Appendix 17.2 Dredging Desk Study

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Appendix 17.2 Dredging Desk Study

Executive Summary

To supplement the assessment of impacts to marine water and sediment quality, information is required on the likely disturbance to sediments and the fate of these disturbed sediments as a result of the dredging activity that may be likely. This Appendix provides a technical assessment of the potential for disturbed sediments as a result of the dredging.

Dredging requirements

The dredging requirement comprises two areas, with a total volume up to 3,000 m^3 of sediment to be removed by dredging:

- A new extended slipway of up to 600 m^3 of sediment to a maximum of 1 m depth.
- A landing jetty requiring approximately 2,400 m^3 of dredging to a maximum of 1m depth. This includes dredging within the footprint of the landing jetty.

The locations of the dredge areas are shown in Figure A17.1 below and includes the locations of the slipway and jetty.

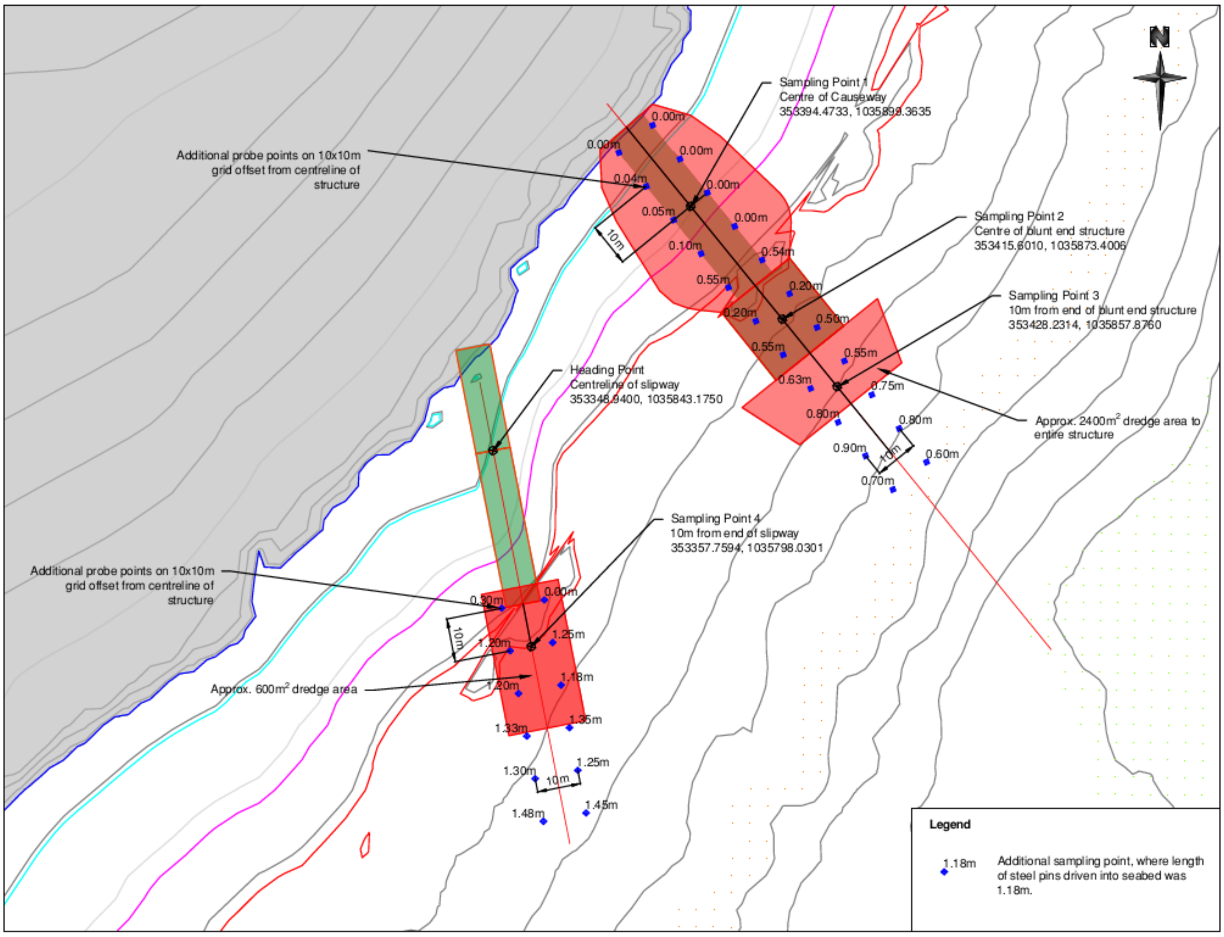

Figure A17.1 Dredging Footprints

Sediment quality

The two dredging areas are relatively close, geologically speaking, and have been described in discussion as having the same sediment characteristics which is:

- Boulders on sand up to approx. 25-30 m from the shoreline.
- Sand from approx. 45-50 m up to 75 m from the shoreline. This extent of 75 m aligns with the seaward end of the dredging footprints.

Particle size analysis

Four particle size analyses were provided where the laboratory tests comprised a 2 mm sieve with the material undergoing particle size analysis by laser diffraction. This was carried out by James Hutton (2021). Gravel was not detected for any of the four samples.

All four locations showed zero to tiny fines contents with an average of 0.4% fines across the four samples. The 10th, 50th and 90th percentiles are shown in Table A17.1 where the overall median grain size is 198 microns.

Table A17.1 – Particle size analysis results summary

PSD output	Location 1	Location 2	Location 3	Location 4	Average
Fines (%)	0.0	0.1	0.8	0.7	0.4
d_{10} (µm)	136	108	102	109	114
d_{50} (µm)	224	188	180	200	198
d_{90} (µm)	393	350	341	425	377

Boulders and sandstone

From discussion with the client, the sandstone is from the Lower Eday Sandstone formation. Analysed samples from churches built of this stone mined from the quarry at Eday (Everett, 2019) show that only 5-10% of the sandstone could be fine material, this fine material forming the cementation between sand particles.

The boulders are of an unknown size and density upon reporting, furthermore it is possible that more boulders are currently undetected below the seabed surface. However, any assumption of rock (or cemented material) would generally reduce the amount of material that is available to be "spilt" during dredger operation and contribute to any sediment plume.

Backhoe Dredgers

Backhoe Dredgers (BHDs) are expected to be used for the dredging works at Faray. BHDs combine excavating equipment with a floating pontoon system. The backhoe may either be free standing or, as with large examples, permanently mounted into the pontoon itself within a fabricated pedestal. The pontoon is positioned using external tug support or by the bucket pulling itself along the seabed and may then undergo smaller movements using the spud system, mounted at the rear of the pontoon. These spuds are fixed poles that anchor the dredger on at least two points on the seabed so that a rigid platform allows the bucket to exert force onto the excavated face.

The bucket size depends on the nature of the material to be dredged and the maximum dredge depth. Tear-out forces decrease with depth and with increasing bucket size; therefore, for harder materials it is normal to see smaller sizes used with over-sized teeth designed to penetrate and rip the material.

Figure A17. 2 Backhoe Dredger (Source: Boskalis)

Dredging methodology

A backhoe and hopper barge operation are the assumed dredging methodology and the spillage rates of dredged material were modelled in order to provide sediment source-terms and release rates.

The disposal site is not confirmed however for the purposes of this assessment is assumed to be the licenced disposal site Stromness A which falls west of the mainland of Orkney, this will be confirmed as part of the dredging marine licence application. The sailing route to this site from the dredging works is approximately 30 nautical miles (Figure A17. 2). Due to the longer sailing distance, the backhoe dredger will operate most efficiently if two hopper barges are provided to the works, or the backhoe operates daytime only operation with disposal occurring by the hopper barge at the end of the shift.

The operational assumptions used to provide the sediment release rates are as follows:

- 12 hour daytime only operation is assumed. This is considered appropriate as mobilising a second crew for a night-shift may not be justifiable for a project of this volume;
- No barge loading downtime is assumed. This assumes therefore that either barge disposal occurs outside of the 12 hour daytime shift, and that the barge is at least large enough to hold one day's production;
- Normal operating efficiencies are assumed, and no significant causes of dredger downtime have been allowed for, such as high wave climate or turbidity restrictions;
- No allowance is made for restrictions due to soil contamination and any mitigation measures that this might require;
- The dredged material is likely to be sand with some instances of boulders. Sand was assumed as being of Loose density;
- No mitigation measures have been assumed for dredger operations to reduce the source-term e.g. using bucket closing lids;
- No overflow (of excess water) is assumed from the barges;
- A backhoe bucket size of 2 m^3, which corresponds to a small backhoe dredger and pontoon.

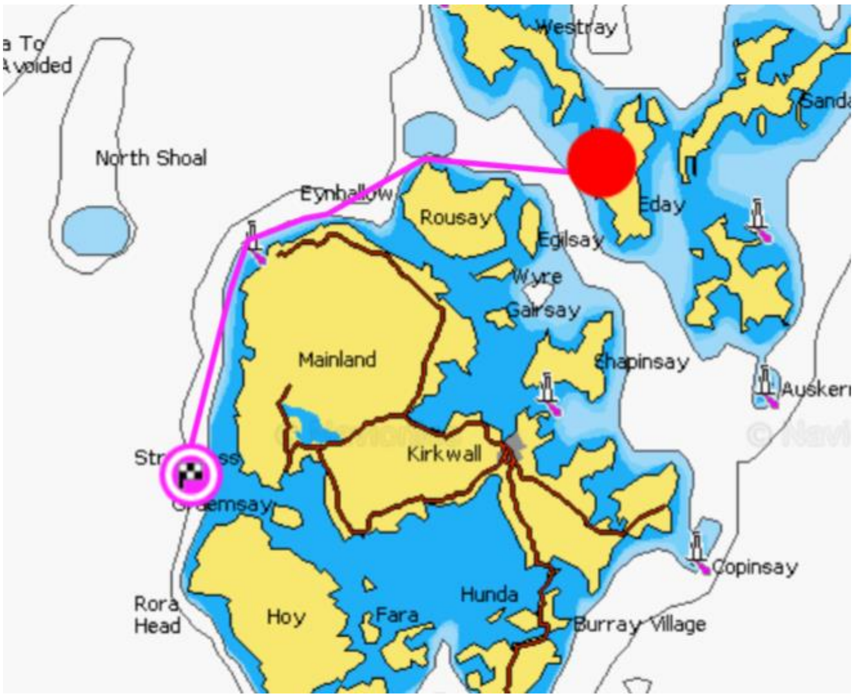

Figure A17. 3 Potential material placement site and approximate sailing route (source: Navionics ChartViewer)

Dredger source-term

Release of sediment into the water column

The estimated backhoe dredger production rate was modelled as 3,400 m^3/week which means that the work would be carried out in under a week. This is expected to produce spillage of soil (i.e. of all sediment fractions) at a rate of 0.6 kg/s. If boulders are found, this release rate can be expected to be even smaller due to natural cementation of material.

The rate of release of fine sediment (silt/clay) particles is 0.4% of 0.6 kg/s, however this produces the almost negligible figure of approximately 0.002 kg/s. Such a low rate of release suggests (e.g. using standard dispersion equation, Fischer et al, 1979) that predicted concentrations of fine sediment (silt/clay) in the water column will be negligible.

Sand particles released from the dredging will descend and deposit on the bed within a few hundred metres (see Table A17.2). Using standard dispersion equations (e.g. Fischer et al, 1979) and accounting for the settling of the sand particles onto the seabed over time, it is possible to estimate the dispersion and concentrations within the dredging plume with distance. Assuming a neap tide current of 0.25 m/s and a spring tide current of 0.5 m/s:

- within 50 m of the dredging the predicted increase in suspended sediment concentration over background concentrations will be around 16 mg/l on neaps and 11 mg/l on spring tides;
- within 100 m of the dredging the predicted increase in suspended sediment concentration over background concentrations will be around 3 mg/l on neaps and 6 mg/l on spring tides;
- within 200 m of the dredging the corresponding concentration increases will be 1 mg/l or less.

Note that as the released particles are sand-sized (rather than silt/clay-sized) there will be a much-reduced effect on turbidity (compared to a similar concentration increase composed of sit/clay particles).

Measurements of background suspended sediment in the Orkney area are limited but satellite-based measurements of sea surface suspended sediment concentrations are available (Marine Scotland, 2020). These show that sediment concentrations at the surface at Orkney are generally in the region of 1 mg/l but increase up to 3 mg/l at times. Within around 200 m of the dredging area the dredging plume has reduced to levels which lie within this range of natural variability. In practice the range of natural concentrations will be higher due to storms which the episodic satellite measurements will not take into consideration, and therefore the impact of the proposed dredging will be even smaller compared to the natural range of conditions.

Deposition of sediment onto the seabed

The sand particles released into the water column will re-deposit onto the bed within a few hundred metres of the dredging. It is possible to estimate the distribution of this re-depositing sediment by considering the rate at which these sand particles will fall back onto the bed and the distance moved by the sand particle (under the influence of tidal currents) over that period. The release of sand particles is estimated to be 5% of the material that would be dredged (though this figure will reduce depending on the prevalence of sandstone boulders). This means that around 150 m^3 of sand will be deposited, a portion of which will redeposit in the dredging areas and be re-dredged.

Approximate transport distances for the average particle sizes calculated in Table A17.1 were estimated using settling velocities calculated using the method of Soulsby (1997). Local currents for the area were estimated from the Marine Scotland Atlas (Marine Scotland, 2021) as being up to 0.5 m/s. It is assumed that peak neap tide currents are half this speed. Water depths at the point of dredging are up to -5 mLAT, equivalent (on the basis of the Marine Scotland Atlas prediction of spring tidal range average depths (to mean sea level) of around 6.5-7 m. An average water depth of 7 m is used to calculate the distance travelled total settlement durations shown in Table A17.2.

Table A17. 2 Maximum distances over which sand particles will settle

PSD fraction	Particle size (µm)	Settling velocity (mm/s)	Maximum distance travelled on spring tides (m)	Maximum distance travelled on neap tides (m)
d10	114	7.5	467	234
d50	198	21.1	166	83
d90	337	49.9	70	35

Using the results of Table A17.2, and accounting for the likely distribution of sand on spring tides and neap tides, and on the ebb and flood tide, it is possible to estimate the likely distribution of sand depositing from the plume. The results are shown in Figure A17. 3.

Figure A17. 4 shows two distributions: the distribution for the 50 m strip closest to the shoreline where deposition will solely arise from the dredging for the causeway; and the distribution for the strip 50-75 m offshore where deposition will arise from dredging for the slipway and for the causeway.

The figure indicates that the deposition is in the region of 8-14 mm within 50 m of the slipway and causeway, 2-8 mm within 50-150 m of the slipway and causeway and falls below 1 mm at a distance of 200 m.

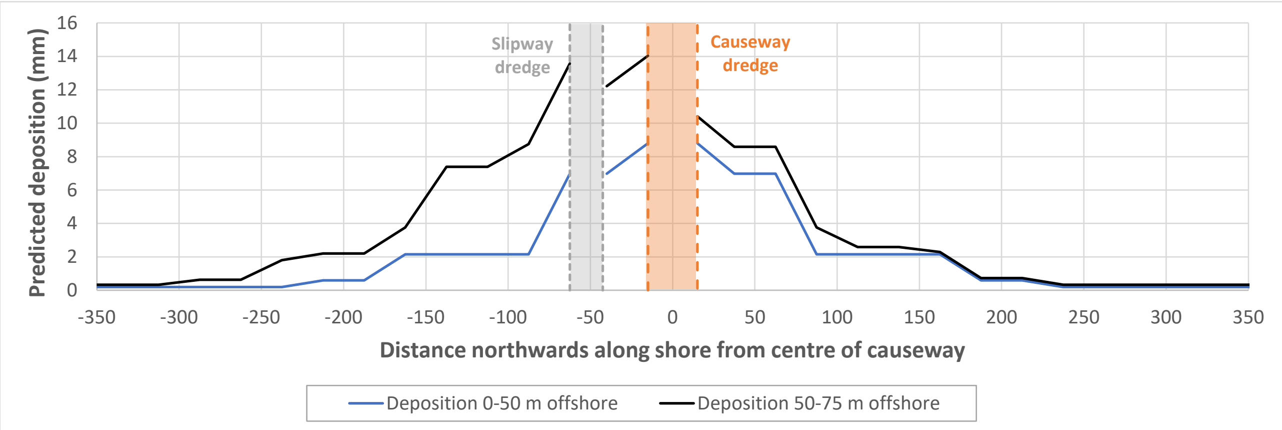

Figure A17. 4 Predicted distribution of sedimentation in the vicinity of the slipway and causeway resulting from the proposed dredging

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