



TRANSNET SOC LTD

**DCT BERTHS 203 TO 205 - RECONSTRUCTION, DEEPENING AND
LENGTHENING**

PORT OF DURBAN

**SPECIFICATION – DREDGING AND RECLAMATION (INCLUDING
VIBRO COMPACTION)**

1785-CO-000-C-SPC-0004 Rev T-00

26 JULY 2019



This document, including all design and information therein, is Confidential Intellectual Property of
ZAA Engineering Projects and Naval Architecture (Pty) Ltd.
Copyright and all other rights are reserved by ZAA Engineering.
This document may only be used for its intended purpose.



CONTENTS

1.0	SCOPE.....	1
1.1	Project.....	1
1.2	Scope.....	1
1.2.1	Dredging.....	1
1.2.2	Reclamation.....	1
1.2.3	Surveying and testing.....	1
2.0	NORMATIVE REFERENCES.....	2
2.1	Reference Documents.....	2
2.2	Standard Specifications.....	2
2.3	Employer's Project Specific Specifications and Standards.....	2
3.0	DEFINITIONS.....	3
3.1	Chart Datum Port.....	3
3.2	Co-ordinate System.....	3
3.3	Tidal Levels.....	3
3.4	Method Statements.....	3
3.5	Approved Disposal Site.....	3
3.6	Approved Offshore Borrow Site.....	3
3.7	Berth Dredging.....	3
3.8	Dredging.....	3
3.9	Reclamation.....	3
3.10	Vibro-Compaction.....	4
3.11	CPTu.....	4
3.12	Cone resistance (qu) and corrected cone resistance (qt).....	4
4.0	REQUIREMENTS.....	4
4.1	Method Statements.....	4
4.1.1	Dredging and disposal.....	4
4.1.2	Compaction of reclaimed material.....	4
4.2	Materials.....	4
4.2.1	Nature of material to be dredged – Basin and berth dredging.....	4
4.2.2	Material within Lot 10.....	5
4.2.3	Material for sandbank extension.....	5
4.2.4	Material for reclamation and caisson infill.....	5
4.3	Equipment.....	6
4.3.1	General.....	6
4.3.2	Basin and Berth Dredging Equipment.....	6
4.3.3	Discharge Equipment.....	7
4.3.4	Silt curtains.....	7
4.3.5	Compaction Equipment.....	7
4.3.6	Survey Equipment.....	7
4.4	Methods and Procedures.....	9
4.4.1	Dredging and dredge material disposal.....	9
4.4.2	Dredging Surveys.....	12
4.4.3	Reclamation compaction.....	15



5.0	COMPLIANCE WITH REQUIREMENTS	16
5.1	Sampling, Testing, Commissioning and Completion	16
5.1.1	Dredging Completion	16
5.1.2	Sampling and testing of reclamation material	16
5.1.3	Acceptance criteria for compaction of reclamation material.....	16
5.2	Tolerances.....	17
5.2.1	Dredging.....	17
5.2.2	Infill reclamation	17
5.2.3	Reclamation compaction.....	17

1.0 SCOPE

1.1 Project

This specification is a project specific technical specification for the DCT Berths 203 to 205 Reconstruction, Deepening and Lengthening Project in the Port of Durban.

1.2 Scope

The scope of this specification covers the *Employer's* requirements for dredging and reclamation, which includes the following:

1.2.1 Dredging

- a) The deepening and extension of the basin including the turning circle and entrance channel as indicated on drawing 1785-CO-020-C-DWG-0002-01. Where dredging of the existing crane yard is to be undertaken to extend the basin and berth 205, this specification covers all dredging below +2.2 m CDP. Removal of the material above +2.2 m CDP is covered under the demolition and site clearance specification 1785-CO-000-C-SPC-0018 Demolition and Site Clearance.
- b) Berth dredging for the new Berths 203 to 205 to provide caisson founding trench and scour protection trench as shown on drawings 1785-CO-020-C-DWG-0004-01 to 1785-CO-020-C-DWG-0006-01.
- c) Dredging of Lot 10 launching dock to allow for launching and towing of caissons as shown on drawing 1785-CO-020-C-DWG-0011-01.

1.2.2 Reclamation

- a) Reclamation of areas between new caisson wall and existing quay wall including vibro-compaction
- b) With regards to the extension of the sandbank, which involves dredging of material from within the basin and from the offshore sand-winning site and depositing adjacent to the existing sandbank, only the dredging portion of the *works* is covered by this specification. The *works* involving the placement of the material to form the extended sandbank are covered in specification 1785-CO-000-C-SPC-0016 Sandbank Extension.

1.2.3 Surveying and testing

All necessary surveying and testing for the dredging and reclamation *works*.

2.0 NORMATIVE REFERENCES

2.1 Reference Documents

The *works* shall be carried out as specified in the following documents:

- a) This Specification
- b) Industry Codes, Standards and Specifications as listed in Section 2.2
- c) Employer's Project Specific Technical Specifications as listed in Section 2.3
- d) Project Drawings:
- e) 1785-CO-020 series of drawings – Dredging and reclamation
- f) Method statement prepared by the *Contractor*, as described in Section 4.1
- g) Project Geotechnical Reports, included in Part 4 - Site Information

2.2 Standard Specifications

The *Contractor* shall provide and maintain current copies of all the standard specifications referred to herein below on the site for reference by both parties.

The dredging and reclamation *works* shall comply with the following standard specifications:

- a) SANS 1200 D:1988 - Earthworks
- b) BS 6349-5:1991 – Maritime Structures – Code of practice for dredging and land reclamation
- c) PIANC Report No 100 – 2009 – Dredging Management Practices for the Environment
- d) PIANC Report No 144 – 2016 – Classification of Soils and Rocks for the Maritime Dredging Process
- e) BS EN 1997-2: 2007 - Geotechnical design – Ground investigation and testing
- f) BS EN ISO 22476-1:2012 - Geotechnical investigation and testing - Field testing - Electrical cone and piezocone penetration test.
- g) IHO Standards for Hydrographic Surveys, Special Publication No.44, 5th Edition, February 2008.
- h) BS 1377-7:1990 - Methods of test for soils for civil engineering purposes. Shear strength tests (total stress) – Determination of shear strength by direct shear (small shearbox apparatus)
- i) BS 1377-4:1990 - Methods of test for soils for civil engineering purposes. Compaction-related tests – Determination of the maximum and minimum dry densities for granular soils

2.3 Employer's Project Specific Specifications and Standards

The dredging and reclamation *works* shall also comply with the following Project Specific Specifications and Standards:

- a) 1785-CO-000-C-SPC-0008 – Scour Protection and Revetments
- b) 1785-CO-000-C-SPC-0010 – Ground Improvement: Rigid Inclusions and Foundation Stone Bed (Caisson Load Transfer Platform)
- c) 1785-CO-000-C-SPC-0016 – Sandbank Extension
- d) 1785-CO-000-C-SPC-0018 – Demolition and Site Clearance
- e) Project Environmental Specifications (PES) as contained in the Works Information and annexures

3.0 DEFINITIONS

All definitions of responsibilities shall be in accordance with the NEC Engineering and Construction Contract (ECC) for the construction of the *works*.

Where the standard specifications referenced in this specification refer the “Engineer”, replace this term with the term “Supervisor”.

For the purpose of this specification, the following definitions shall apply:

3.1 Chart Datum Port

Chart Datum Port refers to the reference level used in the Port of Durban, which is 0,900 m below Mean Sea Level. All levels referred to in this document are relative to Chart Datum Port (CDP).

3.2 Co-ordinate System

The co-ordinate system to be used for all setting out and survey shall be World Geodetic System 1984 (WGS84), LO31, referred to as WG31.

3.3 Tidal Levels

The Astronomical Tide Predictions as defined by the SA Navy Hydrographer and Chart SAN 2006 are as follows:

Table 3.1 – Tide Data

Tide	Abbreviation	Level m, Chart Datum Port
Highest Astronomical Tide	HAT	2.287
Mean High Water Springs	MHWS	1.997
Mean Level	ML	1.097
Mean Low Water Springs	MLWS	0.197
Lowest Astronomical Tide	LAT	-0.013

3.4 Method Statements

Method statements shall be compiled by the *Contractor* for all activities. The method statements shall be submitted to the *Supervisor* for acceptance three weeks in advance of the particular activity being undertaken. Full details of all proposed Equipment (including temporary works) and methods shall be provided for acceptance by the *Supervisor*.

No activity shall commence until the method statement has been accepted by the *Supervisor*.

Further details of the requirements of particular method statements are provided in Section 4.

3.5 Approved Disposal Site

The Approved Disposal Site refers to a site located offshore, the locality of which is shown on drawing 1785-CO-020-C-DWG-010-01.

3.6 Approved Offshore Borrow Site

The Approved Offshore Borrow Site refers to a site located offshore, the localities of which are shown on drawing 1785-CO-020-C-DWG-010-01.

3.7 Berth Dredging

Dredging of material below -16.5 m CDP for the caisson foundation trench, scour trench and the slope that extends from the caisson foundation trench to the existing wall. Material within this area above -16.5 m CDP is classified as Basin Dredging.

3.8 Dredging

Excavation of all types of material within the marine environment below the Highest Astronomical Tide (HAT) level, in accordance with the SA Navy Hydrographic Office (SANHO) and as defined in Section 3.3, regardless of the type of Equipment or methods employed.

3.9 Reclamation

The process of creating new land or extending the sandbank with dredged/imported material.

3.10 Vibro-Compaction

“Vibro-compaction”, also known as vibro-flotation is a technique in which the density of granular soil is increased by the insertion of a heavy vibrating poker to a desired depth, which imparts horizontal vibrations into the surrounding ground that breaks down the frictional contacts between soil particles, thus causing them to settle into a denser state.

3.11 CPTu

“CPTu” is the abbreviation for “Cone (or Continuous) Penetration Test with pore water pressure measurements”, which test entails measuring forces required to cause (a) a small diameter, steel, cone-tipped rod to penetrate the ground, and (b) a steel sheath to overcome friction such as to slide relative to the central rod, at various selected depths; as well as simultaneously to measure corresponding changes in the hydraulic pressure in water that occupies the void space between and around the soil particles; the results of which correlate with important properties of the soil penetrated, including its proportions of sand and fines, and its density.

3.12 Cone resistance (q_u) and corrected cone resistance (q_t)

Cone resistance (q_u) is the resistance of the soil (as a pressure, measured in MPa) at a particular depth to penetration by a CPTu cone, computed as the total force acting on the cone divided by the projected area thereof.

Corrected cone resistance (q_t) at a particular depth is computed from the measured cone resistance (q_u) at that depth less the effect on such resistance to penetration by simultaneous and corresponding changes in pore water pressures.

4.0 REQUIREMENTS

4.1 Method Statements

The *Contractor* shall prepare method statements that shall include, *inter alia*:

4.1.1 Dredging and disposal

- Description of the Equipment (type of dredger, basic dimensions and specifications, booster pump stations, hopper barge capacity, power characteristics, production rates per material and per length of delivery pipe etc.).
- The planned cycle times, production rates, expressed in terms of the in-situ bulk volume (m^3) of solids dredged per week and per hour, allowing for mechanical and weather downtime and also capacity variation with respect to length of discharge pipeline and booster stations (if required).
- The sea state conditions under which the Equipment may operate safely for survival conditions and operational conditions for dredging, dumping and reclamation.
- The *Contractor's* methodology for controlling sedimentation and turbidity within the vicinity of dredging and discharge activities.
- The *Contractor's* proposed layout of discharge pipelines for the reclamation.

4.1.2 Compaction of reclaimed material

- Details of the compaction methodology and Equipment to be used including vibration frequencies, energies etc.
- Work procedures and control criteria.
- A work plan for the production work outlining the spacing/grid layout, location and depth of the probes to achieve the criteria outlined in this specification.
- A work plan for the performance testing by CPT of completed work outlining the spacing/grid layout, location and depth of the probes to achieve the criteria outlined in this specification.

4.2 Materials

4.2.1 Nature of material to be dredged – Basin and berth dredging

Various geotechnical investigations of the basin have been undertaken and the results thereof are provided in the various reports included in annexure A of the Site Information. The *Contractor* will be deemed to have made its own assessment of the materials to be dredged from the information provided in the Site Information and from the *Contractor's* own visual inspection of the Site and available cores.

The *Contractor* is in addition referred to the Demolition Works specification (1785-CO-000-C-SPC-0018) and drawings regarding the nature of the material below and adjacent to the existing return quay wall that is to be demolished.

The *Contractor* is to note that various sections of the dredged slope for the caisson foundation trench will intersect the rock rubble founding bed below the existing quay wall and the *Contractor* shall make allowance for the dredging of this rock rubble material. In addition, the *Contractor* shall make allowances for dredging the stone bed and rock rubble associated with the demolished existing return quay.

The *Contractor* is made aware that the dredging operations are in a working port and adjacent to operational quays. The presence of debris or foreign matter, e.g. wires, chains, tyres and scrap can be expected. The *Contractor* shall plan his Dredging Equipment and procedures accordingly to minimise delays associated with encountering obstacles. The *Contractor* shall in planning its dredging works take note that there is a risk of encountering unforeseen objects or obstructions below ground level or seabed level, and shall maintain the ability to divert his dredging work to other areas until such time as the *Contractor* is able to remove the obstruction. The *Contractor* is to notify the *Project Manager* or *Supervisor* immediately if obstructions in the dredge area are identified.

4.2.2 Material within Lot 10

The launching dock was previously project dredged to -11 m CDP and the access channel beyond it was dredged to -10.5 m CDP. From the bathymetric surveys conducted by Others, it is known that siltation has occurred with the level varying from -12.2 m CDP at the boundary of the Maydon Wharf Channel to approximately -8 m CDP at the launching dock. The launching dock is to be dredged to a level of -12.62 m CD to create sufficient draft for the installation of the synchrolift and for the launching of the caissons.

The *Contractor* is made aware that as the proposed dredged level is lower than the previously dredged level, the dredge material below -10.5 m CDP will be harbour beds and contains interbedded layers of sand and firm to very stiff clays. Further information is provided in the geotechnical report contained in the Site Information.

4.2.3 Material for sandbank extension

Details of the material required for the sandbank extension are provided in specification 1785-CO-000-C-SPC-0016 Sandbank Extension.

4.2.4 Material for reclamation and caisson infill

The material for the reclamation behind the caissons will be dredged from the offshore borrow site. The *Contractor* shall compile a dredging plan to ensure material dredged for the infill falls within the borrow site and shall provide the *Supervisor* with detailed track plots as described in section 4.4.1.9 to confirm compliance.

Report “*Geophysical and Sediment Sampling Survey Of Two Proposed Sand Winning Areas In The Durban Bight by W.R.Miller and R. Leuci; Report No. 2001-0158, Council for Geoscience*”, included in annexure 1 of the Site Information, details investigations, tests and classifications of the material at the offshore borrow site. The material generally comprises a calcareous sand.

Material placed for the reclamation and caisson infill shall comprise not more than 10% fines by mass (i.e. particles smaller than 0.063mm).

A representative sample of every barge-load of dredged material as may be contemplated for reclamation shall be tested beforehand to confirm compliance herewith, failing which such load shall be discarded. Records shall be kept of such test results and of the corresponding volumes of material placed for reclamation and that discarded respectively.

Every care shall be taken to avoid contamination of sand that is otherwise compliant with unsuitable material and the consequent requirement wastefully to discard of the same. Excessively fine soil on the current seabed (i.e. bottom “mud”, comprised largely of silt and clay) shall, if any, therefore be separately removed and disposed of to the designated, off-shore, spoil, dump site, and not uplifted and mixed together with suitable compliant material beneath. The *Contractor* shall sample the upper 0.5m to 1.0m below the current seabed to determine whether and where such unsuitable superficial soil must thus be separately uplifted and disposed of.

4.3 Equipment

4.3.1 General

The *Contractor* shall take full and entire responsibility for the sufficiency of his Equipment to provide the *works*. The *Contractor* shall submit details of all Equipment to be used to the *Supervisor* for acceptance at least 3 weeks prior to dredging and reclamation work commencing.

All marine Equipment used to provide and inspect the *works* shall be subject to the requirements of the South African Maritime Safety Association (SAMSA). Floating *Contractor's* Equipment shall be maintained in a satisfactory and seaworthy condition, shall have adequate attendance by competent seamen at all times, shall be fully provided with sound and satisfactory ropes, line and moorings and shall be fully equipped with lights. At all times the *Contractor* shall be wholly responsible for the protection and safety of all floating craft engaged by him. The *Contractor* shall be cognisant of the expected sea and wave conditions within the port as well as outside of the port en route to and from the sand winning and disposal sites. The *Contractor* shall ensure the adequacy of his Equipment to operate in such conditions such that the program for the *works* is not affected by weather and wave conditions that fall within the 1:10 year return period storm conditions for the Port of Durban area as well as the offshore sand winning and disposal areas.

The *Contractor* shall immediately and at his own cost re-float or raise and remove any *Contractor's* Equipment (floating or otherwise), vessel, craft or Materials or any other property in his care or belonging to him or to any Sub-*Contractor*, which may be stranded or sunk in the course of execution and completion of the *works*. Until such sunken object is raised and removed the *Contractor* at his own cost shall set buoys and display such lights and do all such things for the safety of navigation as may be required by the authorities concerned or by the *Supervisor*.

Should the *Contractor* fail to meet the foregoing obligations the *Employer* may buoy and light each sunken object and re-float or raise and remove the same (without prejudice to the right of the *Employer* to hold the *Contractor* liable) and the *Employer* shall be entitled to recover from the *Contractor* the cost thereof or may deduct the same from any monies due or that become due to the *Contractor*.

The provisions of this Section shall apply to all *Contractor's* Equipment, vessel, craft, Materials and property therein referred including such *Contractor's* Equipment, vessel, craft, materials and property which may be declared a total loss or may be covered by insurance.

Where work is carried out from pontoons or other un-powered floating equipment, a suitably powered craft shall be in attendance at all times.

The *Contractor's* floating equipment shall be in contact with TNPA, Port Control via radio on a VHF channel to be prescribed by the Harbour Master. An additional channel shall be made available for emergencies.

4.3.2 Basin and Berth Dredging Equipment

The specification is non-descriptive in terms of the type of dredging Equipment to be employed (other than the constraint of NOT permitting Trailer Suction Hoppers Dredgers (TSHD) for Berth Dredging) and the *Contractor* is responsible for selecting the type of Equipment and method of dredging to be employed to Provide the *Works* in accordance with the technical and environmental specifications. The *Contractor* shall interpret the various geotechnical reports contained in Annexure 1 of the Site Information and shall select the dredging Equipment accordingly, in particular to meet the specified tolerances for the various aspects of the dredging *works*. The dredging and excavation Equipment used for the *works* shall be suitable for the work required, taking into consideration the volumes of material to be dredged, the type of material to be dredged, the programme to provide the *works*, the climatic and sea conditions, the disposal of dredged material and the dredge and excavation tolerances specified.

Trailer Suction Hopper Dredgers are NOT permitted for Berth Dredging or for any dredging within 20 m of an existing structure.

The *Contractor* shall provide and maintain on board all dredging Equipment a position fixing systems giving the position of plant to an accuracy of +/-0.5 m in the horizontal plane, together with competent operators to ensure that the position of dredging plant can be accurately located.

All hoppers for transporting of material shall have load indicator equipment on board in order to ensure that the hopper doors are not leaking and that no part of the load is deposited anywhere other than in the designated disposal site. The hoppers shall, in addition, be fitted with track plotting equipment.

4.3.2.1 Lot 10 Dredging Equipment

Dredging within the Lot 10 launching dock is restricted due to the lateral extent of the launch dock. As detailed in section 4.2.2, very stiff clay is expected at the dredge depths. The *Contractor* is to select suitable Equipment accordingly.

4.3.3 Discharge Equipment

4.3.3.1 Offshore disposal

Disposal of the material at the offshore disposal site shall be via bottom-dumping and the hoppers shall be suitably equipped to facilitate bottom dumping.

4.3.3.2 Discharge for reclamation behind caisson wall

Material for the reclamation behind the caisson wall shall be placed using a floating pipeline with a diffuser.

4.3.3.3 Discharge for sandbank extension

Equipment for the discharging of material for the sandbank extension is covered under specification 1785-CO-000-C-SPC-0016 Sandbank Extension

4.3.4 Silt curtains

The *Contractor* shall provide silt curtains as may be required to create paddocks for minimising spread of fines within the reclamation area. The silt curtains shall be provided as follows:

- a) Silt curtains shall be sourced from reputable manufacturers with a proven track record.
- b) Silt curtains shall be designed for the specific application and shall follow the manufacturer's recommendations and guidelines for setting up and maintaining such items as well as guidelines for installation and safety measures.

Silt curtain requirements for the sandbank extension are detailed in specification 1785-CO-000-C-SPC-0016 Sandbank Extension.

4.3.5 Compaction Equipment

It is envisaged that a form of Vibro Compaction will be used for the densification of the infill material. However, it is ultimately the *Contractor's* responsibility for selecting a suitable compaction method to achieve the required performance based CPTu acceptance criteria. The *Contractor* shall evaluate the material available from the borrow site and shall select suitable Equipment.

The *Contractor* shall supply all compaction equipment with the following minimum requirements:

- a) Compaction Equipment capable of imparting sufficient energy at an optimum frequency to achieve the required compaction.
- b) Compaction equipment with sufficient power output to achieve compaction over the full depth of the reclamation material.
- c) Instrumentation and markings allowing visual determination of depth of treatment.
- d) Instrumentation to measure power output, frequencies and amperage (if applicable).
- e) CPTu testing equipment capable of testing the full depth of treatment.

4.3.6 Survey Equipment

The *Contractor* shall provide Equipment required for the in-surveys, out-surveys and surveys of the off shore disposal and borrow sites as specified. This survey equipment is to be provided by the *Contractor* when the surveys are required, and is not required full time on site.

The minimum Equipment to be made available for surveys is the following:

- a) A seaworthy boat with a cabin suitable to accommodate and operate survey Equipment consisting of a sonar survey system capable of doing a continuous underwater survey of the seabed in the basin and the seabed at the offshore disposal site. The *Contractor* shall supply the necessary survey vessel suitable for the hydrographic and multibeam swath surveys, taking into account the different water depths, winds,

waves, currents and other significant site conditions that may be experienced on site. All lighting, safety features and equipment required for the safe operation and mooring of vessels must be supplied by the *Contractor* and must be approved by the relevant Maritime Safety Authority. The *Contractor* shall provide qualified personnel to operate the boat as well as the survey equipment and shall keep the equipment in working and seaworthy order at all times.

- b) A differential GPS system capable of a horizontal positioning accuracy of better than 250 mm at the 95% confidence level must be used for all positioning. The DGPS receiver(s) aboard the vessel must be configured such that satellites below 8 degrees above the horizon are not used in position computations. The age of pseudo-range correctors used in position computation must not exceed 20 seconds. Horizontal Dilution of Precision (HDOP) must be monitored and recorded, and should not exceed 4 nominally. Satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. Other variables, including satellite pseudo-range residuals, are to be used in conjunction with HDOP to estimate DGPS horizontal accuracy. A minimum of four satellites must be used to compute all positions. Horizontal and vertical offsets between the GPS antenna and transducer(s) shall be observed and applied with a precision better than 0.05 m.
- c) Navigational instruments and vessel motion sensors including:
 - Roll, heave and pitch sensors.
 - Heading: Gyro/Fluxgate compass.
 - Navigational computer for on-line navigational control during the survey.
 - Digital acquisition (data logging) of all the above sensor outputs.
- d) A high quality multibeam echo-sounder with a frequency of not less than 200 kHz is to be used for the surveys. The multibeam sonar must have an effective beam width of no greater than 1.5 degrees in both the along-track and cross-track directions and lateral coverage of at least 30 m for depths greater than 10 m. The system shall be capable of measuring to depths of up to 90 m.
- e) Logging and Processing Equipment including:
 - A data logger system having adequate electronic storage capabilities. The system shall store multiple inputs (Date, Time, X, Y, Z Position, vessel movements and heading and echo sounder data) on an electronic medium, which can be transferred to a personal computer. The data shall be stored at 1-second intervals or less.
 - Post processing, for motion correction of the ship movements and heading.
 - Conversion of all bathymetry data into absolute (x, y, z) files for Digital Terrain Models (DTM) for producing special reports with maps, contours, cross profiles, etc.

The *Contractor* shall be responsible for calibration of the survey Equipment required on the survey boat and provide the *Supervisor* with proof thereof. The *Contractor* shall also be responsible for arranging of tidal recordings concurrent with underwater surveys where the tide is required to determine surveyed underwater levels.

The *Contractor* shall provide all personnel to operate the launch as well as the survey Equipment and shall ensure that the equipment is in working and seaworthy order when required by the *Supervisor*.

The *Contractor* shall provide and maintain for the duration of the Contract durable temporary automatic, continuously recording tide gauges at two locations agreed by the *Supervisor*. The Equipment shall be fixed in readily visible positions where practicable, and shall be arranged so that the tide level is readable to an accuracy of +/- 25 mm at any time. At least one gauge shall be installed within 500 m of any area within which soundings or dip surveys are to be taken.

4.4 Methods and Procedures

4.4.1 Dredging and dredge material disposal

4.4.1.1 Extent of work

The extent of work, dredge profiles and levels are as shown on the 1785-CO-020 series of drawings. The following dredging and disposal cycles shall be undertaken:

- a) Dredge from sand rich zones within the basin (Zones A and B as shown on drawings 1785-CO-020-C-DWG-009-01) and discharge on south bank of sandbank for sandbank extension. Should the material available in the sand-rich zones within the basin prove of insufficient quantity to complete the sandbank extension, the *Contractor* shall dredge from the offshore borrow site and discharge on south bank of sandbank for sandbank extension.
- b) Dredge from foundation and scour trench and basin, other than Zones A and B, and dispose of at offshore disposal site.
- c) Dredge from offshore borrow site and discharge in and behind caissons for reclamation/infill.
- d) Dredge from Lot 10 launching dock and connecting link from dock to channel and dispose of at offshore disposal site.
- e) *Contractor* is responsible for ensuring that Esplanade Channel and approaches from Lot-10 remain at design depths for safe caisson towing.

4.4.1.2 Dredging methodology

All excavation and dredging *works* shall be carried out in accordance with the principles contained in BS 6349: Part 5: 1991, except as amended herein.

The *Contractor* shall dredge any material which, during the periods between the dates of commencement and completion of all excavation and dredging operations, accumulates above the specified dredged levels within the areas to be dredged as defined in the drawings. For berth dredging, this applies until such time as the stone bed and caisson have been placed.

Agitation dredging, being the attempted removal of material by the use of natural water currents or artificially induced water currents, shall not be permitted.

When dredging is undertaken adjacent to structures, due care shall be taken to avoid damage to these structures. Should any damage or alleged damage to a structure take place, the *Contractor* shall arrange, in conjunction with the *Supervisor*, for an inspection. In the case where the damage is underwater, the *Contractor* shall arrange for a diver's inspection. Any damage to structures caused by the *Contractor's* operations shall be repaired at the *Contractor's* expense. The repair schemes shall be agreed with the *Supervisor* and any affected third party.

The *Contractor* shall profile all slopes to the gradients and levels shown on the drawing in a controlled manner that prevents slope failure during dredging. Dredging/undercutting at the toe of the slope to intentionally cause slope failure and slumping of material is not permitted.

The *Contractor* shall compile a dredging plan to ensure material dredged for the sandbank extension falls within the demarcated zones and shall provide the *Supervisor* daily with detailed track plots as described in section 4.4.1.9 to confirm compliance. Any material used for sandbank extension that is not dredged from the demarcated zones shall be removed by the *Contractor* at his own cost and shall be deposited at the offshore disposal site.

4.4.1.3 Sailing and navigation constraints

Vessels conveying material to and from the disposal and borrow sites will be required to navigate within the confines of the Port of Durban and its immediate approaches. All vessel movements are controlled by Port Control to ensure safe navigation. The *Contractor* shall allow for the fact that commercial shipping will take precedence over dredging vessel movements.

The fullest collaboration between the *Contractor*, Harbour Master and the *Supervisor* is essential with regard to the working of the port. All correspondence, applications and notices with the Port Authorities shall be directed through the *Supervisor*.

Dredging operations shall be planned and executed in conjunction with Port Control in order to limit the impact of dredging operations on port operations. The *Contractor* must take note that all *works* are subject to the provisions of the Harbour Regulations. It is the duty of the *Contractor* to obtain the regulations from the port authorities.

The *Contractor's* method for dredging and transporting materials shall be such as to avoid leakage, spillage, scouring on land or the deposition of dredged material in shipping channels, basins or berths. In the event of any such leakage or deposition occurring, the *Contractor* shall remove such leaked materials, repair scoured areas, or restore such channels, basins or berths to their original depths.

The *Contractor* is responsible for establishing limiting sea states for his vessels, obtaining forecasts of approaching weather and operating his vessels safely in terms of the criteria.

No vessel shall leave port if the forecast weather conditions are expected to approach any of these limits and the vessels shall return to port immediately if such conditions arise while out of port.

The *Contractor* shall take all precautions, and shall at all times maintain radio communication between all his vessels and Port Control. The *Contractor* shall comply at all times with the instructions of Port Control regarding shipping and navigation safety. Any disruption of port shipping due to encroachment of the *Contractor's* moorings into the designated shipping channel will not be permitted.

The *Contractor* shall adhere to the speed restriction within the Port of 10 knots.

4.4.1.4 Offshore disposal

The approved offshore disposal sites are identified on drawing 1785-CO-020-C-DWG-0010-01. The dumping of any material outside the approved disposal site is not allowed. Disposal of the material at the offshore disposal site shall be via bottom-dumping. The *Contractor* shall ensure that material is not concentrated locally in the disposal site and shall ensure as even a spread as practicable with no dumping on top of an area that has had a load previously dumped on. The *Contractor* shall provide the *Supervisor* with a track plot of the dump location of each load as detailed in 4.4.1.9.

4.4.1.5 Discharge in caissons

The caissons will be ballasted full of seawater during installation to lower the caissons on to the stone foundation. Filling with approved sand material shall be carried out immediately after the caisson has been placed. The material is to be placed using a floating pipe line fitted with a diffuser. Discharge is to be in a controlled manner (position of pipeline outlet and rate of discharge is to be controlled) to ensure that segregation of fines is minimised and the fill is placed in evenly spread, homogenous layers. The maximum differential in height of the fill during placement within the caisson shall not exceed 1 m.

4.4.1.6 Discharge behind caissons

Filling behind the caissons shall only take place once all caissons, including the infill panels, have been placed for a particular phase such that the reclamation area is cut off from the open basin.

The material is to be placed using a floating pipe line fitted with a diffuser. Discharge is to be in a controlled manner (position of pipeline outlet and rate of discharge is to be controlled) to ensure that the fill is placed in evenly spread, homogenous layers. The fill is to be brought up in layers, with a maximum layer height of 2 m.

Acceptance of the compacted reclamation is based on performance testing. The *Contractor* is responsible for selecting appropriate placement methods such that the material placed is able to meet the performance criteria once compacted. Segregation of fine material will result in pockets of silt or clay forming that are unlikely to meet the performance criteria. The *Contractor* shall therefore employ suitable placement methods to minimise segregation.

The quantity of material to be placed in this area shall be to meet the levels shown on the drawings. The *Contractor* shall place material to a certain level above the final design level such that the design level is achieved after compaction allowing for settlement of the fill due to densification. The *Contractor* is responsible for estimating this allowance for settlement.

The *Contractor* shall provide and lay all placement pipelines inclusive of fittings and booster pumps, from the dredging plant in such a manner that other construction activities and commercial shipping is not interrupted or affected in any way. The *Contractor* shall arrange to repair pipeline leaks immediately. The proposed route of all reclamation pipelines shall be subject to acceptance by the *Supervisor*.

Should the *Contractor* require hardened surfaces for access or haul roads on the reclaimed fill in the execution of these works, he may construct such temporary roads subject to the approval of the *Supervisor*.

4.4.1.7 Sequencing of dredging works

The following sequence shall be adopted for completion of the dredging works:-

- **Phase 1 – Berth 205 Dredging, Basin Dredging and Berth 205 Reclamation**
 - a) Dredge Lot 10 Launching Dock and link to Esplanade Channel to allow for installation of synchrolift.
 - b) Commence with basin dredging excluding Zone B. Zone A material to be deposited on the sandbank and the remainder of the basin material to be deposited off shore.
 - c) Zone B basin dredging to commence in vicinity of existing return quay only once temporary sheet piles to retain dredge slope have been installed (refer to 1785-CO-080 series of drawings for details of temporary sheet piles). Zone B dredging to be undertaken in conjunction with existing return quay wall demolition such that demolition / removal of the return quay takes place in a controlled manner.
 - d) Zone B dredging to proceed in a westerly direction but shall be halted before encroaching on the piling construction works ongoing for the new return quay. Zone B basin dredging shall be halted at a sufficient distance away from the new return quay to ensure a stable slope and sufficient working space for the return quay construction.
 - e) Berth 205 dredging (foundation and scour trench) to proceed after basin dredging and demolition of existing return quay. Dredging to start at 205 / 204 interface and proceed in westerly direction towards return quay.
 - f) After completion of the steel piling for the cellular caisson return quay, the remainder of Zone B dredging can commence.
 - g) After completion of Zone B dredging, the remainder of the berth dredging and the dredging of the return quay scour trench can commence.
- **Phase 2 – Berth 204 Dredging and reclamation**
 - a) The berth dredging for Berth 204 can only commence once the *Contractor* is given access to Berth 204 which is after completion and handover of Berth 205.
- **Phase 3 – Berth 203 Dredging**
 - a) The berth dredging for Berth 203 can only commence once the *Contractor* is given access to Berth 203 which is after completion and handover of Berth 204.

4.4.1.8 Monitoring of existing quay wall during dredging

The *Contractor* shall undertake monitoring of the existing quay wall from date of *site access* to completion of the works. Monitoring of the existing quay wall shall be undertaken using two methods, the primary method being electronic inclinometers and a secondary back up system being a surveyed baseline. Details of the proposed monitoring system are to be submitted by the *Contractor* to the *Supervisor* for acceptance.

The *Contractor* shall establish a surveyed baseline in the form of steel pins inserted into the existing capping beam at 10 m centres along the entire length of the existing quay prior to the commencement of any works. The *Contractor* shall, on a bi-weekly basis, survey the baseline and shall compare the data with that obtained from the inclinometers to verify the electronic system.

The inclinometer system shall consist of an articulated chain of sensor elements (segments). The segments, each containing a multi-axial accelerometer, shall be interconnected in such a manner that they can move in relation to one another in all directions but shall not twist. The instrument shall be capable of following and presenting deformation and tilt with a resolution of 0.01 mm per 500 mm in the direction perpendicular to the quay wall. The accuracy, expressed as lateral deviation over a length of 30 m of casing shall be 6.00 mm x 30 m. The inclinometers shall be calibrated with a calibration tool after installation.

The inclinometers shall be mounted in casings firmly attached to the existing quay wall. The inclinometer chain shall extend from the foundation level of the wall all the way up to the top of the capping. The bottom end shall serve as a fixed reference point. Inclinometers shall be installed at a spacing of 20 m along the face of the existing quay wall.

The reading units that interrogate the sensors shall be housed in a central instrumentation room set up within the *Contractor's* on site offices. The data collected shall be processed on a PC using dedicated software in accordance with manufacturer's specification. The data shall be collated on a daily basis and shall be presented to the *Supervisor* daily during the dredging operations.

The instrumentation shall be capable of operating in temperatures ranging from 0 °C to 50 °C and shall be capable of operating in the wet and the dry.

The inclinometers shall remain in place until reclamation begins. During periods when dredging has been completed but reclamation has not yet begun (e.g. during Rigid Inclusion installation and caisson placement), data collation and reporting shall be on a weekly basis.

4.4.1.9 Dredging track plots

A Global Positioning Satellite (GPS) record is to be kept for all dredging and disposal activities. This record shall include the following data:

- a) Start time, end time and location of individual track plots for dredging (filling of hopper).
- b) Departure time from the dredge site (off shore borrow site or basin).
- c) Route followed by the vessel (GPS track) to disposal/discharge site (offshore disposal site, reclamation or sandbank extension).
- d) Time of arrival at the disposal/discharge site.
- e) Position of the vessel at the time of starting to discharge the dredge spoil.
- f) Heading and speed of the vessel at the time of starting to discharge the dredge spoil.
- g) Position of the vessel at the time of completion of discharge of the dredge spoil.
- h) Quantity of material discharged.
- i) Heading and speed of the vessel at the time of completion of discharge of the dredge spoil.
- j) Time of departure from disposal site.
- k) Route followed by the vessel on route back to the dredge site.

The daily long track plot shall be recorded electronically on a compact disk in ASCII format and shall be submitted to the *Supervisor* on a daily basis.

4.4.1.10 Dredging progress reporting

The *Contractor* shall keep daily written records as required by the *Supervisor*, and submit a signed copy to the *Supervisor* not more than 3 days after the date to which the record relates. The records shall give details of the dredging area, the material being dredged and any delays to the dredging operation.

The *Contractor* shall prepare a weekly report to cover the work executed each week from midnight on Sunday. The report shall be submitted to the *Supervisor* by Tuesday noon following the week covered by the report. The report shall include a return of the *Contractor's* Equipment and Personnel employed the previous week and of the *works* on which they were engaged. The *Contractor* shall submit to the *Supervisor*, on a weekly basis, a coloured chart showing the extent of dredging and profiling, together with the areas from which material has been dredged.

On the first weekday following the issue of the *Contractor's* monthly progress report to the *Supervisor*, the *Contractor* shall attend the *Supervisor's* office for a meeting to discuss the progress achieved during the previous month and the progress planned for the current month.

4.4.2 Dredging Surveys

4.4.2.1 Requirements of marine surveys

All co-ordinates used during this contract shall be to WG31.

All survey work shall be carried out and certified by a qualified hydrographic surveyor (IHO Cat A/B recognised hydrographic surveying course or equivalent). The *Contractor* shall give the *Supervisor* unlimited access to the survey vessels at all times.

4.4.2.1.1 Tidal Data

Regardless of whether RTK GPS is used for position fixing, independent tidal measurements for purposes of water level corrections are required. The tide gauge must be calibrated using a local benchmark to determine the installation level to within 2 cm. Tidal records shall be corrected for onsite barometric pressure changes.

4.4.2.1.2 Multibeam Echo-sounder

The hydrographer shall ensure that the multibeam coverage shall have an overlap of at least 50% in order to check the surveyed data. Heave, roll, pitch, heading, and navigation timing error (latency) corrections shall be applied to multibeam soundings to correct the effect of vessel motion caused by waves and swells (heave, roll, pitch), the error

in the vessel's heading, and the time delay from the moment the position is measured until the data is received by the data collection system (navigation timing error). Heave shall be observed in no coarser than 0.05 m increments. Roll and pitch shall be observed in no coarser than 0.05 degree increments. Heading shall be observed in no coarser than 0.1 degree increments. Navigation timing error shall be observed in no coarser than 0.01 second increments.

4.4.2.1.3 Multibeam Sonar Calibration

Prior to commencing the survey operation, the hydrographer shall conduct a system accuracy test to quantify the accuracy, precision, and alignment of the multibeam system. Testing shall include determination of residual biases in roll, pitch, heading, and navigation timing error. These values will be used to correct the initial alignment and to calibrate the multibeam system. System accuracy testing should be conducted in an area similar in bottom profile and composition to the survey area, and during relatively calm seas to limit excessive motions and ensure suitable bottom detection. The order in which these biases are determined may affect the accurate calibration of the multibeam system. The hydrographer should determine the biases in the following order: navigation timing error, roll, pitch, and heading (yaw).

4.4.2.1.4 Sound Velocity Profile

To ensure that the overall depth measurement accuracy criteria are met, velocity of sound observations shall be taken with sufficient frequency, density, and accuracy. The accuracy with which the speed of sound correction can be determined is a complex function of the accuracy with which salinity, temperature, and depth, or alternately, sound speed and depth, can be measured. The sound speed profile in the survey areas must be measured and monitored at sufficient frequency and to an appropriate depth to assure that the bathymetric data provided meets the required depth accuracy specification. The sound speed profile should be determined with a calibrated system capable of measuring the speed of sound with errors no greater than 2 m/sec (at the 95% confidence level). A calibrated sound speed measuring system capable of measuring the sound-speed profile to at least 95% of the deepest anticipated depth in the survey area must be available, though collection of sound speed data to 95% of the full depth of the survey area will only be required before and after the completion of the surveys. Velocity of sound correctors shall be applied to soundings to compensate for the fact that echo-sounders may only display depths based on an assumed sound velocity profile while the true velocity may vary in time and space.

4.4.2.1.5 Error Budget Analysis for Depths

The accuracy of measured depths in the hydrographic survey applies to the systematic measurement of general water depths and to the least depths determined over any obstructions. The total sounding error in a measured depth at the 95 percent confidence level, after systematic and system specific errors have been removed, shall not exceed ± 100 mm (Z co-ordinate) and the Total Horizontal Uncertainty (THU) 250mm horizontal (X and Y co-ordinates). The maximum allowable error in measured depth includes all inaccuracies due to residual systematic and system specific instrument errors; the velocity of sound in water; static vessel draft; dynamic vessel draft; heave, roll, and pitch; and any other sources of error in the actual measurement process. The hydrographer shall document in the Descriptive Report the methods used to minimize the errors associated with the determination of depth (corrections to echo soundings).

4.4.2.1.6 Towed Side Scan Sonar

Dual frequency digital side-scan sonar and PC-based acquisition system is required to collect the sonar graphs. The scan range on the sonar should be set to 37 m or less in order to image any potential debris on the sea floor and 200% bottom coverage is required. Both frequencies must be processed to enable target detection. The tow-fish altitude must be kept between 10-20% of the scan range used in order to obtain an acceptable slant range.

4.4.2.1.7 Deliverables and Data Presentation

The *Contractor* shall submit a survey quality control plan to the *Supervisor*. A survey report shall be submitted to the *Supervisor* on completion of all in and out surveys. It must give a clear account of how the survey was carried out, the results achieved, the difficulties encountered and the shortcomings. Emphasis must be placed on the analysis of achieved accuracies.

The *Contractor* upon completion of the survey shall produce the following:

- a) Shoal-biased (or median biased) high-resolution multi-beam colour bathymetric image map of the areas, inserted geographically referenced into a DXF or DWG file, contoured at 0.5m intervals.

- b) Two hard copies of the bathymetric image map and electronic copies (pdf) are required.
- c) Track Chart of all survey lines in DXF or DWG format.
- d) ASCII data files of all the points recorded.
- e) ASCII data files reduced to give one point per square meter (mean of all points in a m2).
- f) All details with regards to the co-ordinate transformation and calibration procedures and results.
- g) A report detailing the findings and all details with regards to the survey. This is to include: Survey personnel, date, time, area, conditions, survey vessel, positioning system, equipment used, software used, accuracies achieved and the respective confidence levels, etc.

4.4.2.2 In-surveys

Before any dredging, profiling, reclamation or sandbank extension may commence, the *Contractor* shall carry out surveys of the area to be dredged or profiled, including adjacent side slopes. The survey shall include the areas within the current basin where reclamation and sandbank extension will take place. These surveys shall be carried out in collaboration with the *Supervisor*. Both parties shall agree on the existing sea bed levels before commencing work. A copy of the final agreed in-survey shall be furnished to the *Supervisor* for record purposes.

The in-survey shall form the basis for calculations of quantities of materials dredged or profiled as detailed in the Pricing Instructions.

4.4.2.3 Out-surveys

The following out-surveys are required:

- a) On completion of the placement of the offshore material at the sandbank extension, a survey of the partially completed extension shall be undertaken for payment purposes.
- b) On final completion of the sandbank extension, a survey of the completed extension shall be undertaken to ensure compliance with the placement tolerances for the sandbank.
- c) On completion of dredging and profiling within the basin, the entire basin area (excluding the berth pocket dredging) shall be surveyed to ensure compliance with the dredging tolerances.
- d) On completion of berth dredging for the caisson and scour trench (berth pocket dredging), the trenches shall be surveyed to ensure compliance with the dredging tolerances.
- e) On completion of all dredging and reclamation, a survey of the offshore disposal and borrow sites.

The respective areas shall be surveyed as per 4.4.2.1 and the final levels shall be recorded on a drawing. The results of this survey shall be made available to the *Supervisor* for acceptance.

The *Contractor* may also be required to undertake interim dip surveys of the caisson and scour trench to ensure compliance with the required tolerances. Scour and caisson trench levels shall be taken on a 3m x 3m grid and the levels shall be recorded to one decimal of a metre. The *Contractor* will also be required to undertake underwater video inspections of the scour trench and cut slope.

Should it be found that the correct levels have not been achieved, the *Contractor* shall carry out further work until the prescribed levels have been achieved.

The out-surveys will be used by the *Supervisor* for assessing the acceptability of the work, and will be accepted as the in-survey for construction of the scour protection and stone bed layer.

A final survey of the basin for certification of Completion will be undertaken by the *Employer's* surveyor.

4.4.2.4 Timing of surveys

Surveys shall be carried out as follows

- a) In-surveys: no longer than two weeks before commencing dredging or profiling in the relevant area.
- b) Out-surveys: as soon as dredging or profiling of the relevant area has been completed and the required tolerances have been achieved.

All surveys shall be witnessed by the *Supervisor*. The *Contractor* shall notify the *Supervisor* of his intention to carry out surveys at least 24 hours prior to commencement of the survey and shall provide facilities for the *Supervisor* to witness the survey when required.

4.4.3 Reclamation compaction

4.4.3.1 Extent of work

The extent of the area and depth requiring compaction is shown on drawings 1785-CO-020-C-DWG-008-01. The *works* include compaction of both the material within the caissons and the reclamation material behind the caisson wall.

The work shall consist of compaction, performance monitoring and testing of compaction as identified in this specification within the defined extents to meet the acceptance criteria presented in section 5.1.3 of this specification. It shall be the *Contractor's* responsibility to determine and implement the systems to achieve the specified acceptance criteria.

4.4.3.2 Compaction methodology

With regards to the compaction of the reclamation material, this specification is non-descriptive and is instead performance based. It is envisaged that a form of Vibro-Compaction will be used for the densification of the infill material however it is ultimately the *Contractor's* responsibility for selecting a suitable compaction methodology to achieve the acceptance criteria. The *Contractor* shall evaluate the material available from the borrow site and shall select a suitable methodology to achieve the required densified soil parameters. The *Contractor* is responsible for determining spacing between compaction points, vibration frequencies, energies etc.

Densification shall be achieved by a form of compaction. Chemical treatment or soil reinforcement of the material to achieve the specified parameters is not permitted.

During compaction of the material within the caisson and directly behind the caisson, care is to be taken to prevent any damage to the caisson walls. The vibratory probe shall be kept at a minimum of 1m away from the walls of the caisson (measured from wall face to outer envelope of probe).

4.4.3.3 Quality Control

All compaction shall be performed under the oversight of the *Supervisor*. Monitoring and logging of all compaction operations for all production work shall be done by the *Contractor* and records submitted to the *Supervisor*. Final acceptance of satisfactory quality of the compaction *works* once complete will be carried out by in situ CPT testing.

4.4.3.4 Compaction record keeping

For the production work, the *Contractor* shall perform tests and take measurements. The following measurements shall be recorded for each Compaction location:

- a) Compaction/probe number
- b) Start and finish time of compaction/probing
- c) Depth of treatment/probing
- d) Approximate backfill quantity
- e) Comments or unusual observations

The *Contractor* shall be responsible for ongoing sampling, testing and monitoring of the material placed during the reclamation to ensure that the required performance can be achieved with the *Contractor's* selected compaction methodology.

4.4.3.5 Monitoring of Caisson Quay Wall during reclamation

Details of monitoring requirements for the new caisson quay wall during reclamation are provided in specification 1785-CO-000-C-SPC-0002 Caisson Construction and Placement.

5.0 COMPLIANCE WITH REQUIREMENTS

5.1 Sampling, Testing, Commissioning and Completion

5.1.1 Dredging Completion

Certification of dredging Completion will be by the *Supervisor* and shall be determined based solely on the levels obtained from the *Employer's* survey measured against the levels shown on the drawings.

5.1.2 Sampling and testing of reclamation material

The *Contractor* shall be responsible for sampling, testing and monitoring of material dredged and placed for the reclamation infill to ensure the material meets the required design classification. On a daily basis during the progress of filling, the *Contractor* shall take two bag samples (of 25 kg each) of the materials placed in the reclamation at locations directed by the *Supervisor*. Samples shall be taken at a maximum depth of 0.5 m. The *Contractor* shall carry out sieve analysis tests on each of the bag samples and shall submit result to the *Supervisor* daily. The samples shall be taken from the material placed on the reclamation (i.e. not from within the hopper) and shall be taken before the subsequent layer is placed.

5.1.3 Acceptance criteria for compaction of reclamation material

All testing to determine specification compliance will be provided by the *Contractor*. CPTu testing is specified for the compaction of the reclamation fill and the caisson infill to confirm compliance with required design densities, strengths and stiffness. Testing of the material within the caissons shall be undertaken prior to construction of the capping beam. Testing of the material behind the caisson wall shall be undertaken prior to construction of the layer-works for the paving. If the required results are not achieved the *Contractor* shall adjust his compaction methodology accordingly and retest until the required result are achieved.

CPTu testing shall be carried out in strict accordance with BS EN ISO 22476-1:2012. CPTu testing shall be carried out as follows:

- A minimum period of 2 weeks should be allowed to lapse between completion of any ground densification and the commencement of testing in that area.
- The location of the probe shall coincide with the centroid location of a compaction grid cell or as otherwise directed by the *Supervisor*
- The frequency of the in situ testing shall be one test per 100 meters squared of site surface area treated, and shall extend to the bottom of the Compaction treatment depth.

5.1.3.1 Compaction acceptance criteria

The reclamation fill shall be compacted such that “corrected cone resistance” (qt) shall not be less than the following magnitudes at the corresponding depths:

Level* (m)	Depth (m)	qt (MPa)
2	0	0
0	2	9
-5	7	14
-10	12	17
-15	17	20
-20	22	22
-25	27	24

Level*: refers to elevation with respect to CDP.

Depth: refers to depth below the specified top of the compacted hydraulic fill.

qt (corrected cone resistance) at each depth: refers to the “2m rolling average” of the measured values corresponding to such depth.

5.2 Tolerances

5.2.1 Dredging

Dredging shall be carried out to the required levels and profiles or such modified levels and profiles. Any out of tolerance work will be rectified by the *Contractor* at his own cost. The *Contractor* shall ensure that cumulative tolerances meet with tolerance requirements as defined within this specification.

For final acceptance the following tolerances shall be applied to dredged areas:

5.2.1.1 Basin dredging

Horizontal (x,y) lines: A maximum deviation of +1.5 m (overdredging) shall be permitted. No negative tolerance shall be allowed.

Levels: A deviation of +0mm above the theoretical CD (Port) level as shown on the drawings will be required. There is no restriction on the over-dredging below the levels shown on the drawings. Although there are no restrictions on overdredging, there is a restriction on the amount of material allowed for disposing of offshore. The maximum volume is stated in the Project Environmental Specification (PES) and the *Contractor* is to ensure that the amount of material disposed of, and hence the amount of material dredged, is below the value stated in the PES.

Within 20 m of any existing structure or proposed new structure the maximum permitted over-dredge, below the specified dredged levels, shall be 500 mm. Ploughing of material from under-dredged areas into over-dredged areas is only permitted for final levelling of areas; the *Contractor* shall not intentionally over-dredge and adopt this method as his main dredging methodology.

5.2.1.2 Berth dredging for caisson and scour trench

A tolerance of + 150 mm to -350 mm from the designated levels shall be acceptable, whilst the tops and toes of the side slopes shall be within 1 m of the locations shown on the drawings.

5.2.1.3 Side slopes

Slopes shall be profiled such that the average gradient of the slope indicated on the drawings is not exceeded.

5.2.2 Infill reclamation

A tolerance of + 150 mm/ - 150 mm from the designated levels shall be acceptable.

5.2.3 Reclamation compaction

- a) The *Contractor* is to provide a plan layout of the proposed compaction grid. Probes shall be performed within 300 mm of the planned location.
- b) The vibrator tip shall penetrate to the full reclaimed depth which is based on the dredged profile.