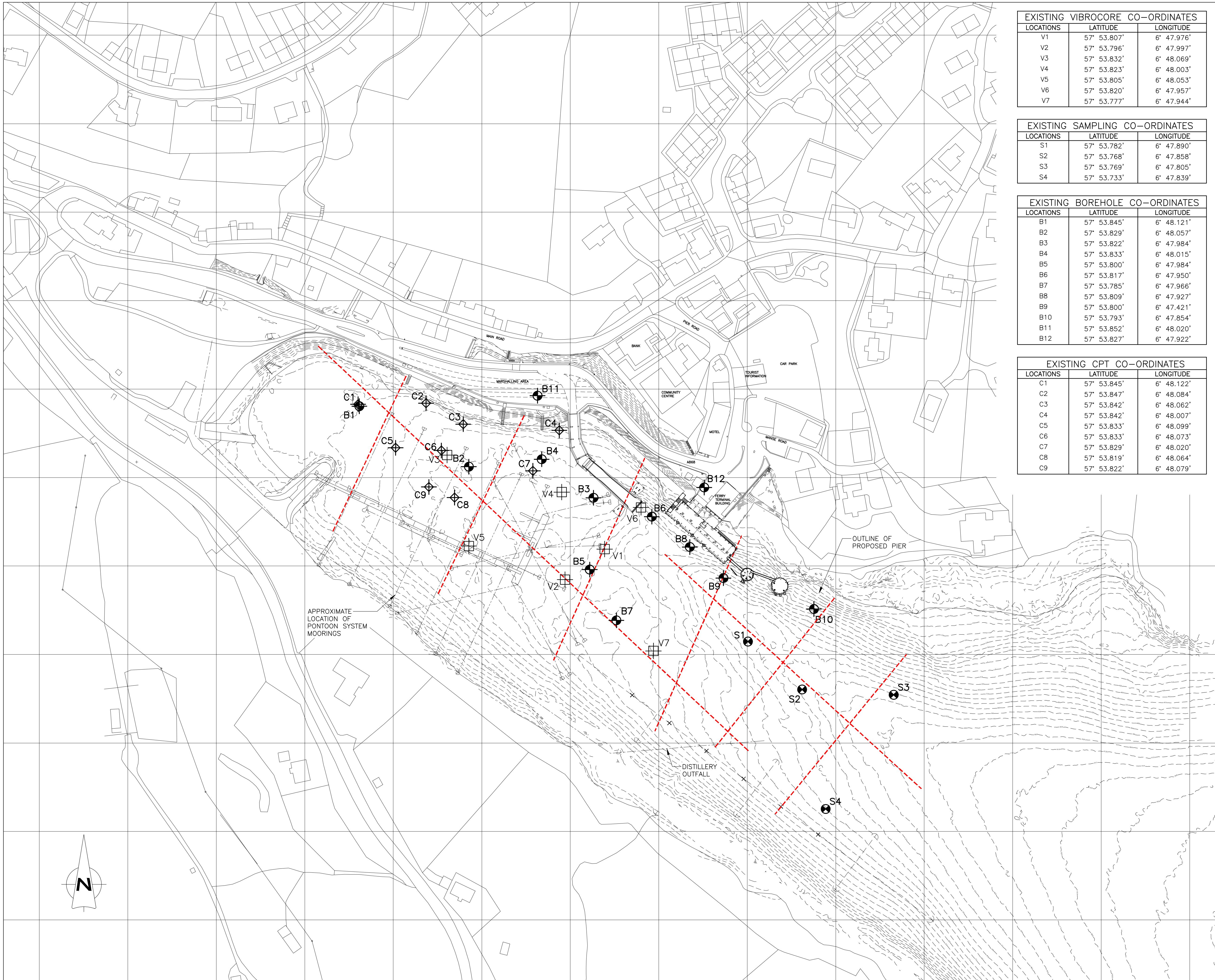
STAGE TENDER

REVISION A

PROJECT No. 1973

DRAWING No. 201

Appendix 2: Sample Locations



EXISTING VIBROCORE CO-ORDINATES		
LOCATIONS	LATITUDE	LONGITUDE
V1	57° 53.807'	6° 47.976'
V2	57° 53.796'	6° 47.997'
V3	57° 53.832'	6° 48.069'
V4	57° 53.823'	6° 48.003'
V5	57° 53.805'	6° 48.053'
V6	57° 53.820'	6° 47.957'
V7	57° 53.777'	6° 47.944'

EXISTING SAMPLING CO-ORDINATES		
LOCATIONS	LATITUDE	LONGITUDE
S1	57° 53.782'	6° 47.890'
S2	57° 53.768'	6° 47.858'
S3	57° 53.769'	6° 47.805'
S4	57° 53.733'	6° 47.839'

EXISTING BOREHOLE CO-ORDINATES		
LOCATIONS	LATITUDE	LONGITUDE
B1	57° 53.845'	6° 48.121'
B2	57° 53.829'	6° 48.057'
B3	57° 53.822'	6° 47.984'
B4	57° 53.833'	6° 48.015'
B5	57° 53.800'	6° 47.984'
B6	57° 53.817'	6° 47.950'
B7	57° 53.785'	6° 47.966'
B8	57° 53.809'	6° 47.927'
B9	57° 53.800'	6° 47.421'
B10	57° 53.793'	6° 47.854'
B11	57° 53.852'	6° 48.020'
B12	57° 53.827'	6° 47.922'

EXISTING CPT CO-ORDINATES		
LOCATIONS	LATITUDE	LONGITUDE
C1	57° 53.845'	6° 48.122'
C2	57° 53.847'	6° 48.084'
C3	57° 53.842'	6° 48.062'
C4	57° 53.842'	6° 48.007'
C5	57° 53.833'	6° 48.099'
C6	57° 53.833'	6° 48.073'
C7	57° 53.829'	6° 48.020'
C8	57° 53.819'	6° 48.064'
C9	57° 53.822'	6° 48.079'

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   MLWS +0.8mCD
   LAT +0.1mCD
4. CHART DATUM IS 2.74m BELOW ORDNANCE DATUM.

SYMBOL KEY

- EXISTING VIBROCORE SAMPLE LOCATIONS (2017–2018)
- EXISTING SEABED SAMPLING LOCATIONS (2017–2018)
- EXISTING BOREHOLE LOCATIONS (2018)
- EXISTING CPT LOCATIONS (2018)
- EXISTING BENTHIC TRANSECT LINES (2017–2018)

REV	DATE	DETAILS	DRAWN	CHK'D	APP'D
E	21.05.18	DISTILLERY OUTFALL ADDED AND INVESTIGATION LOCATIONS REVISED	JA	BP	TR
D	20.02.18	BENTHIC TRANSECT, VIBROCORES AND SAMPLE LOCATIONS ADDED	JA	BP	GB
C	12.02.18	BENTHIC TRANSECT LINES AND VIBROCORE LOCATIONS REMOVED	JA	BP	GB
B	26.01.18	PROPOSED BOREHOLES	JA	BP	GB
A	30.11.17	PROPOSED TRANSECTS	JR	BP	GB

AMENDMENTS

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DRAWING TITLE

GROUND INVESTIGATION PLAN

Redacted

DATE	DATE	DATE
NOV'17	NOV'17	NOV'17

SCALE (A1) 1:1000

STAGE INFORMATION

REVISION A B C D E

PROJECT No. 1973

DRAWING No. 005

Appendix 3: Attributes

Attribute	Description	1	2	3	4	5
Alignment with Policy	How complex are the regulator requirements and what risks are posed.	In direct conflict with policy.	Does not fully align with policy.	No policy implications.	In the spirit of policy.	Positively implements policy.
Cost	Financial Cost of the Option	>£2Million	£1M to £2M	£500,000 to £999,000	£100,000 to £499,000	<£100,000
Timescale	Will the timeframe for the option impact on the works schedule for the development? Dredging Scheduled 14/10/19 to 20/12/19 (10 weeks).	Dredge could not be completed within project timescale 2019.	Risk dredge couldn't be started within required timeframe for works schedule	High risk dredge couldn't be completed within required timeframe for works schedule	Risk not all areas could be dredged within required timeframe for works schedule.	Allows dredge to be completed comfortably within required timeframe for works schedule.
Material Suitability	Is the chemical makeup and PSD of material suitable for the option selected?	Not all of the material is acceptable.	Requires significant mitigation to be made suitable.	Acceptable with mitigation.	Acceptable material for option.	Ideal material for option.
Distance	Impact location has on logistics for material movements.	Beyond 50 miles	40-50 miles	30-40 miles	1-30 miles	Within 1 Mile
Technically Feasibility	Is the option within the capabilities of the CMAL to carry out?	Technology not proven.	Complex requirements, but proven technology.	Simple proven technology available.	Practicable with basic management.	Standard practice
Environmental Effects	Potential environmental effects associated with implementing the option.	Very Significant	Significant	Minimal	Trivial	None
Impacts on Harbour Operations	Level of interfere with normal harbour operations.	Very Significant	Significant	Minimal	Trivial	None
Legislative Complexity	How complex are the regulator requirements and what risks are posed.	Significant risk additional permits, licences or consents will not be granted.	Requires significant additional permits, licences or consents.	Requires additional permits, licences or consents.	Minor management required to comply with legislation	Complies with all relevant legislation.

Appendix 4: Options Scoring

Attribute	Tarbert New Disposal Site	Stornoway HE035	Plough Dredge
Alignment with Policy	2	2	2
Cost	2	4	3
Timescale	1	5	3
Material Suitability	4	4	4
Distance	5	4	5
Technically Feasibility	5	5	3
Environmental Effects	4	4	3
Impacts on Harbour Operations	4	4	4
Legislative Complexity	1	4	4
Total	**28**	**36**	**31**

Appendix 5: Reasoning for Attribute Scoring

Attribute	Tarbert New Disposal Site	Stornoway HE035	Plough Dredge
Alignment with Policy	Disposal at sea is low on the waste hierarchy and as such does not align to policy.		
Cost	Costs associated with this option will be significantly higher than disposal at an existing sea disposal site. This is due to the licence requirements to designate a new site as outlined in the Dredging and Sea Disposal Sites: Guidance on Creating a New Sea Disposal Site. (Marine Scotland, 2013).	Estimated a lower cost than other options / dredger would complete the disposal operation no further costs associated with the works.	Cost associated with this as a singular option would be lower than disposal of all material to Stornoway as this is a proportion of the dredge area, however, to complete the entire required dredge there is the need to mobilise a second dredge and disposal campaign.
Timescale	Timeframes associated with the application and consenting of a new dredge disposal site can be lengthy and is therefore unlikely to permitted within the required timeframe for the scheduled dredge.	It should be practical to implement this option within the required timeframe. As disposal can be completed quickly during dredging.	It should be practical to implement this option within the required timeframe. As disposal can be completed quickly during dredging.
Material Suitability	Material is acceptable for the option of sea disposal under the Pre-Disposal Guidance issued by Marine Scotland.		
Distance	New proposed disposal site would be within 1 mile of the development.	Site is within 30 miles from the ferry terminal development dredge area. This is the closest open site to the proposed works.	Site is within 1 mile of the proposed dredge
Technically Feasibility	The disposal to sea is an established and well-practised methodology.	The disposal to sea is an established and well-practised methodology.	The plough dredging is an established and well-practised methodology. However, the process will not be able to access all areas required for the dredge.

Attribute	Tarbert New Disposal Site	Stornoway HE035	Plough Dredge
Environmental Effects	The initial effects of disposal at a new site will have been assessed alongside the application to have the area classified as a new disposal site. Though smothering will occur there should be minimal environmental effects, with temporary effects on water quality possible.	The disposal to sea at an existing disposal site will have minimal environmental effects, temporary effects on water quality may occur.	Plough dredging could lead to increased sediment loading in the water column for a longer period of time than other dredge options in the East Loch Tarbert area, reducing the water quality and having knock on ecological and visual impacts.
Impacts on Harbour Operations	Dredging works are required to ensure safe access for the new vessel and improvements to the existing infrastructure. Existing operations would need to be managed around the dredging works.	Dredging works are required to ensure safe access for the new vessel to the terminal. Alongside improvement of existing ferry terminal infrastructure. Therefore, existing operations will need to be managed around the dredging works.	Dredging works are required to ensure safe access for the new vessel to the terminal. Alongside improvement of existing ferry terminal infrastructure. Therefore, existing operations will need to be managed around the dredging works.
Legislative Complexity	Designation of new disposal site would require licensing from Marine Scotland in line with the guidance issued on this. Once designated disposal would be permitted under the dredging marine licence.	Disposal to sea would be permitted under the dredging marine licence.	Disposal by plough would be permitted under the dredging marine licence.