Aberdeen Harbour Expansion Project

Construction Environmental Management Document

11th May 2017

DRAGADOS

Contents

Chapter 7

Dredging and Dredge Spoil Disposal Management and Monitoring Plan

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7 Dredging and Dredge Spoil Disposal Management Plan

7.1 Introduction

7.1.1 Outline

For the Aberdeen Harbour Expansion Project (AHEP), Dragados have contracted Jan De Nul NV (JDN) for the dredging works. Drilling and blasting operations will also be part of JDN's scope. This plan outlines JDN's approach for the environmental management and monitoring of the dredging and dredged material disposal activities.

JDN regards environmental and community issues as integral elements of its business and is committed to best practice environmental management in all aspects of the operations. This commitment to good environmental management is supported by an Environmental Management System (EMS) that complies with ISO 14001 (See Appendix A1).

JDN has established, implemented and maintains documented environmental objectives and targets, at relevant functions and levels within the organization. The objectives and targets are measurable and consistent with the environmental policy, including the commitment to prevent pollution, to comply with applicable legal and other applicable requirements, and to improve continually.

In addition to the corporate system, JDN will comply with the project objectives and targets.

During the execution of the project, following aims will be taken into account:

- Mitigation of the impact on the environment caused by construction activities;
- To minimise any disturbance to the human population and to the fauna and flora;
- To minimise waste production
- To prevent any contamination of the land and marine environment through disposal of waste, spillages or leakages of chemicals
- To ensure the project is implemented in accordance with environmental permits and requirements

JDN's aim is to execute the works in compliance with the requirements set out in the AHEP Environmental Statement (ES, 2015), Marine Licenses (ML), Harbour Revision Order (HRO), the Specifications of the Contract and applicable laws.

7.1.2 Roles, Responsibilities and Cross-Referencing

Table 7.1 details the responsibility of selected staff with regards to construction dredging and blasting.

Table 7.1: Roles and Responsibilities Table

Job Title	Name	Responsibilities
JDN Project Manager	TBD	Responsible for all dredging and blasting activities, including HSE and complying with all relevant regulations. Managing the relevant parts of the CEMD. Task delegation.
Environmental Manager	TBD	The EM will manage the environmental control facilities and monitoring and liaise with Dragados on a day to day basis. They will be responsible for the daily environmental tasks.
ECoW	Emma Bias	Toolbox Talks, Audit the JDN procedures
Dredge Master	TBD	Dredging operations

7.1.2.1 Cross-Referencing

The Dredging and Dredge Spoil Disposal Management Plan should be read in conjunction with the following CEMDs:

- Construction Method Statement;
- Waste Management Plan;
- Pollution Prevention Plan;
- Vessel Management Plan;
- Marine Mammal Mitigation Plan;
- Fish Species Protection Plan; and
- Nigg Bay SSSI Management Plan.

7.2 Dredging and Blasting Management Plan

Detailed information on the construction methods for the complete development are available in the Construction Method Statement (CMS), Chapter 3 of the Construction Environmental Management Document (CEMD). The area to be dredged is shown in blue in Figure 7.1, and the area that is expected to need blasting is hatched in red in Figure 7.1.

The licensed offshore Disposal Ground (CR110) is situated 2.2 nautical miles south east of the dredge area.

Cross reference should be made to Chapter 8: Fish Species Protection Plan, Chapter 11: Marine Mammal Mitigation Plan and Chapter 16: SSSI Management

Plan where mitigation measures to protect specific receptors such as fish, marine mammals and the SSSI are fully described.

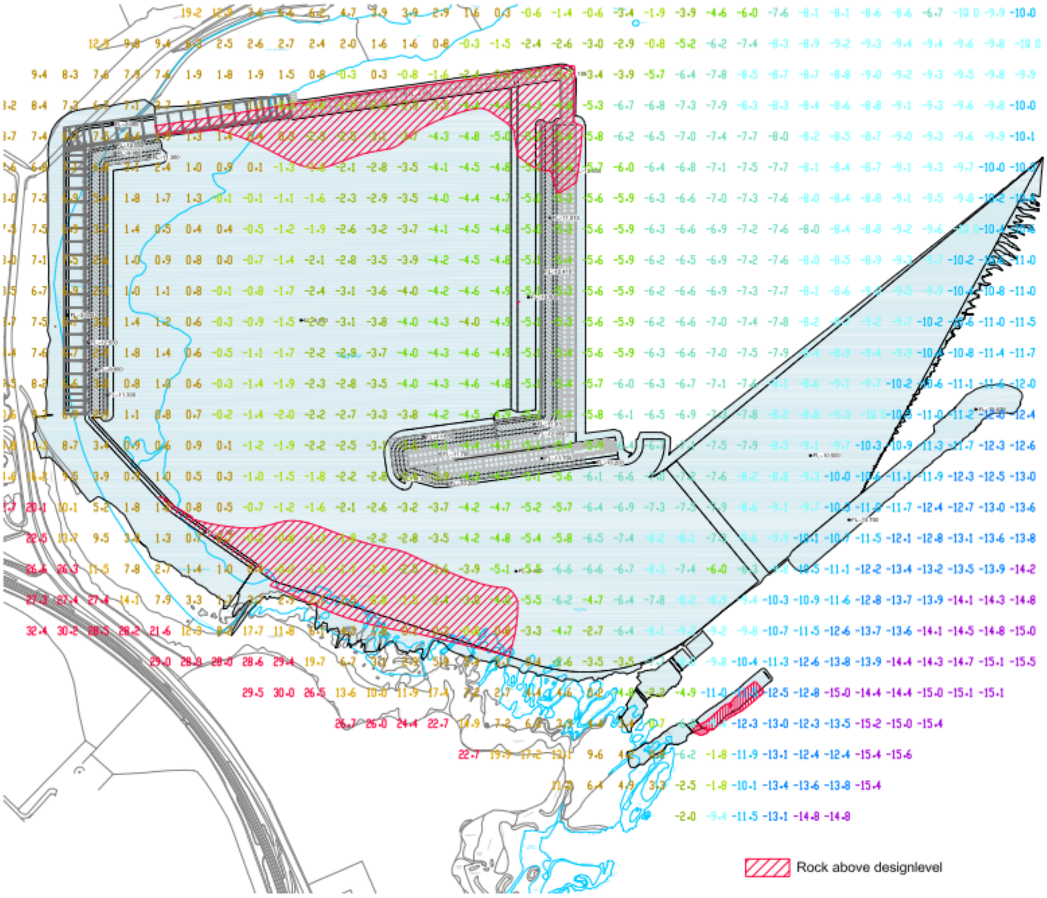

Figure 7.1: Dredging and blasting areas

7.2.1 Dredging and Blasting Techniques

7.2.2 Trailing Suction Hopper Dredger (TSHD)

The TSHD is a common dredging vessel. It is a sea-going, self-propelled vessel and its main working components and their respective function in the dredging process are briefly explained below. A TSHD is in general deployed for the mining and hauling of granular materials and the dredging of soft to firm clays. The general layout of a TSHD is shown on Figure 7.2.

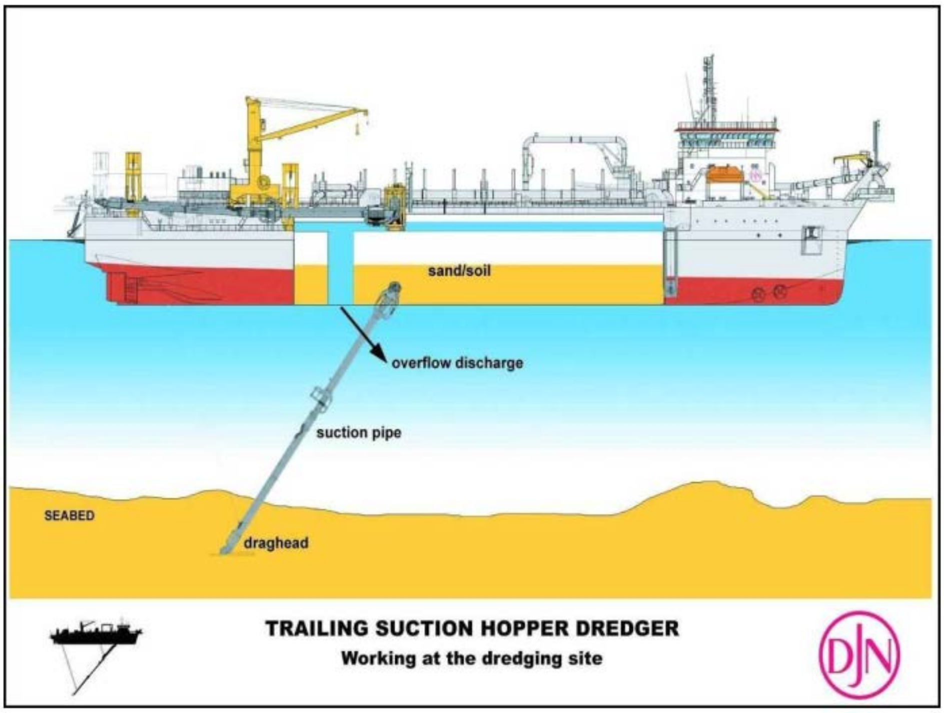

Figure 7.2: General Layout of a TSHD

A trailing suction hopper dredge is commonly used for dredging silty, sandy or gravely soils or soft clayey soils. While all other types of dredges rely on other tools for transporting the dredged materials, a TSHD will store the dredged materials in its cargo hold, called the hopper. The dredged materials can thus be transported over long distances.

Conventional hopper dredging activities can be divided in following consecutive activities: loading (dredging), sailing loaded, unloading and sailing back empty. A complete set of these four activities is called a dredging cycle.

7.2.2.1 Sailing to the Borrow Area

The dredging cycle starts with the empty TSHD sailing to the dredging area guided by its in-house developed, highly accurate navigation systems.

7.2.2.2 Dredging

The dredging systems of a TSHD consist of one or two suction tubes, each driven by a powerful centrifugal pump, called the sand pump. During the dredging, and in a process which is quite similar to the domestic vacuum cleaner, the lower ends of the suction tubes are trailing along on the seabed, while the sand pumps provide the suction power to lift the materials from the seabed into the hopper.

Once the TSHD approaches the dredging area, the sailing speed is reduced and the suction tubes will be hoisted over board and lowered to the seabed.

Figure 7.3: TSHD draghead

At the lower end of the suction tube, a special draghead is attached which is designed for maximizing the dredging production during the loading phase (see Figure 7.3). The suction power is provided by the sandpump, which is normally installed in the pumproom in the engine rooms of the dredger. Alternatively, the suction power can be provided by an underwater pump mounted on the suction tube itself. This underwater pump enables high dredging productions at greater water depths.

During the dredging, while the draghead is on the seabed, the TSHD will maintain a low trailing speed. Such trailing speed is depending on the nature of the materials being dredged.

The materials lifted from the seabed are pumped into the hopper (see Figure 7.4) as a soil/water mixture. Care is taken to minimise the water content in the mixture.

Figure 7.4: Hopper well

Specialised operators control the highly computerised dredging process. The dredge master and the navigating officer will be, each one responsible for his area of control, co-operate closely. The computerisation covers all possible parameters involved in the dredging including dredging productions, engine and pump loads, draghead positions and hopper levels, amongst others.

While the soils in the dredged soil/water mixture will settle in the hopper due to the gravity forces, the excess water is discharged via an adjustable overflow system.

The overflow, which is built inside the hopper, consists of a height adjustable funnel mounted on top of a vertical cylinder which ends under the keel of the dredger. The excess water is discharged under the dredger, which is the lowest level possible, thus minimising the dispersion of fines into the surrounding waters.

Further, the design of the overflow is such that, by avoiding the entrapment of air in the overflow water, a minimum of turbidity is created.

7.2.2.3 Sailing to the Disposal Site

As soon as the hopper is fully loaded, the suction tubes will be hoisted back on board and course will be set towards the disposal site. During this transit the hopper dredger is sailing as a regular cargo vessel.

7.2.2.4 Discharging / Disposal

There are several ways to discharge the hopper load.

a) Bottom door disposal

The fastest way to unload the hopper is by discharging the load through the opened bottom doors of the hopper.

When the hopper dredge has arrived at the disposal site and the navigating officer is confident that the hopper dredge is on the area where the hopper load is to be unloaded, the command will be given to open the bottom doors to dispose the hopper load (see Figure 7.5).

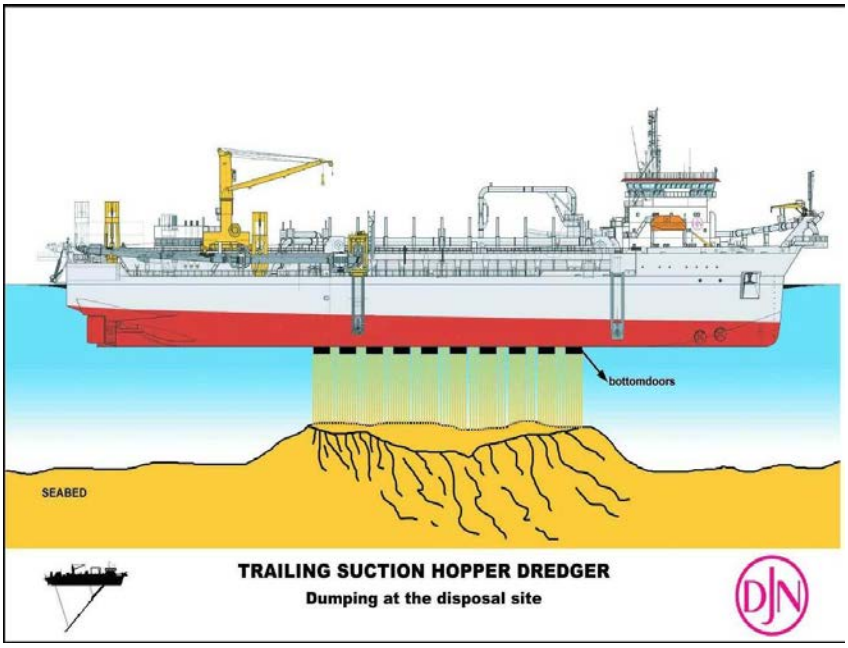

Figure 7.5: Bottom door disposal

Waterjets inside the hopper will ensure the hopper is completely empty and free of dredged material prior to closing the bottom doors.

A new dredging cycle can commence by sailing back to the dredging area.

b) Pumping ashore

Some TSHDs are equipped with pumping ashore facilities. This enables them to pump the hopper load via a combination of a floating pipeline and shore pipelines directly into a reclamation area onshore. To this end a coupling system will be prepared consisting of a flexible floating pipeline with at its seaside end a special bow connection piece. The other end is connected to the shore pipeline.

The hopper dredger, upon arrival at the coupling area, will be connected via the bow connection on board to this floating pipeline. Now the jets in the hopper will fluidise the sand in the hopper. The sand pumps will pump this fluidised mixture of sand and water through the pipelines to the reclamation area (Figure 7.6).

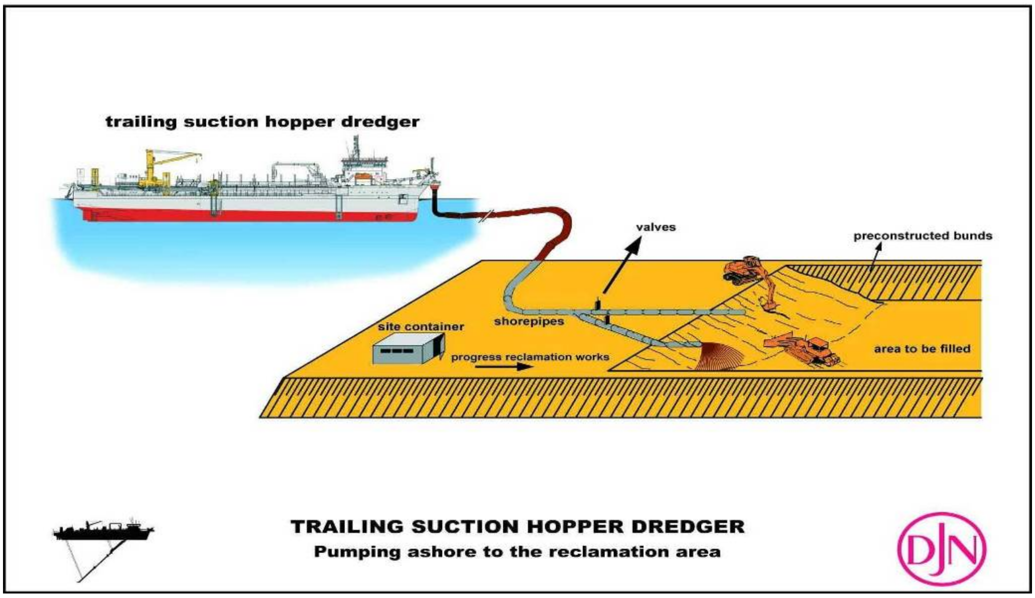

Figure 7.6: Pumping ashore

7.2.3 Cutter Suction Dredger (CSD)

7.2.3.1 Description of the Equipment

A CSD is one of the most commonly used types of dredging equipment. It is a stationary dredging vessel and its main working components and their respective function in the dredging process are briefly explained below. A CSD is in general deployed for the re-handling of sand and the dredging of stiffer clays and hard strata.

The CSD scheduled for this project is a self-propelled vessel, meaning that she can be repositioned under her own propulsion, i.e. when all dredging gear is hoisted from the seabed she can freely navigate to other sections of the work.

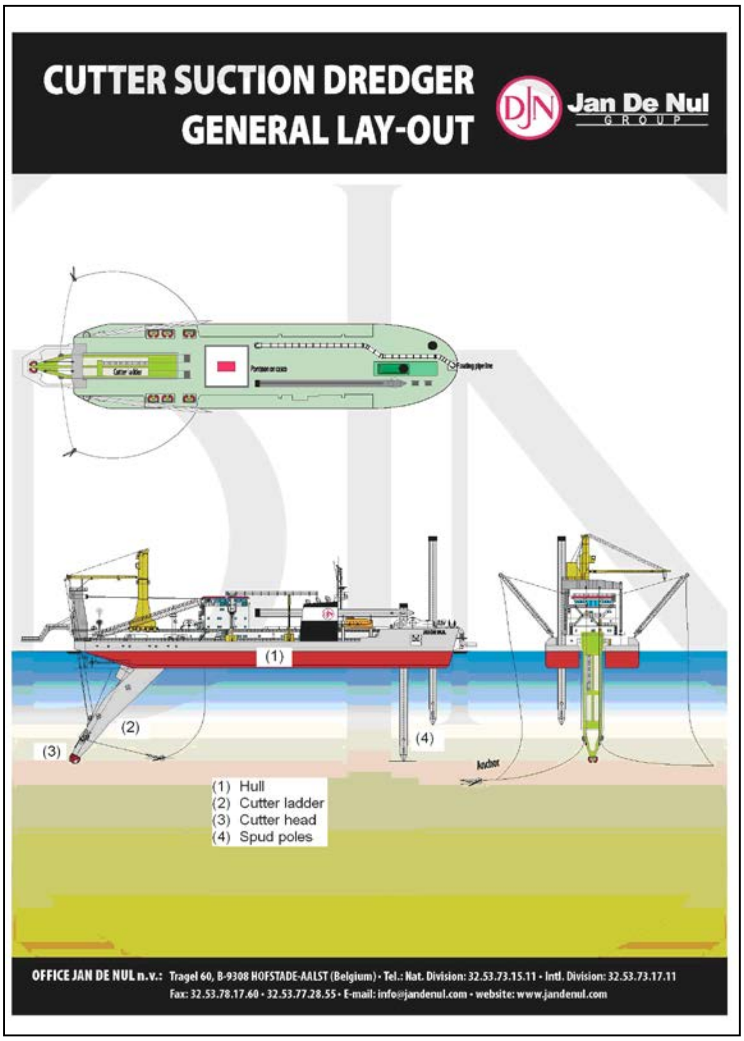

Figure 7.7: General layout of CSD

The pontoon (or casco) is the hull of the vessel housing the living quarters, engine and pump rooms, propulsion system, on-board mechanical workshop, fuel, lubricants and fresh water storage, wheel house, spare parts stores, food supplies etc. The overall size and weight of the casco will determine the main working limits of the vessel.

The cutter ladder pivots up and down around a pin that connects it to the casco. It not only houses the cutter engine and the underwater pump that sucks the material-water mixture through the cutter head towards the main pump(s), but its other main function is providing the sheer weight to force the cutter head into the cutting face. The ladder is hoisted for regular maintenance and inspection by means of the ladder hoisting wires.

The cutter head (see Figure 7.8) is the rotating cutting tool mounted at the end of the cutter ladder that creates a mixture of material and water that can then be discharged hydraulically. The cutter head consists of a set of blades that form a half-sphere shape. The number of blades and hence also the opening between them varies with the type of material that needs to be dredged. If required cutter heads can be changed in a fairly short time to cope with changing soil characteristics.

Figure 7.8: Cutterhead

On each blade a set of adaptors is installed on which steel teeth of a special alloy are locked into position. These teeth or pickpoints provide the chiseling effect and the shape of the blade provides the slicing effect. Different types of steel are available for different soil types. These teeth need to be inspected and replaced fairly frequently to ensure cutting efficiency. The adaptors and the cutter head are also brought regularly to the workshop on land for maintenance.

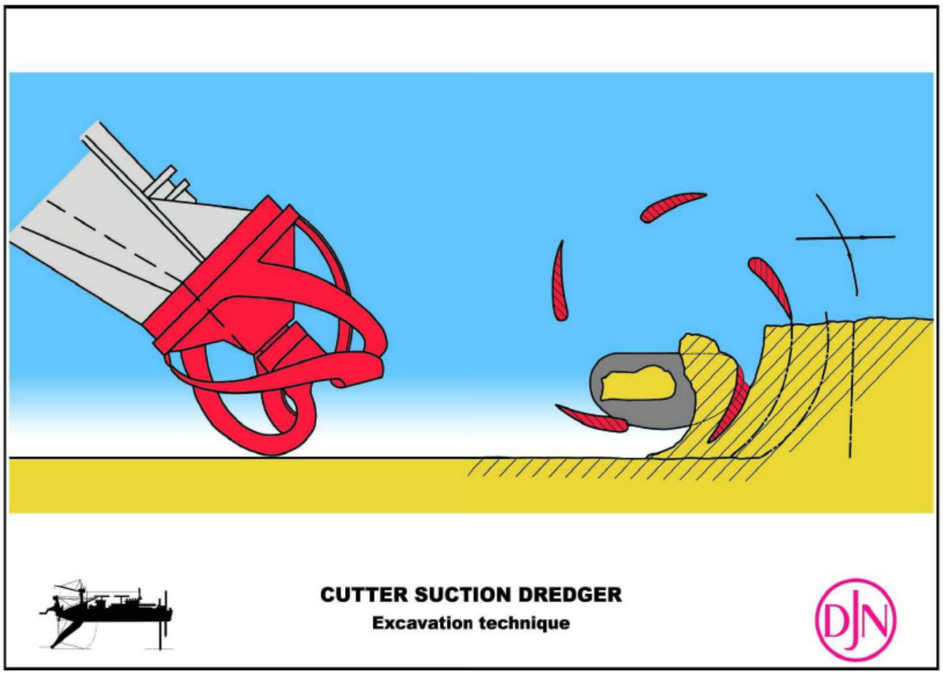

Figure 7.9: Excavation technique

The cutter engine is mounted on the cutter ladder and via the cutter shaft it drives the cutter head.

A set of side wires swings the ladder from left to right and back. They pull on large anchors (swing anchors) deployed on each side of the vessel. This pulling power together with the weight of the ladder provides the force needed to cut into the soil.

A swing anchor is attached to the end of each side wire. At regular intervals the anchors are repositioned to optimize their effectiveness. Sidewire Anchors of 15t will be used as swing anchors for the CSD. The fluke angel of the Sidewire Anchors can be adjusted to suit various soil conditions, i.e. if more or less fluke penetration is required or desired. These anchors can be repositioned by the dredge's own means (anchor booms) or by the auxiliary equipment (multi-cat or anchor handling barge).

The vessel has two such spud poles: a main pole and an auxiliary one. The main spud pole at the back of the vessel serve two functions: one is to provide the fixed point around which the ladder is swung from side to side and secondly it provides the resistance needed to keep the cutter head into the cutting face. Without enough counterforce the cutter head won't slice enough material, decreasing the vessel's performance considerably, especially in hard strata. The auxiliary spud pole is only deployed to keep the CSD in position when the main pole (mounted in the spud carriage) needs to be repositioned.

The spud carrier provides the forward motion of the CSD. The ship at the end of a swing will be pushed away from the main pole by extracting a hydraulic ram which has a maximum stroke of 9 m. Discrete steps of 0.5 to 2.0m are taken when pushing the vessel forwards. The magnitude of the step is determined by the soil resistance: 0.5m for hard strata and 2.0m for sandy materials.

The dredge pumps transport the dredged materials towards the discharge location. Several types of discharge exist. On this project, the material will be discharged in Split Hopper Barges.

Barge loading: barges are moored alongside the CSD and a discharge boom is lowered over the barge's hull (see Figure 7.10). The boom has several openings allowing a good spread of the dredged material inside the hopper barge.

Figure 7.10: Barge loading

7.2.3.2 Working Principles

The rotating cutter head will first cut out the materials to be dredged, in order to get them in a suitable state for removal by hydraulic means. The loosened material then enters the suction mouth, passes through the suction pipe and the pump (or pumps) and into the delivery line. The CSD is operated by swinging about the central work spud using moorings leading from the lower end of the ladder to anchors. By pulling on alternate sides the dredge clears an arc of cut, and then moves forward by pushing against the work spud using the spud carriage.

Once the spud carriage has reached its end position (6 or 9 m) the auxiliary spud will be lowered and the work spud raised, thus keeping the dredge in position. The main spud in its spud carriage will then be brought back in its original start position, where after the work spud will be lowered and the auxiliary spud raised in order to commence a new cutting arch.

The side anchors are lifted and moved forward when the dredge has progressed far enough and the force on the anchors is not sufficient anymore. The anchors are shifted using the dredge's own anchor booms system or with an auxiliary anchor handling vessel.

The control of the dredging process is maintained by means of the dredging computer and the Differential Global Positioning System. The output of this positioning system will be X and Y coordinates of the vessel. The Z coordinate is calculated by the dredging computer.

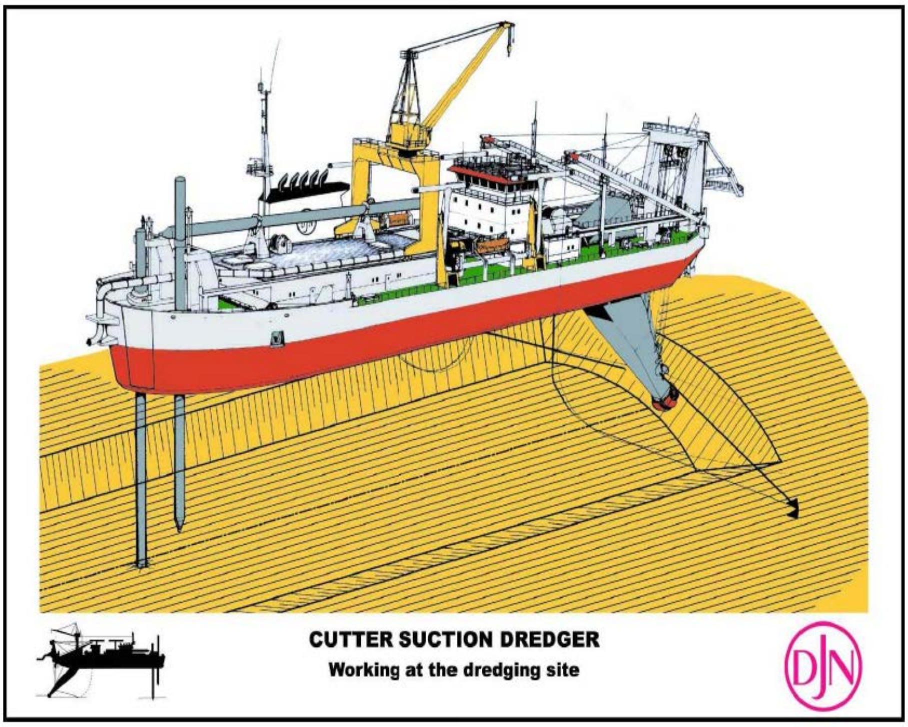

Figure 7.11: Cutter Suction Dredger working at the dredging site

7.2.3.3 Control Over the Dredging Operations

Control over the dredging operations is provided using following systems:

- DGPS positioning system: all main vessels are equipped with a differential GPS which means that to augment the accuracy of the coordinates acquired from the GPS satellites, a correction signal is received from a shore-based reference station. The position of this reference station is very accurately determined before it starts transmitting its corrective signal. The auxiliary craft are equipped with a GPS.

  The position of the GPS receiving antenna that is mounted on board the CSD is then used to compute the position of all the ship's major parts (essential in this exercise is the proper calibration of the ship's gyro compass) such as spud poles and cutter head.

- Survey computer: this system will take as inputs the DGPS-acquired position, the cutter head or drag head position relative to the vessel (provided by the Cutter Position Monitoring system), tidal info and ship's heading. The outputs provided by this system are the position of the vessel and the cutter head or drag head visualized on a screen with a bathymetric background, obstacles, buoys and of course the lines and limits of the project. A graphic representation of the survey data will be made so that the dredge master sees on his display how the cutter head/drag head is positioned relative to the existing seabed and the profile that needs to be dredged. A plan view can also be generated with a colour chart showing the areas and quantities still to be dredged.

- Cutter Position Monitoring: this system comprises a set of angle transducers measuring the exact angle of the cutter ladder vis-à-vis the casco allowing the determination of the cutter head relative to the ship. These relative x, y and z coordinates together with the absolute coordinates from the positioning system allow the dredger's computer to compute the exact position of the cutter head with respect to the existing seabed.
- Survey feedback: at regular intervals newly acquired survey data will be fed into the survey computer so that the dredge master is always presented with the most actual seabed 'view'. The quality and speed of this feedback is of great importance for not only the efficiency of the dredging process but of course also the overall result, i.e. working within the specified tolerances.

7.2.4 Backhoe Dredger

The backhoe dredger is a common type of dredger, generally non-self propelled. The main component is a hydraulic excavator, performing the dredging operation, mounted on a pontoon (see Figure 7.12).

The dredger will be towed into an approximate operating location by tugs and/or self-propelled split barges and will subsequently be anchored by lowering the three heavy-duty spuds. The dredger will move into the exact starting position by using the walking spud/spudcarrier and the bucket. In general the areas will be dredged in parallel lanes. The lane separation and bench-height will be decided during the dredging operation and are dependent on the nature and stability of the material, the siltation rate and the dredging capacity.

The dredging layout will take into consideration impacts from shipping activities, currents and wind and wave actions. Parts of the operation can if necessary be adapted to facilitate the dredging and other related activities. The start and end position as well as the bearing for each dredging line will be calculated in advance for the dredger to follow.

The most frequent width of one dredging lane will be 10 - 15 m. The dredger will dig steps of approximately 5m length. When one step is completed the dredger will release the front spuds from the sea bottom and raise them approximately 2m over the sea bottom. The walking spud/spudcarrier will shift the dredger 5m backward in the dredging lane and then start the new digging step.

Figure 7.12: BHD working

For horizontal positioning the dredger will use Differential GPS systems in combination with gyrocompasses.

For controlling the bucket position, the dredger is fitted with IHC digviewer systems or similar. These systems will measure:

- the angles for the boom, stick & bucket
- the pontoon draught
- the pontoon tilt
- bearing

The operator can follow the excavation operation on two video screens, one for horizontal bucket position and the other for vertical bucket position. The system will enable the dredge operator to follow the exact movements and the depth of the bucket, and facilitates digging in a controlled manner to the designed limits.

In this system the required dredging levels and slope angles can be pre-set in the computer so the operator can see the digging lines as well as the bucket position, in relation to the pre-set limits, on his video screens.

7.2.5 Water Level Control

Water level information will be provided by a radio-linked tide gauge. The tide gauge will be placed in the water close to the dredging area. The dredger will be equipped with a radio-linked receiver to monitor the tide level during the dredging operation. The "digviewer system" will receive the actual tide level several times per minute and the dredging depth is automatically updated.

7.2.5.1 Logging

The supervisor or the main operator on each shift will keep a log for noting events of significance for the dredging operation, such as operation hours, breakdowns, repairs, production rates, weather conditions, dredging area, dredging depth etc.

The area which has been dredged during the last shift will be marked on the specially designed dredging lay out drawings.

On board the barges a barge-report will be completed for each load, specifying date, shift, load number, departure time from dredger, the unloading berth and the unloading place.

7.2.5.2 Anchoring

The dredger is anchored by three heavy duty spuds, all wire operated with hydraulic winches, which are controlled from operator’s cabin.

7.2.5.3 Transportation of Dredged Soil

The transportation of material from the dredging areas to the unloading facilities will be executed by means of sufficient self-propelled split-barges.

7.2.6 Communication

All floating equipment will be equipped with VHF radio and mobile telephone.

7.2.7 Drilling and Blasting

7.2.7.1 Working Principles Drilling

For drilling, a heavy duty Top-hammer Rock Drill Sandvik Tamrock HL 1540 is used. 60 mm drill rods are used to drill holes in diameter ranging from 115 to 126 mm.

The drill tower is mounted to a frame which is holding the tower sideways from the platform over the water (see Figure 7.13). From one spud position a total area of 30x4m can be drilled. This usually means in practice two parallel rows of holes on a grid of 4 x 4 m (16 holes per spud position).

A typical field for blasting can be 40 to 80 holes.

Before drilling starts, the outer guidance tube is lowered on the seabed and pushed into the overlaying layer, down to the rock level, by means of air wash. The vertical position of the outer guidance tube is used for recording the top of rock level. This level is logged in the blasting plan chart, and is later used to calculate the amount of explosive. Drilling of the hole now starts. The length of the hole, and the final depth of drilling is determined by the required amount of over-drill, a parameter that shall be minimized, however selected in such a way that when dredging is executed after the blast, the excavation can take place to the required level without encountering hard spots. When drilling is on a grid of 4 x 4 m, the vertical overdrill is 2.5 meter. When the drilling is on a 2 x 2 m grid, as proposed for the part of the caisson trenches, the vertical overdrill is 1.5 m.

Figure 7.13: Movable drill tower

The pattern is always chosen in a way so that on one side there is an open face, so that the rock during blasting can freely expand sideways (see Figure 7.14).

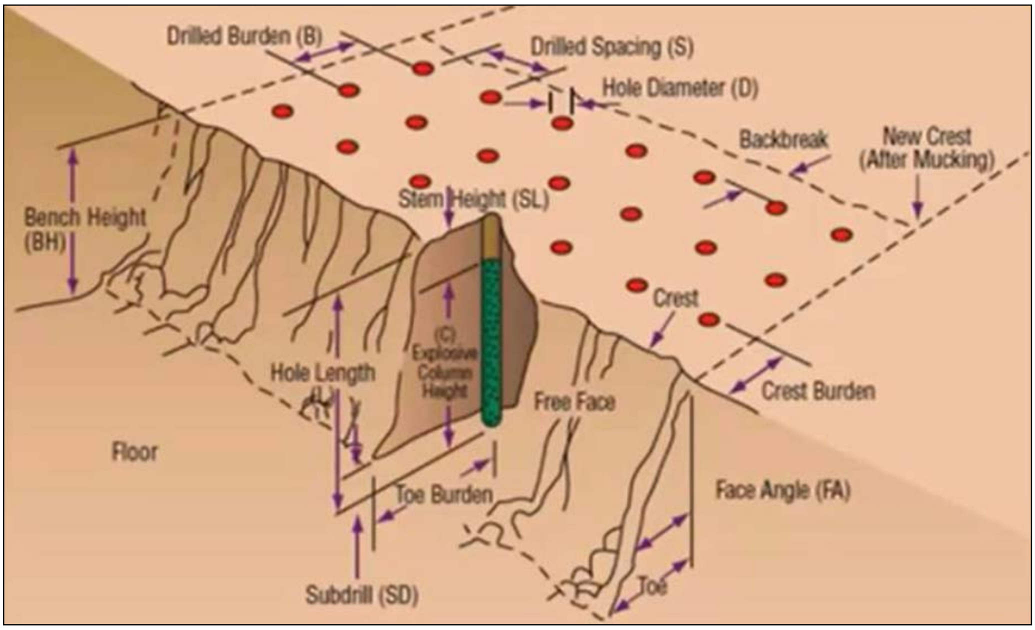

Figure 7.14: Typical lay out of one drill field

When the drilling of a hole is finished, the drill rod is removed, and the hole is ready for charging. Prior to pumping the explosive, the igniter/starter is placed in the bottom of the hole. The amount of explosive pumped in to the hole is carefully monitored and logged for each hole by the loading computer. After the hole is charged, the drill rig is moved on top of the next hole position, upon completion of the row, the second row is drilled and charged, after that the pontoon is moved to its next spud position, by means of stepping round one lowered spud at a time.

Positioning of the platform is secured by RTK/DGPS positioning system that provides accuracy up to +/- 5 cm. The drill pattern is pre-programmed and the computer map which is displayed on the operator’s monitor for accurate and efficient positioning.

7.2.7.2 Explosives

Immediately after each hole is drilled; the holes are filled by a computerized special pump with the explosives in the form of the pumped emulsion, together with the Nonell (Non-electric) igniters. The explosives consist of an emulsion called “Merikemmiiti”, a specialized, proven slurry for underwater use. Merikemmiiti has been used in Scotland on previous projects. Either imported Merikemmiiti, or the equivalent sourced through a local supplier, will be used.

Holes are typically charged applying a quantity of approx. 1 kilogram of explosive per m^3 of rock.

Supply of the explosives will be from a company in the UK that has the appropriate licence and permits to transport and store the explosive.

Transportation from the stock to the quay will be in small batches. This material can be safely transported as this type of explosive can only explode if in contact with a fused detonator. As the detonators are kept away from the explosives so that there is no risk of early initiation (ignition).

From the truck, which takes the material from the temporary stockpile, the bulk material (in containers of 1 m^3) will be lifted on a vessel at an approved quay place, then the vessel takes the holding containers to the blasting pontoon once per day.

On board the drilling platform a special container is used to keep the explosives for 1 day's usage. On a daily basis the quantity of explosives on board is topped-up, from the approved stockpile on land, using an approved company for storage and transportation. Excessive explosives are transported back to storage after blasting is complete. On board only personnel with the proper qualification and/or licence are allowed to handle the explosives. Nonell igniters are kept in a designated special container separate from the explosives.

The stock of holding containers with explosives on board is stored in a specially isolated 12 foot sea-container, which can be released from the deck and launched in the water in case of fire. The detonators are kept in a separate container which is 30m away from the emulsion container.

7.2.7.3 Working Principles Blasting

When the drill supervisor has decided that a field is complete, the field is immediately blasted. Blasting is expected to take place once or twice per day, unless the platform switches to dredging. In that case the dredging may continue for a period up to one week, after one of drilling may follow.

The parameters for blasting are:

- Hole spacing
- Hole diameter
- Hole depth to design level
- Over drill (sub drill)
- Charging the hole with explosives (kg / m^3 rock)
- Delay between the rows and delays between the holes
- Number of holes in a row, and number of holes in a field

The first number of blasts are executed with reduced loads and are used to determine parameters by which the optimum blasting parameters are calculated.

Prior to the actual blast, agreed and approved safety and warning procedures are followed. For this project the agreed procedures could read as follows:

1. One hour prior to the blast the Blast master alerts the agreed parties of the coming blast.
2. Drill platform / dredger is moved to safe distance from the blast area
3. 1 hour before the blast the Blast master informs the Marine Mammal Observer and Passive Acoustic Monitoring (PAM) operator in order to jointly make sure that environmental mitigation is adhered to and no marine mammals will

be present prior to blasting. MMO/PAM operator notify Blast Master if any animals spotted. (See Marine Mammal Mitigation Plan for further details)

4. Noise mitigation measures (bubble curtain) are activated after instruction of the Blast master (See Marine Mammal Mitigation Plan for further details).
5. Blast master is visually checking the area of blasting, to make sure no ships come near.
6. Blast master is assuring himself that there are no swimmers / divers are in the water of the bay.
7. If there is a vessel approaching (or other activity occurs in or near) the area of blasting, procedure is suspended, until the vessel has left the area
8. Blast master will make final check with MMO/PAM operator that no marine mammals are present.
9. During the one minute before the blast DB pontoon will signal the load horn using the blasting signal (increasing intervals).
10. Blasting
11. Immediately after blasting, DB pontoon will signal the “no more danger” signal (one long signal)
12. Bubble curtain switched off, any fish kill etc. or unusual activity recorded. (See Fish Species Protection Plan Section 8.5.5 and protocol for dead, injured or moribund fish found during construction activities)
13. DB pontoon is put back into position, the Nonell cords are gathered, drilling can be resumed
14. Blasting/dredging areas where blasting took place, and original depths are not yet restored, shall be marked by yellow buoys.

7.2.8 Test Blasting

On every jobsite the circumstances (depth, rock characteristics) are different. Due to nearby man-made structures / facilities different vibration limits may apply. It may be clear that vibrations very much depend on the distance from the blast.

Prior to blasting, the surroundings of the blasting area are surveyed by taking photographs of relevant parts of nearby buildings and structures. A careful set up blasting plan is in place prior to start of execution of the blasting works. This plan contains the limits set for vibration and thus for the characteristics of the blast (hole spacing, charge per hole, etc.).

Mitigation for test blasting will be deployed as per full blasting (so bubble curtain, MMO and Passive Acoustic Monitoring).

7.2.9 Subsea Rock Installation

The rock installation vessel ‘Adhémar de Saint Venant’ (see Figure 7.15) is equipped with front and rear azimuth propellers as well as powerful bow thrusters which can be operated by the Dynamic Positioning (DP2) system enabling the vessel to manoeuvre in any direction, or remain at a fixed position or track during less favourable sea and wind conditions.

Figure 7.15: FPV Adhémar de Saint Venant

The vessel has a rock carrying capacity of 5,100 tonnes and is equipped with a fall pipe and inclined fall pipe. Depending on the project requirements, the inclined fall pipe can be modified to allow installation of large diameter rocks.

The fall pipe tower consists of a hopper with a conveyor belt system which feeds the fall pipe. The amount of the installed material can be adjusted by setting the feeder output and the vessel’s tracking speed.

The vessel "Adhémar de Saint Venant " is able to work in sea conditions in the range of Hsig = 2.0m. When working at the most shallow location, this can be further reduced depending on the actual water depth, tide and existing structures.

All the equipment on board is supplied with adequate spare parts for ordinary maintenance and repair. Vital equipment components or units may need a 100% spare part supply on board or a full back-up unit to meet the operational objectives.

The works will be executed in a sequence similar to the following:
- The vessel will be loaded with rock;
- Once the vessel is loaded it will sail to the project site;
- Prior to rock installation, the works manager will define the sequence of the in-survey, rock installation and out-survey operations. He will take into account weather, currents, site constraints, rock load, etc.;
- Once arrived in the field, the vessel will enter DP mode. Position checks will be done before proceeding with the actual works;
- After the in-survey, the rock will be installed;

- After the rock installation, an out-survey will be done;
- Once the vessel is empty, it will sail back to for reloading.

A quality assurance system will be set-up to assure that the rock is installed according to the requirements and scope of work.

7.3 Work Method Statement and Planning

The material to be dredged can be split up in three main types of soil: gravelly sand, a layer of glacial till (a glacial deposit consisting in general of over-consolidated sediments as a mixture of hard clay, very dense silt, sands, gravels, cobbles and boulders) and zones with hard rock (granite and gneiss). Because of these different soil types, different types of dredging equipment are needed to complete this work.

The Trailing Suction Hopper Dredger (TSHD) will start with removing the top sand layer. Some softer parts of the underlying glacial till (where the water depth is sufficient to give access for the TSHD) will also be removed by the TSHD. The hopper dredge will dispose its load at the designated disposal area at 2.2 Nm south east of the project area. The TSHD will need 4-5 weeks to complete her job. The TSHD will come back in 2018 to dredge the access channel; all material dredged from this location can be re-used on land.

The main part of the top sand layer and the underlying till will be dredged by the Cutter Suction Dredger (CSD). The CSD will load the dredged material straight into split hopper barges (SHB) with capacities of 3700m^3. The barges will transport the dredged material to the designated disposal site and dispose its load by splitting the hopper. The CSD will also dredge some of the zones with rock (about 40 000 m^3). The CSD can do this work in 2 weeks whereas if blasted this would take at least 8 weeks.

In total the CSD will need about 12 weeks to finish the above dredging.

The BHD will mainly focus on dredging the top sand layer and the glacial till in the shallow areas. The BHD will also be used to take away the blasted rock. The BHD will load the dredged or blasted material straight into SHB of 1800 m^3. The SHB will sail to the disposal area to dispose the material (sand/glacial till) or bring the material to the offloading location for re-use on land (rock).

The Drilling and Blasting will start a soon as the top layer of softer material is taken out by the TSHD and/or CSD. After being blasted, the fragmented rock will be dredged by BHD. SHBs loaded by the BHD will move the rock to where it is to be re-used or stored.

All dredging will be undertaken 24 hours a day, 7 days a week; the blasting however will only be undertaken during daylight hours

Table 7.2 gives an overview of the dredging planning, the zones and volumes that will be dredged by each type of equipment.

Table 7.2: Overview of planned dredging zones and volumes

SEASON 1 - 2017			
Equipment	**Material**	**Duration**	**Approx. total volume to dredge**
TSHD	Sand & alluvium	4 weeks	250 000 to 500 000 m³
CSD	Glacial till & boulders	10 weeks	1 500 000 m³
CSD	Outlying superficial rock toes	2 weeks	40 000 m³
Drilling & Blasting pontoon	Rock	27 weeks	195 000 m³
SEASON 2 - 2018			
Equipment	**Material**	**Duration**	**Total volume to dredge**
TSHD - Reclamation into caissons	Sand & alluvium	5 weeks	200 000 m³
TSHD - Reclamation behind North Quay	Sand & alluvium	2 - 3 weeks	106 000 m³
BHD	Glacial till & boulders	8-9 weeks	250 000 m³

The Marine Licence allows the disposal of 2,190,000 m³ at the disposal site. The material that will be dredged at the entrance channel will be re-used as fill for the caissons and the reclamation area behind the North Breakwater. Also, suitable material from the drilling and blasting will be re-used as much as possible for this purpose.

No later than 1 month prior to the commencement of dredging and disposal activities, JDN will inform the licensing authorities the name of the vessels that will be mobilised for implementation of the works. A Notice to Mariners will also be released stating the nature and duration of the activities. This will follow processes detailed in the Vessel Management Plan.

Blasting activities will be registered in the Marine Noise Registry no later than 7 days prior to start-up.

All works will be undertaken according to dredging best practices. The specific management measures that will be taken to minimise the impact on the environment are stated below.

7.4 Environmental Management

7.4.1 Project Team and Responsibilities

The JDN Project Manager (PM) is responsible for all dredging and blasting activities, including HSE. He will be the main interface with Dragados for all matters. The PM is responsible for the following environmental management aspects:

- Making sure that the project activities comply with regulations and requirements and that all employees understand the environmental requirements.

- Ensuring the availability of an effective Environmental Management System (EMS) and the implementation of this System and ensuring that appropriate technical and financial resources are made available to support the EMS.
- Verifying whether the different tasks are performed by qualified and competent personnel.

JDN will appoint an Environmental Manager (EM) who will be assisted by an Environmental Engineer. The EM will manage the environmental control facilities and monitoring and liaise with Dragados on a day to day basis. He/She will be responsible for the daily tasks including:

- Give environmental inductions and trainings where and when required
- Ensure all environmental management and monitoring described in this plan is complied with.
- A correct and complete department administration on site
- Installation and calibration of his equipment and computer systems
- Organization of environmental monitoring surveys on various works assigned to him according to the respective planning's and stipulated method statements
- Conduct environmental monitoring and sampling campaigns at different locations and sites per the Contract requirements.
- Process data obtained during environmental monitoring surveys and sampling campaigns.
- Interpret, evaluate and report obtained results to Employer.

7.4.2 Environmental Coordination / Progress Meetings

Regular structured meetings will be undertaken to ensure that effective communications occur between Dragados EM, JDN PM and JDN EM as well as JDN sub-contractor and the project workforce.

Communication and consultation on site will be in languages that are clearly understood by the employees. The contract language will be English.

7.4.3 Environmental Awareness Training

The Environmental Team will establish the Environmental training programme schedule which will cover all topics of the environmental management relevant to the project:

- Environmental responsibilities of all those on site
- Contractor's environmental policy
- Significant environmental issues (e.g. marine mammals)
- Areas of the site including site boundaries
- Waste types, segregation method and location of waste disposal containers
- Location of washing areas, refuelling stations and maintenance of vehicles, plant and equipment

- Incident management and spill clean-up process
- Emergency response plans
- Reporting process for environmental incidents, etc

This programme will be initiated together with the HSE department and will be included in the site induction for all staff arriving on site.

JDN recognises that raising awareness of environmental risks to employees is an important preventive measure to avoid environmental incident or non-conformity.

In addition, specialist training will be given to individuals with specific roles and responsibilities, including but not limited to: Chemical and fuel handling, handling of organic solvents, handling of toxic materials and hazardous wastes. Specialised training will include but not be limited to:

- COSHH Risk assessment
- Accident and Incident investigation
- Emergency preparedness and response
- Fire fighting
- Spill control and response
- First aid and CPR training

JDN will hold weekly toolbox meetings. Additional toolbox meetings will be organised after an accident, incident or a near miss should they arise. The meetings will be held by supervisory staff (QHSE staff will assist) regarding subjects relevant to the work.

Toolbox meetings, which will take around 15-20 minutes, will take place in the team's work area, provided that the environment is suitable (safe location, absence of noise, disturbances, other teams or work nearby, etc.). The meetings will take place during working hours, at the (appropriate) time chosen by the supervision (i.e. at the beginning of shift or after a break).

Records (signed attendance sheets) will be kept of each toolbox meeting including registration of the subjects discussed and attendants.

7.4.4 Water Quality Management

The suspended sediment levels as presented in the ES show average background SSCs in Nigg Bay ranging from 24 mg/l in the outer bay area to 144 mg/l in the inner bay area. Maximum SSCs of up to 529 mg/l and 899 mg/l have been recorded in the outer bay and inner bay areas during high energy wave events.

According to the model in the ES, the turbidity plume generated by the dredging works reaches the entrance of Aberdeen Harbour and the outer coastal area. The peak increases in SSC north of Girdle Ness are predicted to be no higher than 100 mg/l to 200 mg/l above background levels, and generally around 10-50 mg/l in front of the mouth of the River Dee, which is well within natural background variation. Therefore, the ES states that the expected increases in SSC as a result of dredging in the areas surrounding Nigg Bay will be within natural range.

In regard to the disposal, the model in the ES shows that high SSCs following a disposal event reduce rapidly with distance from the disposal site. Total SSC values fall to 92 mg/l and 99 mg/l approximately 500 m north and south respectively of the disposal area.

Therefore, no exceptional high turbidity events above these background values are expected.

Based on the source term numbers (expected release of fine material at the dredging and disposal site) and the production rates it is expected that the amount of fine sediment brought into suspension by all the different types of dredging will not exceed the values predicted in the ES.

The turbidity in the water will be monitored on a regular basis and compared with values as estimated in the ES. See Chapter 7.6 Water Quality Monitoring Plan for details on the monitoring and the related adaptive management.

7.4.5 Waste Management

JDN will work within the Dragados overarching Waste Management Plan with reference to JDNs specific Waste Management Plan. Reference is made to the Dragados Waste Management Plan, which can be found in Chapter 18 of the CEMD.

7.4.6 Hazardous Waste

Reference is made to the Dragados Waste Management Plan for all waste related management. For a detailed description of all management measures, reference is made to JDN’s Safety Instruction document on Use of Hazardous Materials.

7.4.7 Sewage

International requirements for the prevention of pollution from sewage are contained in Annex IV of the International Maritime Organization's Pollution Convention, Regulations for the Prevention of Pollution by Sewage from Ships.

As applicable, all JDNs vessels hold an International Sewage Pollution Prevention Certificate (ISPPC) and have an IMO/MARPOL MEPC.2 (VI) annex IV type approved waste water treatment installation (black and grey waste water) on board and will therefore not dispose untreated waste water during the project.

Reference is made to the Dragados Vessel Management Plan, which can be found in Chapter 17 of the CEMD.

7.4.8 Oil Spill Management

JDN will adhere to the Dragados Vessel Management Plan and Pollution Prevention Plan, including oil spill contingency planning. Reference is made to JDNs Oil Spill Prevention and Response procedure.

Reference is made to the Marine Mammal Protection Plan, Chapter 11 of the CEMD, which includes all necessary mitigation measures that will be taken by JDN to protect marine mammals. The measures will be in line with the HRO and Marine Licences.

7.4.9 Biosecurity Management

Reference is made to the Dragados Marine Invasive Non-Native and Biosecurity Management Plan, which can be found in Chapter 12 of the CEMD.

7.4.9.1 Ballast Water Management

JDN will adhere to the Dragados Vessel Management Plan and Marine Invasive Non-Native and BioSecurity Plan, Chapters 17 and 12 of the CEMD respectively. All JDN vessels comply with International Maritime Organization guidelines and have a Ballast Water Management Plan as well as a Statement of compliance for International Ballast Water Management. These documents can be provided when the final decision is made on which vessels will be mobilised to the project.

7.4.9.2 Hull Fouling

In line with international guidance on bio-fouling, and in order to reduce the potential for introduction or spread of Invasive Non-Native Species (INNS) submerged vessel surfaces will have been treated with antifoul coatings which will be maintained in accordance with manufacturers guidelines.

In regard to harmful anti-fouling paints, JDN follows the IMO convention on the control of harmful anti-fouling systems on ships. Anti-fouling paints used on JDNs vessels are TBT free and each vessel has the required certificates.

7.4.10 Noise and Air Quality Management

7.4.10.1 Introduction

JDN has the required control measures in place on its vessels concerning occupational noise. Reduction of noise levels at fixed work places was considered during the design of the vessels. JDN’s vessels are designed and built conform the IMO Resolution A.468 (XII) ‘Code on noise levels on board ships’.

Concerning air quality, reference is made to the MARPOL 73/78, Annex VI ‘Regulations for prevention of air pollution’, Regulation 16 ‘Shipboard incineration’. The rules set limits on sulphur oxide (SOx) and nitrogen oxide (NOx) emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances.

The incineration of particular waste on board can occur in the shipboard incinerator, taken into account that most garbage is amenable to incineration with the exception of metal and glass. Special precaution is required for hazardous material and certain types of plastics.

Jan De Nul Group vessels are equipped with fire-fighting systems that are free of ozone depleting substances.

7.4.10.2 Expected in Air Ambient Sound Levels

JDN has organised extensive internal sound monitoring campaigns for previous projects in order to map the amount of sound that is being released to the environment. The sound that is being produced by the dredgers depends on the type of vessel, the type of dredged material, and other factors such as weather conditions, etc.

Reports have shown that dredgers are not a significant source of noise. Underneath, a short summary of past monitoring campaigns in similar conditions as the Aberdeen Harbour Extension Project and their results is given.

TSHDs of similar size to the Pinta, which will be used at AHEP, have shown in past studies a source level of approximately 85 dB(A). The propagated sound of the dredger usually approximates background levels between 150 and 200m away from the vessel (i.e. 50-60 dB(A)).

CSDs such as JFJ De Nul and Niccoló Machiavelli were monitored recently and have shown an average source level of 89.1 dB(A). CSD Zheng He (which is currently scheduled for this project is a sister vessel of CSD Niccoló Machiavelli – and same noise levels apply). As was the case for the TSHD measurements, sound levels around CSDs also rapidly return to background levels at approximately 150m from the source.

Campaigns around BHDs resulted in source levels of 87 dB(A) and a rapid decrease in sound levels to return to background level at 150m.

Figure 7.16 to Figure 7.18 show images of recent monitoring campaigns around the different types of dredgers.

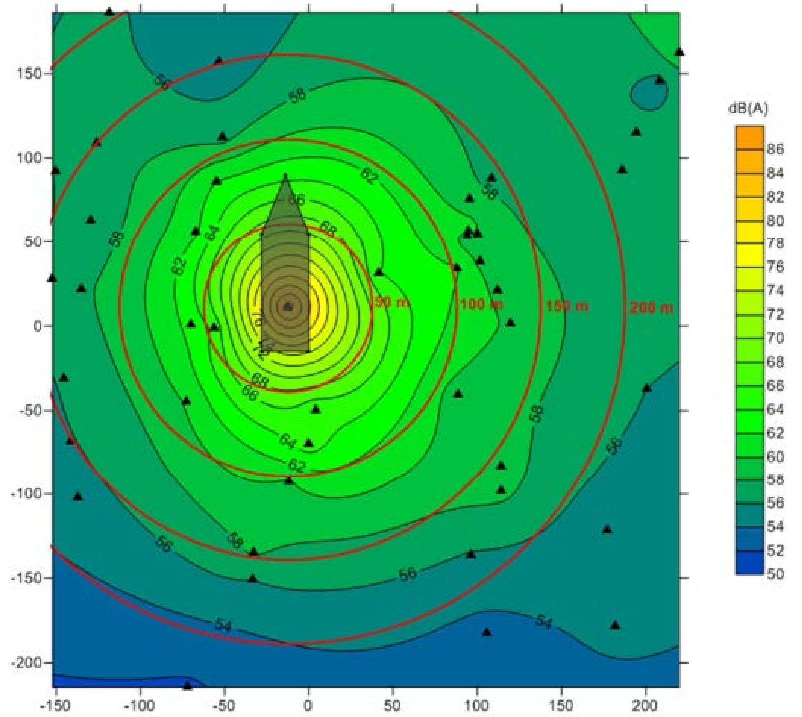

Figure 7.16: Sound monitoring map of a dredging TSHD – all values in dB(A)

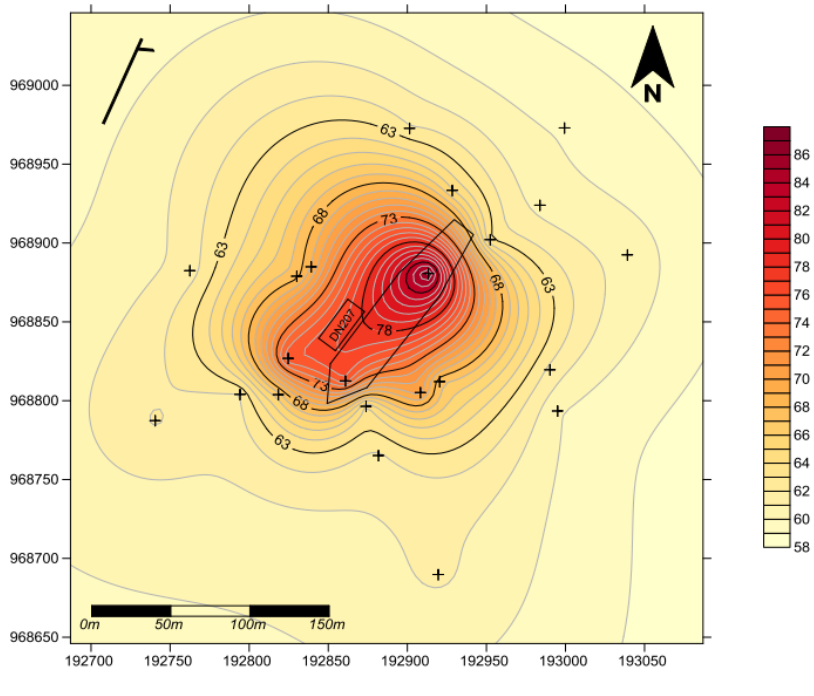

Figure 7.17: Sound monitoring map of a working CSD – all values in dB(A)

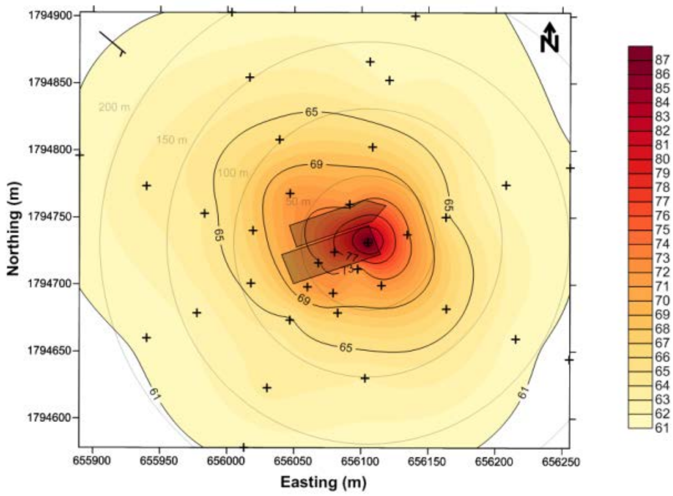

Figure 7.18: Sound monitoring map around a working BHD – all values in dB(A)

7.4.10.3 Expected Underwater Sound Levels

Overall, source levels for CSDs appear to range from 157.5-187 dB re 1µPa@1m depending on the vessel size, activity being undertaken and the environmental conditions at the time of monitoring (Jones and Marten, 20161). Reine et al. (2012)[2] recorded and analysed underwater sounds generated by a large hydraulic CSD fracturing rock while engaged in the New York & New Jersey Harbour Deepening Project. Based on a 15 log (R /1m) scaling, the calculated source levels reached 175 dB re 1 µPa2m2. Most sound energy was below 2.5 kHz.

Source levels of underwater sound of a BHD ranges from 154-179 dB re 1µPa@1m with the sound returning to background levels at max 350m from the source (Jones and Marten, 2016).

The TSHD has sound levels ranging from 160-180 dB re 1 µPa2m2 with the difference in sound levels not due to materials dredged in most cases but a result of differences between the dredging vessels observed (Jones and Marten, 2016). De Jong et al. (2010)[3] showed that dredging itself did not produce louder sounds than those produced by the dredger during transit between the dredging and placement sites. Also Robinson et al. (2011)[4] came to the same conclusions in a similar investigation. They found that six TSHDs emitted sound levels at frequencies below 500 Hz, comparable to a deep-draft draught cargo ship travelling at modest speed.

[1] Jones, D. and Marten, K., 2016, Dredging Sound Levels, Numerical Modelling and EIA, Terra et Aqua 144.
[2] Reine, K. J., Clarke, D. & Dickerson, C. 2012b. Characterisation of Underwater Sounds Produced by a Hydraulic Cutterhead Dredge Fracturing Limestone Rock – ERDC-TN-DOER-XXX. Washington DC: Department of Energy Resources.
[3] de Jong, C. A. F., Ainslie, M. A., Dreschler, J., Jansen, E., Heemskerk, E. & Groen, W. 2010. Underwater noise of Trailing Suction Hopper Dredgers at Maasvlakte 2: Analysis of source levels and background noise – TNO-DV 2010 C335.
[4] Robinson, S. P., Theobald, P. D., Hayman, G., Wang, L. S., Lepper, P. A., Humphrey, V. & Mumford, S. 2011. Measurement of underwater noise arising from marine aggregate dredging operations – MEPF report 09/P108. Marine Aggregate Levy Sustainability Fund.

Studies were performed around the TSHDs Cristoforo Colombo and Taccola and the CSD JFJ De Nul by Subacoustech Ltd in 2004 (These reports are however not publically available.). They concluded that the source levels at 1m were respectively 201, 180 and 169 dB re 1 µPa at 1m. (Howell and Nedwell, 2004[5] and Langworthy et al. 2004[6])

A recent in-house study of underwater sound from the BHD Postnik Yakolev indicated sound levels of Sound Pressure Level (SPL) 140 dB re 1 µPa at 25m which fell below the background level of SPL 125 dB re 1 µPa at 250m.

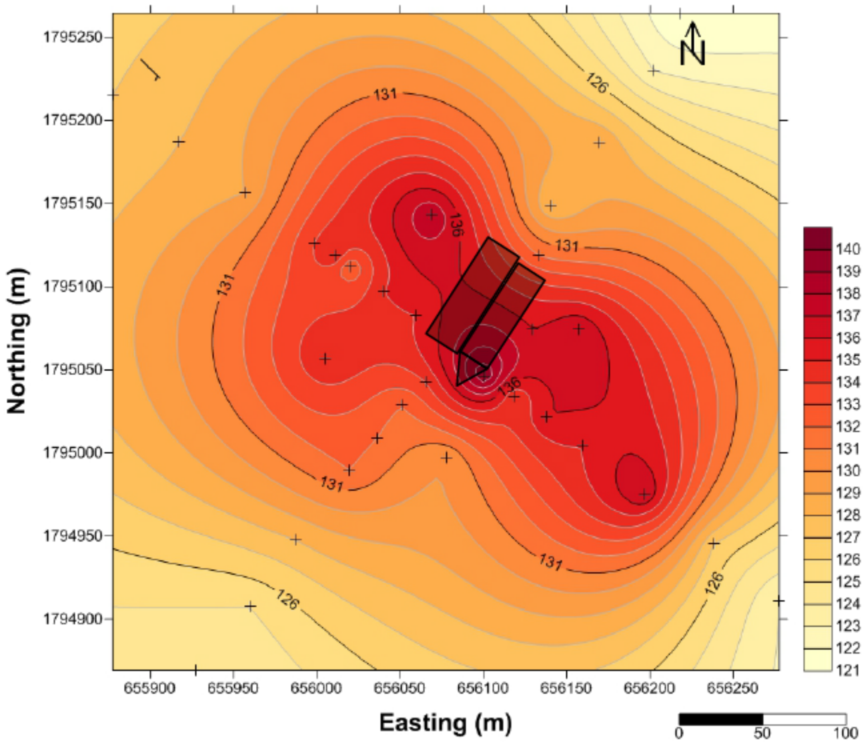

Figure 7.19: Interpolation map of the underwater sound level for the BDH Postnik Yakovlev

[5] Howell, D. and Nedwell, J., 2004, An assessment of the underwater noise radiated by the dredgers JFJ De Nul and Cristoforo colombo. Report No. 602 R 0206
[6] Langworthy J.W., Howell D. and Nedwell J. 2004. An assessment of the underwater noise radiated by the dredger Taccola. Report No. 614 R 0205

7.5 Dredging Monitoring Plan

7.5.1 General

The ES and additional surveys by Aberdeen Harbour have shown that given the low levels of contaminants in the sediment, no significant release of pollutants into the water column is anticipated to occur as a result of the dredging and disposal activities. The residual effect of the operations is believed to be negligible. This is due to the relatively localised nature of contaminants within the sediment and the substantial dilution that will occur during the dredging process. This is discussed in more detail in Section 7.5.2.

7.5.2 Marine Contamination Assessment Summary

An extensive programme of sampling and testing of marine deposits has been undertaken between 2013 and 2016. The 2016 surveys sampled 34 locations with sub-samples from each core analysed at 0.5-1m intervals, providing a comprehensive 258 samples for analysis.

The pre-dredging sampling results indicate levels of heavy metals above AL1 at several locations spread across the bay, although many of them had values only slightly above AL1 for only 1 or 2 heavy metals. Only 6 locations showed levels of several heavy metals higher than AL1 but still well below AL2. PAH levels above AL1 were only found in the upper sand layer, therefore when dredging the underlying glacial till it is not expected to have levels of PAH above AL1. For TBT and PCBs, no concentrations above AL1 were found at all in any of the sampled locations or depths.

Following discussion and agreement with Marine Scotland Science, a further marine sediment assessment was undertaken on contamination test data from the 2013[7] and 2016[8] Ground Investigation surveys. The test data was compared to published Effects Range Medium (ERM) and Effects Range Low (ERL) sediment toxicity datasets (Goreham-Test 1998[9], Long et al 1998[10]) to assess the potential risk of actual biological effects being realised from contaminants within the sediments, namely heavy metals and individual polyaromatic hydrocarbons (PAH’s).

The ERL/ERM method of assessment is adopted by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) in England for the monitoring of dredged material disposal sites in England.

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[7] Soil Engineering: Ground Investigation Report for Bay of Nigg Harbour Development, Aberdeen Vol 1-3. 9th January 2014
[8] Fugro Geoservices Ltd: Aberdeen Harbour Expansion – Nigg Bay – Ground Investigation.
[9] Gorham-Test, C. (1998). Regional Environmental Monitoring and Assessment Program: Galveston Bay 1993. US EPA report no EPA/906/R-98/002. 51 pp.
[10] Long, E.R., Field, L.J. & MacDonald, D.D. 1998. Predicting toxicity in marine sediments with numerical sediment quality guidelines. Environmental Toxicology and Chemistry, 17(4): 714 – 727.

The ERL/ERM assessment[11][12] concluded that for both heavy metals and PAH's that:

- Isolated elevations of concentrations of contaminants above the ERM were recorded; however, the extent of material that exceeds the ERM is relatively localised in the vertical and horizontal planes with the vast majority of samples recorded at levels closer to or below the ERL. Adverse biological effects are rarely observed at concentrations below the ERL with the ERM representing concentrations towards the middle of the effects ranges.

- The dredging and disposal process will lead to considerable mixing of the dredged materials during all stages. This will result in substantial dilution of the limited volume of material containing elevated concentrations of contaminants above the ERM with the much greater proportion of material that is below the ERL. Based on the assessment undertaken, it is considered that the risk posed to biological communities or the marine environment from the levels of contaminants within the materials to be dredged is negligible.

The assessment also highlights the Aberdeen Harbour maintenance dredging activity and the comparison of heavy metal test data from the dredged material (over a period of several years) to test data from the offshore disposal site CR110. The results identify that despite maintenance dredged materials from Aberdeen Harbour containing elevated heavy metals between AL1 and AL2 that the concentrations of these contaminants at the disposal site have remained below AL1. This suggests that there is no evidence of accumulation of heavy metals at the disposal site above the AL1 threshold. The maintenance dredging activity whilst a smaller operation than the proposed capital dredging from AHEP, is an activity that has been taking place for many years under licence using the same disposal techniques that are proposed for AHEP.

7.5.3 Dredge Sediment Monitoring

Taking these results into account the following monitoring will be undertaken. One (1) sample will be taken in the hopper of the TSHD and one (1) in the hopper of a SHB (from the CSD or BHD dredging) on a weekly basis during dredging for offshore disposal. Initially, when dredging materials from an area are identified as being above AL1, a sample will be taken of this material and analysed. If samples demonstrate the conclusion drawn by AHEP that it is unlikely levels above AL1 will be encountered, with the agreement of MS LOT, this increased sampling will be stopped. Based on the results of the pre-dredging sampling campaign, the samples will be analysed for the Heavy metals (Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Zinc), Tributyltin (TBT), Polychlorinated Biphenyls (PCB's) and Polycyclic Aromatic Hydrocarbons (PAHs) and the results compared to the Marine Scotland Action Levels (Table 7.3).

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[11] Aberdeen Harbour Board: Aberdeen Harbour Expansion Project - Additional Environmental Information Report. 2016.
[12] Aberdeen Harbour Board: Aberdeen Harbour Expansion Project – Clarifications Document: Marine Scotland Science. 29th June 2016.

Samples will be stored in a dark, cool environment for transport to the laboratory. The samples will be delivered to the laboratory within 24 hours after sampling. Duplicate samples will be collected for Marine Scotland and will be delivered to Marine Scotland within 24 hours. Details of the location where the material was dredged and where the material is disposed will be logged. Reports on the analysis of the given parameters will be provided to JDN within 10 working days. Once JDN has received the reports, these will be forwarded to MS-LOT by email within 24hrs of receipt.

Table 7.3: Marine Scotland Action Levels

Contaminant	Revised AL1 mg/kg dry weight (ppm)	Revised AL2 mg/kg dry weight (ppm)
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
Tributyltin	0.1	0.5
Polychlorinated Biphenyls	0.02	0.18
Polyaromatic Hydrocarbons		
Acenaphthene	0.1	
Acenaphthylene	0.1	
Anthracene	0.1	
Fluorene	0.1	
Naphthalene	0.1	
Phenanthrene	0.1	
Benzo[a]anthracene	0.1	
Benzo[b]fluoranthene	0.1	
Benzo[k]fluoranthene	0.1	
Benzo[g]perylene	0.1	
Benzo[a]pyrene	0.1	
Benzo[g,h,i]perylene	0.1	
Dibenzo[a,h]anthracene	0.01	
Chrysene	0.1	
Fluoranthene	0.1	
Pyrene	0.1	
Indeno(1,2,3cd)pyrene	0.1	
Total hydrocarbons	100	
Booster Biocide and		
Brominated Flame Retardents *		

In accordance with the requirements of Marine Scotland's *Pre-disposal Sampling Guidance Version 1 2017*, the laboratory performing the analyses must be ISO17025 accredited for marine sediment analysis and take part in intercomparison exercises such as QUASIMEME. The laboratory must meet the limit of detection (LOD) sensitivity requirements set out in the CSEMP Green Book.

Based on the pre-dredge sampling results presented in the ES and Aberdeen Harbour Assessment[13], all material is deemed to be suitable for disposal at sea based on the findings of the assessment undertaken which is described in Section 7.5.2.

7.5.4 Adaptive Management

As identified in Section 7.5.2, a robust investigation and sampling program has been undertaken to establish a comprehensive understanding of the dredge site marine chemistry. The presence of contaminants above Marine Scotland Action Levels within the material to be dredged and disposed of have been identified to be isolated and relatively localised within the vertical and horizontal planes; in addition, there will be substantial dilution of contaminants during all stages of the dredging process. The assessments performed have concluded that the risks posed by the material to be dredged and disposed at sea to biological communities and the marine environment are negligible.

During the dredging process, material will be removed from the seabed using either a TSHD, a BHD or CSD. The material will be either pumped into a large hopper (in the case of a TSHD and CSD) or placed mechanically into a barge using a backhoe. In both cases, there will be considerable mixing of the dredged material during all stages of the process, including: the point at which material is removed; within the hopper; and during the bottom-dumping disposal process at the offshore disposal site.

As identified in Section 7.5.3, it is proposed that samples are collected within the hoppers on a weekly basis to actively monitor the material that is being disposed of at sea at the licenced acceptance ground. Additional samples will be collected when dredging commences in areas where levels above AL1 have been identified.

Whilst it is considered unlikely that material between the AL1 and AL2 thresholds will be encountered during the hopper monitoring sampling, a clear and structured adaptive management approach is necessary to ensure that MS-LOT are informed of any breaches of soil action levels and to ensure that no adverse impact to the environment is realised.

The following adaptive management measures will be undertaken in the event that contamination above AL1 is encountered during the hopper monitoring testing.

1. Inform MS-LOT of exceedance of monitored sample by email within 48hrs of receipt of elevated result. Notification will include specific details on the dredge sample location, depth, date and time. Notification will also be made to

[13] Aberdeen Harbour Board: Aberdeen Harbour Expansion Project - Additional Environmental Information Report. 2016.

MS-LOT regarding the disposal location of material where the exceedance occurred.

2. The exceedance will be assessed in line with the contamination assessment[6] performed by AHB and will permit an assessment on whether the exceedance would lead to any increased level of risk to the marine environment compared to the baseline contamination assessment, this would be in line with the ERM/ERL assessment[11, 12]

3. In the unlikely event of identifying material greater than AL2 within the hopper samples, adaptive measures 1-2 will be undertaken and dredging will move to another dredge location whilst a specific assessment of the elevated source location is conducted. In parallel, we would recover grab samples from the relevant area of the disposal ground for subsequent analysis to enable the potential impact on the disposal site to be appropriately assessed.

4. Following conclusion of an assessment, proposals for mitigating environmental risk will be presented, this could include a review of the dredging processes to maximise the mixing and dilution of any elevated levels of contaminants within dredge materials to reduce any environmental impact to acceptable levels. Changes to processes would be forwarded to and discussed with MS-LOT for agreement.

Dragados will prepare a monthly sampling report and submit it to Marine Scotland Licensing Operations Team (MS-LOT). Disposal Site Monitoring Plan

7.5.5 Dredged Material Disposal

JDN will produce daily progress reports on the volume of dredged material and where it was disposed. The TSHD and each Split Hopper Barge (SHB) will keep a register with details on every trip it makes to the disposal area. The register will include the following data:

- Name of the vessel
- Source of the dredged material
- Start and end time of the loading of the TSHD or the SHB and its position
- Date, time and position at which the disposal began and ended. The position will be given in latitude/longitude and there will be a reference to the corresponding grid cell of the disposal site
- The quantity of the disposed material, stated in cubic meters
- Details of monitoring samples taken for chemical analysis. Details to include date and time sample taken, sampling method, sample storage and details on chain of custody transfer of samples to laboratory courier service.

The disposal site will be divided into different cells according to a grid that will be determined after the in-survey. An example of such a grid and disposal strategy is given in Figure 7.20. This assures an even distribution of the dredged material in the disposal area.

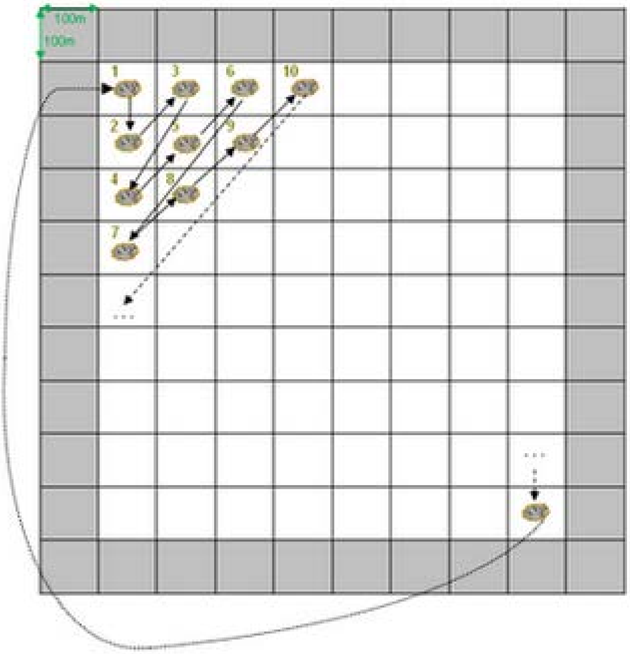

Figure 7.20: Disposal site grid and disposal progress

In the event that anthropogenic material (fishing gear etc) is found in the TSHD, it will be fished out (unless there is a risk to health and safety) and disposed responsibly onshore.

7.5.6 Disposal Site Sediment Sampling

Monthly sediment sampling of the disposal site will be organised by JDN’s Environmental Engineer. Four samples will be collected at the disposal site and analysed at an accredited laboratory. The samples will be collected with a Van Veen grab at 4 fixed points within the disposal site. This will allow a comparison of results through time. The disposed material will be spread over a large part of the site, which will be covered by four sampling points:

- Point D1: 57°07’07” N – 02°00’15” W
- Point D2: 57°07’07” N – 01°59’45” W
- Point D3: 57°06’52” N – 02°00’15” W
- Point D4: 57°06’52” N – 01°59’45” W

Figure 7.21: Sediment sample locations at disposal area (red dots)

Based on the results of the pre-dredging sampling the samples will be analysed for Heavy metals (Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc), Tributyltin (TBT), Polychlorinated Biphenyls (PCB's) and Polycyclic Aromatic Hydrocarbons (PAHs). The storage, transport, analysis and reporting on samples collected will be as described in Section 7.5.3.

7.5.7 Bathymetric Surveys

Bathymetric surveys at the dredging and disposal site will be conducted during the dredging works in order to assess the changes in the seabed following the dredging and disposal activities. All surveys are carried out along pre-determined lines, both parallel and at right angles to the route or slope. Where reasonably practicable, levels will be obtained up to the visible high water line on shore, so to obtain an overlap with the topographical data.

Line spacing and extension of survey lines are specified by the Client, or mutually agreed upon by Client and Contractor. In case of a multi-beam survey the complete area will be covered. A copy of the surveys will be forwarded to MS-LOT for information. The surveys will be provided in a .DWG and .PDF format.

The purpose of the surveys is to keep track of the dredging and disposal process and to check that disposal activities are carried out according to regulations and that the dredged material is being disposed evenly in the disposal area.

JDN proposes a two monthly survey as long as disposal activities are ongoing.

7.5.8 Adaptive Management

In case the surveys show an uneven distribution, a change can be made in JDN's disposal strategy by adjusting the grid progress and aim at another – but still even – distribution of dredged spoil at the disposal site.

Based on the ES and additional information provided by Aberdeen Harbour, no exceedances of acceptable limits of contaminants are foreseen. In the event of recorded exceedances within hopper monitoring samples , the adaptive management activities outlined in section 7.5.4 will be instigated.

7.6 Water Quality Monitoring Plan

7.6.1 Monitoring

Dragados commit to undertaking one of the following in terms of monitoring turbidity. The exact detail will be agreed with MS-LOT prior to dredging commencing:

- A continuous monitoring system will be installed at a location agreed with MS-LOT capable of measuring turbidity and transmitting results via GPRS / GSM networks with results displayed real time on a website. A continuous monitoring buoy will allow real time alerts to (via SMS or email) if thresholds are breached or if data stops transmitting.

  or

- An independent third party will undertake water quality measurements daily during dredging operations from a survey vessel with a handheld measuring device during dredging and disposal activities. If this is not possible, and only with agreement of MS-LOT, the campaign will be undertaken by Dragados/JDN and verified by an independent third party. The survey team will note the time that samples are collected so that this can be cross-referenced to the dredging and disposal activity at that time. The turbidity will be measured approximately 2 meters under the water surface and 2 meters above the seabed. Turbidity will be measured in NTU values, which will be converted in mg/L after the determination of a correlation coefficient (see Appendix 3 for details on the methodology).

  At all proposed locations background measurements will be recorded before start-up of the project. Nevertheless, natural variability will not be captured during this one time baseline measurement, therefore background turbidity levels will be measured each time a monitoring campaign is done at locations not influenced by the dredging or disposal activities.

If suspended sediment concentrations are exceeded, these will be reported to MS-LOT immediately initially by a phone call to the Mike Bland or a member of the MS Projects Team on: 01224 295579 and by a follow up email (within 1 hour of the exceedance being detected) to ms.majorprojects@gov.scot and copied to Michael.Bland@gov.scot.

7.6.1.1 Dredging Site

If monitoring turbidity from the survey vessel, in the vicinity of the dredging area, AHEP proposes to monitor turbidity at the following locations, as shown on Figure 7.22: Water quality monitoring locations at dredging site

- Point W1: 57° 7’49.57”N – 02° 2’22.74”W
- Point W2: 57° 8’2.51”N – 02° 2’13.83”W

- Point W3: 57° 8’15.45”N – 02° 2’5.81”W
- Point W4: 57° 9’0.71”N – 02° 2’58.52”W
- Point W5: 57° 8’43.17”N – 02° 3’34.46”W
- Point W6: 57° 8’30.76”N – 02° 4’8.88”W
- Point W7: 57°10’5.37”N – 02° 3’58.14”W
- Point W8: 57° 6’51.35”N – 02° 2’28.62”W

Points W6, W7 and W8 will count as background sampling locations.

Based on estimates within the ES, a maximum of 50 mg/L turbidity increase at W1-W4 is considered to be acceptable. The monitoring results at W1-W4 will be compared to measurements taken at W7 and W8 in order to assure that the 50 mg/L limit is not exceeded. No impact is expected at W5 as a result of the dredging activities in Nigg Bay. Therefore, W5 will be compared to the measured background value at W6. In case elevated levels of suspended sediment are measured, adaptive measures can be implemented.

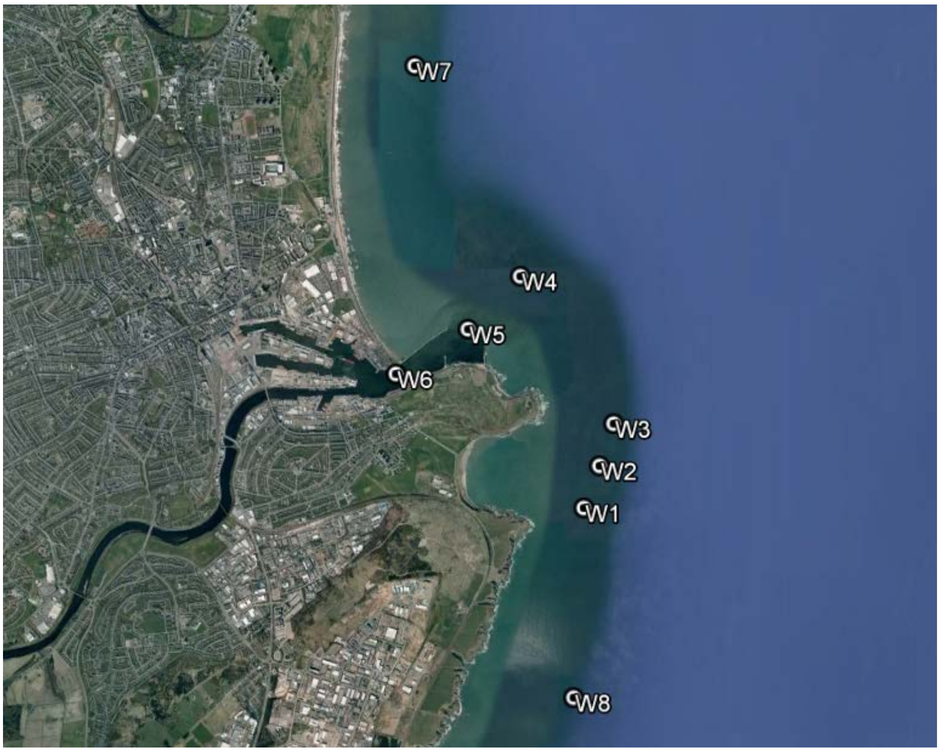

Figure 7.22: Water quality monitoring locations at dredging site

7.6.1.2 During re-use of dredged material

Dragados plan to reuse dredge material where possible and are committed to re-use of rock excavated during blasting and dredging operations. The exact re-use will depend on the quality and quantity of material but is likely to involve use in caissons or behind the quays. At least 4 weeks prior to re-use of material commencing, Dragados will agree with MS-LOT a sediment monitoring and management regime to be implemented during the proposed re-use operation. Sediment monitoring will be undertaken either via a conitnous monitoring buoy, by an independent third party or the surveys will be undertaken by Dragados/JDN and verified by an independent third party)(as per the commitment made at Section 7.6)

7.6.1.3 Disposal Site

At the disposal site, water quality monitoring will be undertaken from a survey vessel either by an independent third party or the surveys will be undertaken by Dragados/JDN and verified by an independent third party. 4 sampling locations will be monitored taking the main current direction into account. 2 locations will be monitored at 100m and 500m to the North of the disposal site and 2 locations at 100m and 500m to the South.

This monitoring will be undertaken on a weekly basis during the time that material is actually disposed at the disposal site.

7.6.2 Adaptive Management

No upper limits are proposed in the ES, HRO or Marine Licence for turbidity/suspended sediment concentration. However, the measured turbidity levels at the monitoring points will be compared to the estimates in the ES. Based on these estimates, a maximum of 50 mg/L turbidity increase at W1-W4 is considered to be acceptable. The monitoring results at W1-W4 will be compared to measurements taken at W7 and W8 in order to assure that the 50 mg/L limit is not exceeded. No impact is expected at W5 as a result of the dredging activities in Nigg Bay. Therefore, W5 will be compared to the measured background value at W6. In case elevated levels of suspended sediment are measured, adaptive measures can be implemented.

At the dredging site, the levels of suspended sediment can be controlled by:

- Stopping dredging and moving to another area.
- Adjusting the overflow position of the TSHD and SHBs.
- Minimise the de-watering process or stop dewatering completely.
- If practicable, the use of silt curtains and similar products to minimise sediment losses
- If practicable, the use of a different dredging technique

At the disposal site, spreading out the subsequent disposals over the disposal grid and taking the current into account when choosing the grid cell will result in a smaller extent of the turbidity plume as a result of the disposal.

7.7 Reporting

All dredging vessels will publish detailed daily progress reports in which all details concerning their activities will be outlined. This will be compiled in a weekly report, and a monthly report. These reports will include, among others, the following information:

- Name of the vessel
- Nature and quantity of each substance that was loaded for disposal
- Cycle details including date and time of departure from port, arrival at the disposal area, etc.
- Details on the disposal activities including date and time of start and end of the disposal, exact location, etc.
- Course and speed throughout each disposal operation
- Weather details including wind strength, direction, sea-state, tidal data, etc.
- Rate and duration of discharge during each disposal operation
- Comments or remarks (e.g. on delays)
- Signature of the Master and Superintendent

Reports for each turbidity monitoring campaign will be compiled and sent to the Dragados. The reports will include all necessary details to give Dragados a complete picture of the campaign. This includes:

- Name of the vessel that was used
- Name of the Environmental Engineer(s)
- Date and time of start and end of the campaign
- Meteorological data
- Sampling locations
- Used equipment
- Results of the in situ measurements with the necessary data processing (e.g. the NTU-TSS conversion)
- Any comments or remarks
- Signature of the Environmental Engineer

Results of the sediment quality monitoring will be reported as soon as the results from the laboratory have been received.

Results of the underwater sound monitoring and marine mammal observations will be reported as stipulated in the Marine Mammal Protection Plan.

Appendix A

Dredging and Dredge Spoil Disposal Management Appendices

A1 JDN Group Policy

POLICY STATEMENT
QUALITY
HEALTH
SAFETY
SECURITY
ENVIRONMENT

We, as Jan De Nul Group, conceptualize, design and realize projects for our clients. We do this in a safe, socially responsible and ethical manner while respecting the law, supporting universal human rights, protecting the environment and creating opportunities from which communities we work in can benefit.

→ OUR VISION

People: Provide a safe and secure working environment for all persons working for or on behalf of Jan De Nul Group, taking into account the physical and mental health.

Planet: Achieve environmental integrity during execution of projects and minimise our footprint.

Clients: Be the partner of choice through our superior capabilities and strong commitment.

Communities: Contribute to their sustainable development and increase their welfare.

Suppliers and subcontractors: Collaborate and assist to meet our Policy and standards.

Our organisation: Pursue continual improvement and sustainable growth through learning and innovation.

→ OUR STRATEGY

- We **invest in people** to strengthen organizational capability and develop a committed, talented and environmentally aware workforce that gets high-quality results through proper operational control.
- We execute projects with excellence through **proactive and accountable leadership** that sets and communicates clear expectations, demonstrates high standards, manages performance and supports team development. We provide the necessary means and user-friendly **management systems** to achieve our vision.
- We stimulate **risk awareness** by elevating the understanding of risks, placing the emphasis on critical risks, ensuring that strategic, financial, compliance and operational risks are identified, assessed and treated while ensuring that lessons learnt are shared. We promote the belief that safety is a result of proper **operational control**.
- We are committed to **prevent pollution** and **minimise waste**. We focus highly on **reduction of energy consumption** while exploring ways to switch to green energy.
- We **comply with** specific customer requirements, company and industry standards for high quality workmanship, applicable local, national, international and maritime laws and regulations.
- We aim for **sustainable procurement** and maintain mutually beneficial relationships with suppliers and subcontractors. We continuously focus on the needs and benefits of our **stakeholders**.

By putting this Policy into effect, Jan De Nul Group will further enhance its status as a leading expert in the dredging, civil, environmental works and offshore services industries.

Jan De Nul Group (Sofidra S.A.)
Director

[redacted]

ir. J.P.J. De Nul

Jan De Nul GROUP

A2 YSI 600OMS

YSI
a xylem brand

SPECIFICATIONS

DOCUMENT #E16

YSI 600OMS V2 Optical Monitoring System

Dissolved Oxygen, Turbidity, Chlorophyll, Blue-green Algae or Rhodamine in a Low-Cost Package

Measure any one of the parameters above in combination with temperature, conductivity, and depth or vented level in fresh, sea, or polluted water.

The 600OMS V2 can take advantage of 6-Series optical sensors from YSI: ROX Reliable Oxygen (YSI 6150) and blue-green algae sensors (YSI 6131 phycocyanin and YSI 6132 phycoerythrin). Utilize the field-proven YSI 6136 turbidity sensor, the YSI 6025 chlorophyll sensor, as well as the YSI 6130 rhodamine WT sensor.

The OMS V2 also incorporates innovations in sensor configuration such as a conductivity and temperature module that fits into the sonde body.

- Wiped optics for maximum anti-fouling protection
- Ideal for long-term deployments
- Low power requirements
- Field-replaceable optical sensors
- 150,000 reading memory
- Integrate with DCPs
- Compatible with EcoWatch® data analysis software
- Compatible with YSI 650MDS display and datalogger

Parameters:
Conductivity/Salinity
Depth/Level
Temperature

Plus one of these optical sensors:
Blue-green Algae PC or PE
Chlorophyll
Dissolved Oxygen
Rhodamine
Turbidity

YSI.com/sondes

YSI 600OMS Sensor Specifications

	Range	Resolution	Accuracy
ROX™ Optical Dissolved Oxygen• % Saturation 6150 Sensor	0 to 500%	0.1%	0 to 200%: ±1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ±15% of reading
ROX™ Optical Dissolved Oxygen• mg/L 6150 Sensor	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L: ± 0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: ±15% of reading
Conductivity••	0 to 100 mS/cm	0.001 to 0.1 mS/cm (range dependent)	±0.5% of reading + 0.001 mS/cm
Salinity	0 to 70 ppt	0.01 ppt	±1% of reading or 0.1 ppt, whichever is greater
Temperature	-5 to +50°C	0.01°C	±0.15°C
Depth Medium	0 to 200 ft, 61 m	0.001 ft, 0.001 m	±0.4 ft, ±0.12 m
Depth Shallow	0 to 30 ft, 9.1 m	0.001 ft, 0.001 m	±0.06 ft, ±0.02 m
Depth Vented Level	0 to 30 ft, 9.1 m	0.001 ft, 0.001 m	±0.01 ft, 0.003 m
Turbidity• 6136 Sensor	0 to 1,000 NTU	0.1 NTU	±2% of reading or 0.3 NTU, whichever is greater*
Rhodamine• 6130 Sensor	0-200 μg/L	0.1 μg/L	±5% reading or 1 μg/L, whichever is greater

• Max. depth rating for optical probes is 200 ft, 61 m; depth rating for anti-fouling optical probes is 656 ft, 200 m.
•• Report outputs of specific conductance (conductivity corrected to 25° C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (ed 1989).

*In YSI AMCO-AEPA Polymer Standards.

	Range	Detection Limit	Resolution	Linearity
BGA - Phycocyanin• 6131 Sensor	~0 to 280,000 cells/mL† 0 to 100 RFU	~220 cells/mL§	1 cell/mL 0.1 RFU	$R^2 > 0.9999$**
BGA - Phycoerythrin• 6132 Sensor	~0 to 200,000 cells/mL† 0 to 100 RFU	~450 cells/mL§§	1 cell/mL 0.1 RFU	$R^2 > 0.9999$***
Chlorophyll• 6025 Sensor	~0 to 400 μg/L 0 to 100 RFU	~0.1 μg/L Chl a§§§	0.1 μg/L Chl 0.1% RFU	$R^2 > 0.9999$****

• Max. depth rating for optical probes is 200 ft, 61 m; depth rating for anti-fouling optical probes is 656 ft, 200 m. RFU = Relative Fluorescence Units

† Explanation of Ranges can be found in the 'Principles of Operation' section of the 6-Series Manual.

§ Estimated from cultures of *Microcystis aeruginosa*.
§§ Estimated from cultures *Synechococcus sp.*
§§§ Determined from cultures of *Isochrysis sp.* and chlorophyll a concentration determined via extractions.

**Relative to serial dilution of Rhodamine WT (0-400 ug/L).
***Relative to serial dilution of Rhodamine WT (0-8 μg/L).
****Relative to serial dilution of Rhodamine WT (0-500 ug/L).

YSI 600OMS V2 Sonde Specifications

Dimensions Diameter	1.65 in, 4.2 cm
Length	21.3 in, 54.1 cm
Weight	1.3 lbs, 0.6 kg
Weight w. Batteries	1.4 lbs, 0.7 kg
Power External	12 V DC
Internal Battery Option	4 AA Alkaline cells, 25 to 30 days at 15-minute sampling interval at 25°C

Ordering Information

600-01	600OMS V2 sonde, conductivity, temperature, optical port
600-02	600OMS V2 sonde, conductivity, temperature, optical port, internal batteries
600-03	600OMS V2 sonde, conductivity, temperature, optical port, shallow depth
600-04	600OMS V2 sonde, conductivity, temperature, optical port, shallow depth, internal batteries
600-05	600OMS V2 sonde, conductivity, temperature, optical port, medium depth
600-06	600OMS V2 sonde, conductivity, temperature, optical port, medium depth, internal batteries
600-07	600OMS V2 sonde, conductivity, temperature, optical port, shallow vented depth
600-08	600OMS V2 sonde, conductivity, temperature, optical port, shallow vented depth, internal batteries

YSI
1725 Brannum Lane, Yellow Springs, OH 45387
Tel +1 937.767.7241 800.897.4151 (US)
environmental@ysi.com
YSI.com

ISO 9001
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A3 NTU-TSS Correlation

Suspended solids concentrations cannot be determined easily and quickly in the field, and transportation to a laboratory and analysis are time-consuming. Therefore, suspended solids measurements cannot be used on a constant basis to detect and correct short-term increases in suspended solid concentrations.

Because of these problems, suspended solids measurements are often replaced by turbidity measurements. Turbidity is easy to measure quickly, but there is no universal relationship between turbidity and suspended solids. The turbidity sensors use the optical backscatter intensity technique to measure the concentration of suspended solids. The intensity of reflection depends on the particle's nature and therefore it is required to establish site-related conversion coefficients to enable determination of suspended solids concentrations.

Verification checks can be conducted at two stages:

Prior to the first deployment: by measurement of the signal intensity for different known concentrations at the laboratory a conversion coefficient can be determined
At a regular interval throughout the project: by comparison of field measurements with laboratory tests on samples

A3.1 Determination of Correlation Coefficient using In Situ Sediment Samples

A3.1.1 In Situ Sampling

Samples of the sediment are taken from the dredging site using a Van Veen grab. If different types of soil occur in the dredging area, a set of samples from the different areas should be taken as the turbidity in NTU and the amount of TSS correlate differently depending on several environmental parameters.

The sensitivity (V/g/l) and concentration range (g/l) of the turbidity sensors depend on particle characteristics, with size being the main factor. As particle size increases, the concentration range will increase but the sensitivity will decrease. Particle colour and shape also influence the response. Conversion coefficient determination for sediment from the monitoring site is therefore essential to attain the optimal accuracy.

A3.1.2 Lab Set-up

The turbidity sensor and a stirrer with adjustable speed are mounted on the laboratory stand and lowered into a non-reflective container. The stirring device is required for maintaining a homogeneous sediment suspension during the conversion coefficient determination. A computer is interfaced to the turbidity sensor to start up the turbidity measurement and to log the data to files. The container must be non-reflective to avoid additional reflection during the measurements.

After lowering the turbidity sensor in the non-reflective container and starting up the logging program, the sensor(s) must be orientated in such a way as to minimise initial reflections. Then the container is filled with a known volume of normal water (tap water) and background reflections are checked again without and with stirring (0 NTU). To approach as much as possible the in-situ situation a water sample from the site should be used but experience has learned that often better results are obtained by using tap water. Particularly when working with salt water in combination with sediment, foam may appear when turning on the stirring device. This causes faulty readings and can be avoided by lowering the stirring speed, which may lead to particle settlement in the container, or by working with tap water.

A3.1.3 Coefficient Determination with Dried Sample

The actual coefficient determination procedure entails adding incremental weights of the dry sediment to a measured volume of clear water and recording the sensor output. Dry sediment is added up to at least a TSS concentration of 500 mg/l. The full calibration takes about 10-15 points for standard turbidity sensors. After each increment of sediment is added, the suspension has to be stirred until the sensor output stabilises, indicating that no more aggregation of sediment occurs. Upon completion of the measurements, the logged NTU data is analysed and correlated to the different weights of dry sediment added. An overall conversion coefficient can then be calculated.

After the final step a sample is taken out of the container. The procedure for analysis of this sample is described below in filtration method. Results of this filtration will give the amount of actual suspended solids compared to the added amount of solids (excluding thus the settled particles and the dissolved salt).

A3.1.4 Coefficient Determination with Liquid Sample

When using a well-mixed liquid sample, a series of dilutions (10-20) are added to the water in the non-reflective bucket up to at least the equivalent of a TSS concentration of 500 mg/l is reached. The suspension has to be stirred continuously while the sensor outputs are logged. For every different dilution added, and after the NTU data has stabilised, the NTU value is logged and a sample is taken from the container. These samples are later analysed for the concentration of solids in suspension using the filtration method. The results from the filtration can then be compared to the sensor loggings to calculate the correlation factor between NTU and TSS values.

A3.1.5 Filtration Method (Determination of TSS out of a Liquid Sample)

The filtering apparatus is assembled and suction begins. The filter is wetted with a small volume of distilled water to seat it against the fritted support.

The sample is shaken vigorously and the predetermined sample volume selected is transferred quantitatively into the filter using a graduated cylinder. The filtration volume will depend on the sample concentration, the balance accuracy and the final accuracy to be achieved. All traces of water are removed by continuing to apply vacuum after sample has passed through.

With suction on the graduated cylinder, filter, non-filterable residue and filter funnel wall are washed with three portions of distilled water allowing complete drainage between washing. All traces of water are removed by continuing to apply vacuum after water has passed through. Consequently the filter is carefully removed from the filter support and dried at least one hour at 103-105°C. The filter is taken out of the oven and weighed. This drying cycle is repeated until a constant weight is obtained.

The TSS is calculated as follows: TSS (mg/l) = (A – B) / C where:

A = weight of filter + residue in mg, B = weight of filter in mg, C = Volume of sample filtered in litres.

A3.2 Field Checks using In Situ Water Samples

The correlation coefficient found during the lab analysis will be checked on a regular basis using infield measurements of turbidity, combined with the sampling of water on the same spot (tube of pump attached next to the turbidity sensor). The water samples are then analysed in the lab using the above explained filtration method (either on site lab or external lab if contractually required). The TSS results are then compared with the logged NTU values from the turbidity sensor.