[13.] HYDROGRAPHIC SURVEY [PM06]

[13.1.] Overall Aims & Scope of Surveying & Dredge Works Monitoring Operations [PM06]

The principal aims of the survey process are:

- Establishing horizontal and vertical spatial control for the project site
- Establishing the boundaries (horizontal and vertical) for the project site
- Establishing the pre / post contract morphology of the project site
- Measuring the progress of the project

Survey provides 2-dimensional and 3-dimensional positioning to the various units employed on the dredging site through the application of RTK reference stations and radio tide gauges. Most of the larger dredging units obtain their 2-D/3-D positioning from outside commercial sources via satellite communication links i.e. C-NAV RTG GPS correction service.

Survey provides a hydrographic survey capability to the project through the operation of a survey vessel and a shallow water survey vessel. These vessels give the project the capability to measure the project prior to the commencement of physical operations, measure the progress of material removal and show to the client when all of the project areas have been dredged to the acceptable level.

Survey is the eyes of the dredging process as the majority of the time dredging operations occur both on water (away from visual landmark) and beneath the water (view of the work area is hidden). Survey gives the dredger the ability to locate itself in the work site and to ‘see’ what they are doing.

Survey is the quality control mechanism for the majority of dredging works. By carrying out progress surveys the management team is made aware of the production of the various dredging units and can adjust / undate scheduling / planning appropriately.

The surveyors of Boskalis Westminster provide the positioning and measurement information for the broad variety of the Group's dredging and infrastructural projects. The division has a strong workforce of professionals, who are exclusively available to Boskalis projects. Using state-of-the-art equipment, they literally act as 'the eyes and ears' of Boskalis in large and small scale projects around the world.

The detailed information collected by the surveyors, is used to form a sound basis for every operation started by Boskalis Westminster. Dredging, stone dumping, bridge protection and tunnel building, all to the same extent, require detailed information about site and circumstances.

Boskalis Westminster is a leader in its field. Surveying has to meet the highest standards, as it often provides the basis for projects with a life span of several generations. Boskalis Survey can draw from a large pool of highly qualified and experienced surveyors to work all over the world. Each local operation is given full back up from the Boskalis headquarters, with its wealth of support facilities, in the Netherlands.

To be able to meet the small scale of detail, which is put into even the largest scale project, Boskalis' surveyors utilise the latest technology. Equipment used includes single and multi beam echo sounders, motion sensors, fibre-optic gyrocompasses and sound velocity probes. Both short and long range (D)GPS provides sub-metre accuracy, whilst real Time Kinematic or LRK GPS satellite systems allow for centimetre precision in positioning. The large flows of

information are computer processed and interpreted for effective input into the process of project execution.

Boskalis maintain close relations with renowned manufacturers to evaluate newly developed R&D equipment and technologies.

For offshore tasks, Boskalis operates a dedicated fleet of survey vessels. These vessels can be purposely equipped for every project, using modular equipment units to fit the exact requirements of a particular situation.

In addition to various specialist software applications native to the sector, Boskalis Survey utilises its in-house-developed software. Designated “DredgeView”, the software helps graphically visualise and interpret the information gathered during survey. This enables Boskalis to enter into any project fully documented and prepared for whatever will be encountered on site.

[13.2.] Mandatory / Statutory Consents Required to Operate the Surveying & Dredge Works Monitoring Operations [PM06]

Local Notice to Mariners (released by QHM) are not normally required prior to the commencement of survey operations and no mandatory/statutory consents are required to operate the surveying and dredge works monitoring operations

BWL have assumed that permission of QHM is required for all survey vessel movements and operations.

QHM and, where required, any relevant stakeholders (for example local marinas, ferry companies, Portsmouth International Port) will be informed of the timing of any surveys.

BWL have assumed that QHM and other stakeholders will be co-operative with BWL when carrying out standard survey operations. In the past there have not been any restrictions imposed on survey operations by QHM.

[13.3.] Assumptions & Provisions With Respect to Interface with Dockyard Operations, Marinas & Other Users [PM06]

BWL will work with QHM and MoVo to ensure the survey works do not compromise normal dockyard operations and also to make best opportunity to survey berth pockets when they become free.

BWL will also work closely with the Middle Slip Jetty contractor to ensure surveys within this area are executed in a safe and timely manner.

BWL has assumed that permission of QHM is required for all survey vessel movements and operations and that normal navigation / collision avoidance rules will apply in the dockyard area.

BWL have assumed that operational Type 45 Destroyers will severely limit survey operation if their ‘electronic systems’ are energised i.e. the interference of survey transmissions in the 458.5-458.9 mhz band and the reception of GPS L1/L2/L3 / GLONASS satellite navigation signals plus the reception of C-NAV RTG satellite based GPS correction signals.

Survey planning will be discussed during the daily ‘Plan of the Day’ meetings with QHM,. Where possible surveys will be undertaken during any periods the Type 45 Destroyers are at

sea, in the event this is not possible QHM will be asked to liaise with the vessels to determine if the above signals can be switched off for a short period. .

The marina operators bounding the work area will be contacted well in advance of the works starting as part of our normal pre works stakeholder dialogue and notices process. Detailed planning will then take place with each individual marina as regards access, timing etc. with surveys then planned to be undertaken at a mutually acceptable time. The DIO Project Manager will be invited to attend these meetings together with the Port Surveyor.

A baseline survey of the main access channels and other easily accessible areas will be undertaken as close as possible to the commencement of the dredging to the same standards and specifications as for the main project.

At agreed periods, interim surveys to monitor any possible effects of siltation may be undertaken, with a final post dredge survey run to detail the condition of the marina footprints on completion of our works.

These surveys will be undertaken over directly accessible areas, with no movement of moorings, pontoons, moored craft, etc.

Surveys will be carried out at less busy periods such as during the week rather than the weekends for instance.

[13.4.] Survey Control - Setting Out of Works and position Fixing in the Dredge Area [PM06]

BWL will submit details of its proposed method of position fixing for the acceptance of the DIO PM before any dredging or survey work is commenced.

BWL will establish and accurately calibrate to Chart Datum, radio tide gauges at suitable locations to accurately represent the tide at the locations being dredged. The dredgers and survey launches will be equipped to receive and display signals from the tide gauges.

All tide gauges will be checked weekly against the Works temporary bench marks and they will be re-calibrated if necessary.

BWL will, as soon as practicable, supply the DIO PM with records in an approved form, relating to all references, pegs, temporary bench marks and tide gauges and will keep such records up to date by formal notice to the DIO PM.

Horizontal control will be by Differential Global Positioning System (DGPS). For this purpose all dredgers and survey vessels will be equipped with receiver units, while a differential receiver/transmitter will be established in or close to the project area.

All positioning will be expressed in local grid co-ordinates or any other co-ordinate system required by the Client. The performance of the positioning system will be checked regularly against existing trig-points.

All vessels performing dredging or survey functions will be fitted with Differential Global Positioning Systems (DGPS), which will be used for horizontal control. Differential corrections will be received and applied at all times. The DGPS received on board the survey vessel will be checked for accuracy prior to deployment. Positions output will be in the Ordnance Survey OSGB 36 co-ordinate system.

For vertical control a radio tidal transmitter will be installed in or close to the operational area.

Survey vessel and dredgers will be equipped with receivers to ensure that tidal data is available on each vessel at all times.

The levels transmitted will be checked regularly against visual tide-boards and/or benchmarks. Vertical measurement will be by precision dual-frequency echo-sounder. The echo-sounder will be calibrated by means of the bar check method before any important survey operation is carried out.

In areas subject to heave, a heave-compensator will be connected to the echo-sounder in order to compensate measured depths for vertical displacements. All vertical measurements will be expressed in local datum or any other datum required by the Client.

On satisfactory completion of the Works, BWL will remove all gauges, profiles, transit stakes, stations, buoys, marks and other temporary work which he may have erected for the purposes of the Contract.

BWL will allow all reasonable access to the DIO PM for checking the setting out of the Works and positioning of the dredging Equipment to be checked.

BWL will give the DIO PM not less than 48 hours' notice in writing of his intention to set out or give levels for any part of the Works in order that arrangements may be made to carry out any checks required.

[13.5.] Resources, Plant & Equipment Required to Deliver the Surveying & Dredge Monitoring Works [PM06]

[13.5.1.] Personnel [PM06]

BWL maintains a permanent Survey Department, including a core of surveyors familiar with working in Portsmouth and other MoD facilities and projects. Further, there is an international survey pool of 75 surveyors available within Boskalis.

Boskalis Westminster is a leader in its field. Surveying has to meet the highest standards, as it often provides the basis for projects with a life span of several generations.

Boskalis Survey can draw from a large pool of highly qualified and experienced surveyors to work all over the world. Each local operation is given full back up from the Boskalis headquarters, with its wealth of facilities, in the Netherlands.

[13.5.2.] Survey Launch [PM06]

BWL will ensure that all survey and/or support vessels used during the course of the survey are suitably equipped and maintained to perform safely all specified survey activities. Due consideration will be given to the expected weather conditions and sea-state, and physical environment of the survey area.

The survey vessel(s) will be capable of being held on station for extended periods during equipment deployment and retrieval and during measurement activities. Vessels will be capable of making good time whilst travelling between sites.

BWL will ensure that the vessels carry sufficient spares for equipment so that the failure or loss of one or more components does not jeopardise survey operations.

BWL will observe the regulations for vessel lights/marks as prescribed by the International Association of Lighthouse Authorities (IALA) and the International Regulations for the Prevention of Collisions at Sea.

BWL will make arrangements and obtain permission to use such safe harbours as it considers necessary.

Approved (SOLAS) and good quality lifejackets will be provided for all personnel on board the survey vessel(s). These will be serviced every 12 months by a recognised SOLAS agent, with service documentation provided by BWL.

The use of VHF radios will be in accordance with the appropriate legislation and regulations. All lifting operations and equipment will conform with the UK Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) and the Provision and Use of Work Equipment Regulations 1998 (PUWER).

Everyone taking part in this operation will have been given the BWL safety induction. Registration forms are kept in the site office. Prior to the day's works a Start Of Shift meeting is held with the operatives to discuss all works during that day.

Toolbox talks with this method statement and the associated risk assessments will be given to the operatives prior to the execution of the works. Attendance is recorded using the toolbox registration form.

Survey operations will take place for the duration of the dredging campaign and will principally be carried out during day light hours.

The survey vessel informs QHM when moving in and out from Portsmouth Harbour. The working area has been notified to other vessels in the area via a local Notice to Mariners.

[13.5.3.] Survey Software [PM06]

All surveys will be run using "Dredge View", an 'in-house' survey package developed by Boskalis. The basic properties of the package are:

Data logging: Vessel position is made visible relative to the centreline of the works and the desired survey line.

Processing: Where depths are reduced to datum, spurious data is removed and the integrity of the data is checked.

Presentation: Processed data can be plotted as bathymetric charts with contour lines, as cross-sections and can be formatted for use on the navigation display of the Captain or Senior Dredge Master on board the dredger.

Volume calculation: Performed by either subtraction of Pre Contract Survey and Post Contract Survey DTM layers or surface areas of cross-sections. (Pre/Post Contract Surveys are sometimes also referred to as "Pre/Post Dredge Surveys").

Positioning of dredging units: To optimize the dredging operation, the package allows the graphical display of the dredger's position, including the position of the drag head, objects of interest such as channel centre/toe lines, buoys, quay walls, dredging limits, etc.

[13.5.4.] Survey & Positioning Equipment [PM06]

The following tables detail the expected equipment deployed for the works:

[13.5.4.1.] Survey Vessel

Survey Vessel		
Description	**Online**	
Surface Positioning		
Trimble SPS Series RTK GPS receiver	1	
Survey Equipment		
RACK Industrial PC computer, incl. DredgeView navigation software package	1	
Position Display Monitor (helmsman)	1	
Octans Gyro Compass and motion sensor	1	
Simrad EM3002 Multibeam Echo sounder, incl. HWS 52 workstation and QPS software	1	
Reson Navisound Single beam Echo sounder or equivalent, 33/210 kHz	1	
Saiv A/S SD204Sound Velocity Probe	1	
Tide Gauge Receiver	1	
AML Smart SVP	1	
Side Scan Sonar (6 week Pre Dredge Investigation Campaign Only)	1	

[13.5.4.2.] Onshore

Onshore		
Description	**On-line**	
Surface Positioning		
Trimble SPS Series RTK reference station	1	
Tide Transmitter		
(Telemetering Tide Gauge)	1	
Desktop computer, incl. software for multibeam post-processing	1	
Desktop computer, incl. DredgeView post-processing software package	1	
A1 Designjet Plotter	1	
A4 Laserjet Printer	1	

[13.5.4.3.] Trailing Suction Hopper Dredger

Trailer		
Description	**On-line**	
Surface Positioning Cc Technologies 2050/3050 RTG GPS receiver	1	
Industrial Rack Computer, with dredging software package DV2_HOP Position Display Monitor Gyro Compass Tide receiver	1 1 1 1	

[13.5.4.4.] Backhoe Dredger

Backhoe		
Description	**On-line**	
Surface Positioning Trimble SPS Series RTK GPS receiver	1	
Industrial Rack Computer, with dredging software package DV2_CMS Position Display Monitor Gyro Compass Tide receiver	1 1 1 1	

[13.5.4.5.] Self-Propelled Hopper Barge

Hopper Barge		
Description	On-line	
Surface Positioning CSI Vector Pro DGPS receiver	1	
Industrial Rack Computer, with dredging software package DV2_HOP Position Display Monitor Gyro Compass Tide receiver	1 1 1 1	

[13.5.4.6.] Standby Recovery Plant

Crane Barge		
Description	On-line	
Surface Positioning Trimble SPS Series RTK GPS receiver	 1	
Industrial Rack Computer, with dredging software package DV2_CMS Coda Echoscope (6 week Clearance Campaign Only) Position Display Monitor Gyro Compass Tide receiver	1 1 1 1	

[13.5.4.7.] Bed Levelling Vessel

Bed Levelling Vessel		
Description	On-line	
Surface Positioning CSI Vector Pro DGPS receiver	 1	
Industrial Rack Computer, with dredging software package DV2_HOP Position Display Monitor Gyro Compass Tide receiver	1 1 1 1	

[13.5.5.] Multi Beam Echo Sounder Bathymetry [PM06]

[13.5.5.1.] Multi Beam - Introduction and Objectives

The following specification applies to the collection of bathymetry data using a Multi Beam Echo Sounder (MBES) referenced to the general specifications given.

The standards identified in this section will, meet or exceed those set down by IHO Special Publication No. 44 for “Special Order Surveys”.

BWL will provide in its Execution Plan a detailed description of the procedures to be implemented, including but not limited to:

a. Geodetic parameters,
b. Survey boat/launch choices,
c. Positioning system used for vessels,
d. Echo sounding equipment and associated calibration method,
e. Proposed survey grid pattern and spacing,

f. Measurement of tidal levels and correction of sounding data for tidal levels,
g. Where used, motion compensation equipment, and limiting sea-states,
h. Survey record keeping, data storage and archiving procedures,
i. Processing details (spike removal, interpolation method, bin sizes, etc.),
j. Document submittals including their format,

This Execution Plan will also include the plan for Single Beam Echo Sounders.

[13.5.5.2.] Multi Beam - Survey Planning [PM06]

As the area to be dredged is largely deep water, the multi beam echo sounder will be deployed over the bulk of the geographic area. However, it is expected that some areas may only be accessible by a shallow draft vessel best suited to Single Beam surveys (see Section 13.5.6.3) due to the risk of damage to the multibeam transducer. These may include the Zone B & D slopes where the single beam would only be utilised at the very top of the slopes where there would be a risk of grounding and Zone E Berth pocket. Multibeam surveys would be carried out at HW periods in order to gather as much data by this method.

The bounding constraint for switching to single beam will be when the underkeel clearance is less than 1m..

Surveys may be undertaken at any time within the dredging works, dependent on the tidal, sea and weather conditions, but will mainly be executed during daylight hours.

The objective of the Multi Beam bathymetry survey will be to create an accurate topographic survey of the seafloor, with full coverage when gridded to an interval of 0.5m x 0.5m, and with a vertical accuracy of better than that specified by the IHO for Special Order Surveys (0.25m).

Hit counts for the survey area will exceed 10 hits per grid square for areas of shallow water depth i.e. less than 20m Chart Datum.

Frequency of the Multi Beam Echo Sounder will be selected such that interference from Single Beam Echo Sounders, sidescan sonars or ADCP's will be minimal. The frequencies of all three systems are selectable and can be setup to ensure that there is no interference between each one.

BWL will select a line spacing such that, for the utilised beam angle, the entire seafloor is covered with a minimum 10% overlap between swaths to ensure there are no significant gaps.

Where possible, run-in lines will be made in combination with slow loose turns to improve Motion Reference Unit (MRU) accuracy.

[13.5.5.3.] Multi Beam – Instrumentation [PM06]

Instrumentation for Multi Beam Echo Sounding will be of an approved 'survey type' operating between 300-450khz, capable of providing cm resolution data. The instrumentation / frequency to be used will be agreed with the Authority prior to commencement of the pre-dredge survey and will then be used for all further surveys. The same operating frequency will be used for all surveys.

The vessel's geometry will be established through a 'local' survey, conducted whilst the vessel is secured alongside a quay wall or similar. Appropriate vessel geometry survey

methods include total station, tape and level line, and RTK GPS measurements. Particular care will be given to installations on larger scales to reduce 'lever arm' inaccuracies and all distances will be made to the proper locations (phase centres, acoustic centres and rotational centres).

Sound velocity will be measured at the Multi Beam transducer head and used to calculate propagation angles and water depth. Sound velocity profiles will also be taken with a dedicated sound velocity probe (SV) prior to commencement of each survey and further SV profiles will be taken at an interval defined by the surface conditions such that surface speeds do not separate from the applied speed by more than ~2ms 1. Equipment type and calibration procedures will be described in BWL's Execution Plan.

Where possible, daily checks will be made over an outcrop, wreck, pipeline or similar feature of constant depth to establish consistency from one survey to another. These results will be averaged over a defined area and logged accordingly, their results will be included in the Hydrographic Survey Report.

A Patch test will be conducted before logging survey data for the first time, after equipment changes are made and at monthly intervals throughout the project to ensure correct equipment geometries are applied, the results of these patch tests will be included in the Hydrographic Survey Report.

An appropriate Motion Reference Unit (MRU) will be utilised in conjunction with a heading sensor and RTK GPS receiver to ensure that beam-forming and survey results are as accurate as possible. The MRU will be monitored using appropriate software to check that it has initialised before any survey begins and to ensure its correct operation throughout survey operations.

[13.5.5.4.] Multi Beam - Data Analysis and Processing [PM06]

Initial data analysis will be carried out daily on board the survey vessel by the operating surveyor to confirm correct operation of all instruments and allow an early interpretation of the results, including identification of areas of interest for possible further survey.

Where spikes are removed from raw data, care will be taken to ensure sufficient data remains in the corresponding grid cells such that interpolation over distances greater than 5m does not occur.

For witnessed Pre-dredge surveys, Interim surveys and Post-dredge surveys, data will not be interpolated over distances greater than 2m.

All depths will be corrected to Chart Datum before reporting, as agreed with the Authority.

The original raw data clouds will be backed up and made available to the Authority on request in addition to the processed equivalents.

[13.5.6.] Single Beam Echo Sounder Bathymetry

[13.5.6.1.] Single Beam - Introduction and Objectives

Where necessary, Single Beam Echo Sounder surveys (SBES) will be undertaken to supplement Multi Beam Echo Sounder survey data. This will most likely be in areas of restricted navigation and/or of limited depth.

We would propose to create a polygon around any data collected by single beam survey techniques and highlight this on all drawings produced. The single beam data would be processed and loaded into the same DTM layers as used for the multi beam data for subsequent production of charts and volumes. Whist the single beam data does not give 100% bottom coverage, this system would not be used for any critical navigation areas. We would not expect that the frequencies of the different systems will detect anything but the seabed surface in these shallow water areas.

The following specification applies to the collection of Single Beam sonar data.
BWL will provide in the Execution Plan a detailed description of the procedures to be used, including but not limited to:

a. Geodetic parameters,
b. Survey boat/launch choice,
c. Positioning system of vessels,
d. Echo sounding equipment and associated calibration method,
e. Proposed survey grid pattern and spacing,
f. Measurement of tidal levels and correction of sounding data for tidal levels,
g. Where used, motion compensation equipment and limiting sea states,
h. Survey record keeping, data storage, archiving procedures,
i. Processing details (spike removal, TIN/interpolation method, etc.),
j. Document submittals including their format.

[13.5.6.2.] Single Beam - Survey Planning [PM06]

A Multi Beam Echo Sounder will largely be used to collect bathymetry data from areas of deep water, however, particularly during Pre-dredging and Post-dredging monitoring surveys, it is anticipated that some berths and slopes adjacent to the dredged areas may be shallow or intertidal so only accessible by a shallow draft vessel best suited to Single Beam surveys. These may include the Zone B & D slopes and Zone E Berth pocket.

Surveys may be undertaken at any time within the dredging works, dependent on the tidal, sea and weather conditions, but will mainly be executed during daylight hours. Due to the nature of single beam methods, much smaller areas will be measured during a normal shift.

The objective of the Single Beam Bathymetric Surveys will be to supplement the MBES data where necessary, in order to create an accurate topographic survey of the seafloor; particularly in the shallow areas encountered in and adjacent to neighbouring berths.

For those areas where vessel draft is an issue, a line plan will be created that allows maximum data recovery from the area, including a margin of 30m around the defined area. This margin will create an overlap between relevant Multi Beam data and that collected from the Single Beam system.

Survey line spacing will be selected to ensure no prominent seabed features are missed between the survey lines. Line spacing will not exceed 3 times the water depth.

For inshore surveys, the survey lines will extend towards the shoreline and conclude either before the point where personnel, vessel and equipment are compromised or until usable survey data is no longer attainable.

Additionally, survey cross-lines will be run at a suitable interval to verify vertical data reductions. These cross-lines will be chosen to allow best comparison between surveys i.e. not on steep slopes or areas of uneven seafloor.

The works identified in this section will exceed an accuracy of ±0.25m in the vertical plane and ±2m horizontally.

Where Single Beam surveys are conducted in the same areas as Multi Beam surveys sufficient overlap will be made between the two for the purpose of QC checking between the two data-sets. However, after checks have been made SBES data in these overlap areas should be discarded in favour of the MBES data.

[13.5.6.3.] Single Beam Instrumentation

The equipment provided for Single Beam bathymetry survey will be of an approved 'survey type' capable of providing data in cm resolution.

The measured data will be reduced to Chart Datum directly from a logged RTK GPS signal, however, it is recognised that Single Beam surveys can be conducted in conjunction with recorded tidal levels, the data being reduced either in real-time or during post processing. Where this occurs, specifications for a suitable tide gauge/tide gauge network will to be laid out in BWL's Execution Plan. Whichever of these methods is used great care will be taken to ensure the most accurate bathymetry measurements are made;

Where the system is set-up to use tidal levels for reduction to Chart Datum, BWL will ensure that a suitably regular update of tidal level can be received at all locations across the survey area.

Where RTK GPS is used to directly reduce the data to Chart Datum in real-time, BWL will ensure that either motion of the vessel is compensated for in the software by use of an appropriate Motion Reference Unit (MRU) or that distances between components in the system are kept to a minimum and that the survey vessel is operating in stable sea conditions at all times.

The primary Single Beam Echo Sounder will operate in the range of 200-220kHz, alternatively a dual frequency echo sounder operating in the range (30-35kHz/200-220kHz may be employed.

The instrumentation/frequency to be used will be agreed with the Authority prior to commencement of the pre-dredge survey and will then be used for all further surveys.

The equipment will be calibrated for transducer depth and velocity of sound by means of a 'bar check' or sound velocity probe prior to commencement of each survey and at intervals as dictated by the environmental conditions.

Equipment type and calibration procedures will be described in detail in BWL's Execution Plan.

[13.5.6.4.] Single Beam Data analysis and Processing

All depths will be corrected to Chart Datum, in a suitable manner as agreed with the Authority and outlined in BWL's Execution Plan, before reporting.

Initial data processing and analysis will be undertaken as soon after completion of the survey as is reasonably practical.

Spikes will be removed from any datasets. Either an automatic filter or manual filter will be employed, however, data will be checked against previous surveys to ensure that quality and consistency are achieved.

[13.5.7.] Survey Control [PM06]

Prior to commencement of survey operations, survey control will be established in such a manner that it can be used for the hydrographic surveys, where possible, for the remainder of the project.

All positioning for hydrographic survey operations will be conducted using Real Time Kinematic (RTK) GPS. In order to achieve this, base station(s) and repeater station(s) (as required to provide full coverage of the site area) will be installed and calibrated using optical levelling to known benchmarks or through continuous logging.

Periodically, the base station(s) and repeater station(s) will be checked by measuring a fixed location. These results will be logged and reported accordingly.

[13.5.7.1.] Horizontal

Survey Grids will be related to Ordnance Survey National Grid (OSGB36).

[13.5.7.2.] Vertical

The level datum to be used on all surveys will be Chart Datum. This will be referenced against Ordnance Datum Newlyn (ODN) in any drawings or reports issued to the Authority. Chart Datum coincides with -2.73m ODN.

In addition to the use of RTK GPS for survey measurements, agreed existing tide gauges or a specially installed network of temporary tide gauges will be used to check RTK measurements against, and where necessary to reduce sounding data to Chart Datum. The selected tide gauge network will allow any wide-area slope in water level to be accounted for.

The tide gauge(s) will be able to output data in cm resolution at 1 minute intervals and will be checked and if necessary re-calibrated at regular intervals (no greater than fortnightly) against a known benchmark.
Tide gauge(s) will be monitored remotely using a radio telemetry link.

If the tide gauge network is installed in a suitable location and manner, it may also be used for determining the vertical position of dredging operations, however, intention to do so will be expressed in BWL's Execution Plan, and indication should be made with regard to preferred tide gauge locations.

[13.5.7.3.] Chart Datum & Tide Levels

The datum to which all levels and soundings of the seabed have been reduced is Chart Datum. Published astronomical tide data for the harbour at 50°48'N 01°07'E are given below. Actual levels will differ depending on location and meteorological conditions.

HAT	+5.13m
MHWS	+4.72m
MHWN	+3.87m
MLWN	+1.90m
MLWS	+0.73m

LAT +0.14m

Chart Datum coincides with -2.73m ODN.

[13.6.] Strategy for Delivering Surveying & Dredge Works Monitoring Options

The project quality control is primarily done through surveys, which are described in detail within the Survey Method Statement attached within Appendix 8 The paragraphs below describe the type and frequency of the different types of surveys.

[13.6.1.] Meteorology

Estimates made at sea of wind speed and direction will be logged before and during all survey operations as part of a survey log sheet. At the same time an estimate of the visibility and sea-state will be made.

[13.6.2.] Record Surveys

Record surveys will be carried out by BWL and monitored by the DIO PM or his nominated representative as follows:

- Pre Dredge Survey
- Interim Survey
- Post Dredge Survey

All surveys will be carried out in accordance with Section 7 of the Specification.

Each survey report will be agreed with the DIO PM's nominated representative, who will record his agreement in writing on the report. In the event that a report cannot be agreed for whatever reason, the DIO PM's nominated representative will record his reasons in writing on the report.

Survey operations will be limited by adverse weather conditions such as swell and wind. Swell will be the main limiting factor. Once significant wave heights reach 1m the acceptability of acquired survey data will decrease depending on the particular purpose of the individual survey operation in question.

BWL survey radio transmitters utilise the non-licence portion of the spectrum i.e. 458.5 mhz to 458.9 mhz.

BWL have assumed that normal navigation / collision avoidance rules will apply in the dockyard area.

[13.6.3.] Pre-Dredge Survey [PM06]

Prior to the commencement of the works a Pre Dredge Survey shall be carried out to establish the physical starting points (e.g. sea-bed level etc).

One survey covering the entire Site undertaken prior to commencement of the Works, including adjacent marinas, Fountain Lake and areas shown on drawing as shown on the Scope of Pre Dredge Survey drawing, dated 28 January 2013.

One survey covering areas outside of the Site as defined in the Drawings, to be undertaken prior to the commencement of the Works.

In areas to be dredged, the surveys will extend at least 100m beyond the actual dredging area except where survey is prevented by proximity of the shore or shallow water.

In areas outside of the dredge zones, the extent of survey will be as shown on the Drawings.

BWL will give the DIO PM not less than seven days' notice of his intention to undertake the pre-dredge surveys and will make arrangements for the DIO PM to be present at the surveys, should he so require.

[13.6.3.1.] Deliverable Performance Target [PM06]

Pre contract survey deliverables will consist of charts, survey report and electronic data. They are generally ready for delivery within a week of the completion of surveys.

[13.6.4.] Interim Surveys [PM06]

The purpose of Interim surveys is to demonstrate progress of the Works for Progress Payment and for quality purposes. The surveys will be processed and presented at a frequency and in a format as required by the Project Manager, Captain / Senior Dredge Master.

During the execution phase of the project, regular interim 'process control' surveys will be carried out to ensure that dredging operations achieve design requirements. The project's Surveyor will ensure that all survey equipment is calibrated and tested, and remains in a serviceable condition.

[13.6.4.1.] Deliverable Performance Target [PM06]

Interim surveys are principally for BWL use to ensure the most effective use of the dredge plant, survey results (chart and DTM update) are delivered normally on the day of completion of the survey.

[13.6.5.] Post Dredge Survey [PM16]

Zones B & E are subject to sectional completion, with separate Post Dredge Surveys Where a zone is identified for Sectional Completion, BWL will give the DIO PM not less than seven days' notice of his intention to undertake the post-dredge survey of that zone and will make arrangements for the DIO PM to be present at the survey, should he so require.

On completion of the whole of the Works a Post Dredge survey be executed, cover the entire monitoring area, including adjacent marinas and Fountain Lake, as shown on the Scope of Pre Dredge Survey drawing, dated 28 January 2013. BWL will give the DIO PM not less than seven days' notice of his intention to undertake the post-dredge survey and will make arrangements for the DIO PM to be present at the survey, should he so require.

[13.6.5.1.] Deliverable Performance Target [PM06]

Post contract surveys deliverables will consist of charts, survey report and electronic data. They are generally ready for delivery within a week of the completion of surveys, with a draft version available sooner to enable the release of the dredge plant.

[13.6.6.] Additional Surveys Specifically Instructed by the DIO PM [PM06]

From time to time, the DIO PM may specifically instruct BWL in writing to undertake additional surveys. BWL will undertake such surveys without undue delay and report the results to the DIO PM in accordance with the requirements of Section 12 of the ITPD.

[13.6.7.] Quality Assurance / Quality Control To Be Applied

Standard BWL QA/QC procedures will be followed for the QEC project.

The RBW-304 procedure describes how the survey activities for the execution of Projects are controlled.

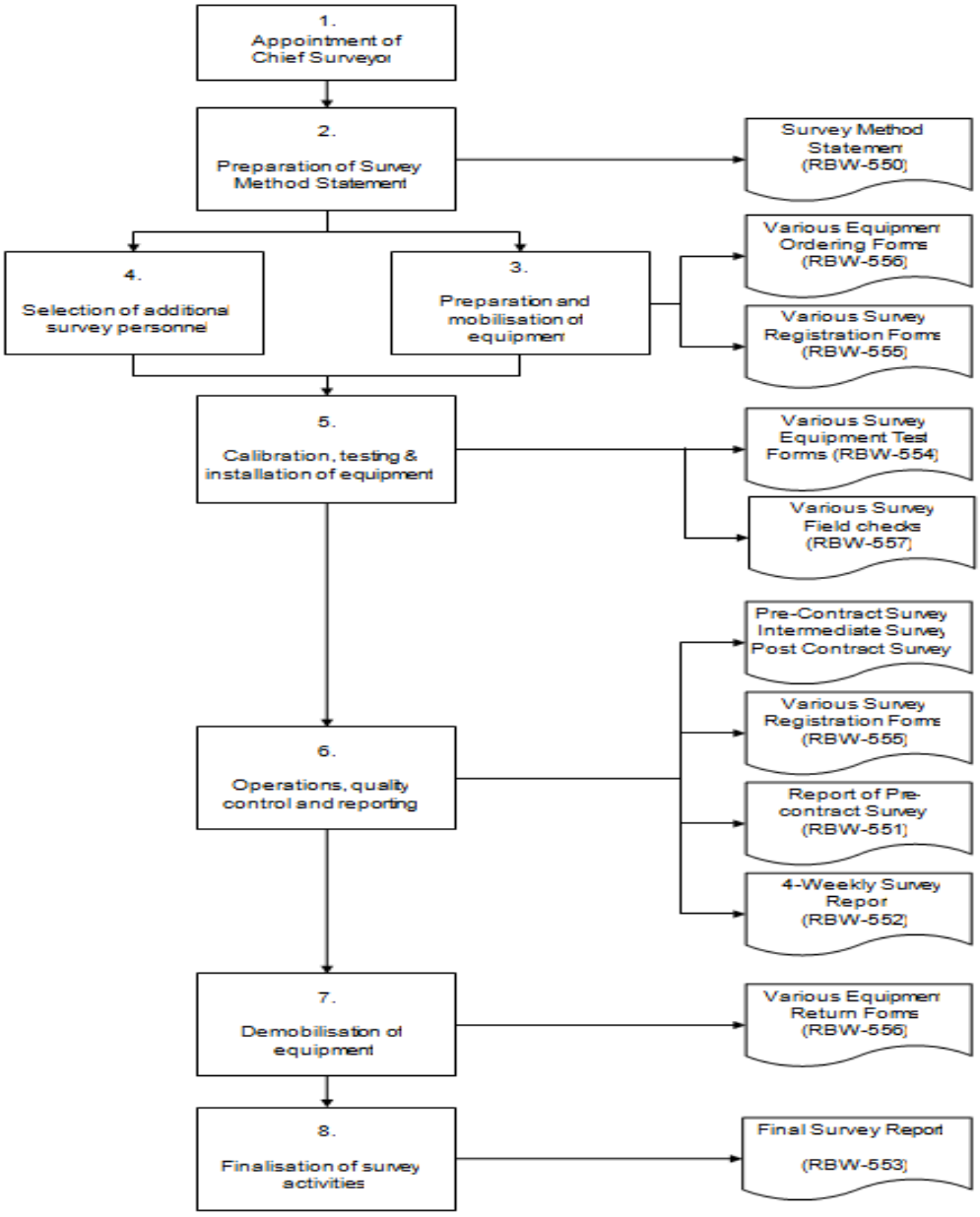
The aim of this procedure is to verify and control all survey activities for the Projects, in order to make sure that the requirements of the Client and/or Boskalis are met.

This procedure applies to all survey activities performed for the execution of Projects of Boskalis, from the start of the preparation activities until the delivery of the final survey report to the Client.

This procedure applies to all persons who undertake survey activities for Projects of Boskalis.

The procedure describes the different phases during the survey activities.

These are presented in a flow chart as shown below.



Supporting documents (standard formats) to this procedure are:

RBW-550: Survey Method Statement

RBW-551: Pre Contract Survey Reporting

RBW-552: 4-Weekly Survey Reporting

RBW-553: Final Survey Reporting

RBW-554: Survey Equipment Test Sheets

RBW-555: Survey Registration Forms

RBW-556: Survey Equipment Order and Shipment

RBW-557: Survey Field Checks

[13.6.8.] Appointment of Chief Surveyor

The Project Manager will appoint a Chief Surveyor for the Project, in consultation with the Specialist Survey Systems (further “SSS”) of the central Survey Department. The Chief Surveyor is responsible for the preparation, execution and evaluation of all survey activities on the project. Until the Chief Surveyor has been appointed, the SSS is temporarily responsible for these activities.

The SSS shall ensure that the Chief Surveyor has been issued with the latest versions of the survey documentation.

The Chief Surveyor shall, from the date of his appointment, keep notes (in the form of a survey diary), which will clearly state all particulars regarding the survey activities and allow for a controlled hand-over in case of absence.

[13.6.9.] Preparation of Survey Method Statement

Prior to the commencement of any survey activities on the project, the Chief Surveyor shall (in co-operation with the SSS) prepare a Survey Method Statement.

In this respect the Project Manager shall inform the Chief Surveyor of any specific requirements of the Client related to survey activities. A copy of the contract will be made available to the Chief Surveyor, including the Bill of Quantities (excluding financial data) and sub-contracts, if applicable.

A typical format for the method statement is given in the supporting document RBW-550 Survey Method Statement, included within Appendix 8

Once the Project Manager has approved the Survey Method Statement, it shall form part of the Project Preparation Operational Summary.

In case of substantial changes in the working methods the Survey Method Statement will be revised and / or additional Method Statements will be submitted.

[13.6.10.] Preparation and Mobilisation of Equipment

Based on the approved Survey Method Statement, the Chief Surveyor shall ensure that all required survey equipment will be made available for the Project.

All equipment shall be ordered and shipped to a location as agreed with the Specialist Survey Systems and according the procedures described in document RBW-556 Survey Equipment Order and Shipment.

The survey equipment will be:

Checked beforehand by the Electronic Department regarding the correct functioning (within the specifications for the Project);

Supplied with the latest software version;

Provided with a “Specification Report” and/or “Calibration Report”;

Labelled individually;

Registered, including the required calibration and test dates, on the “Survey Equipment List” (see for a standard format RBW-555a);

Provided with sufficient spares, tools, consumables, manuals and the like.

On arrival of all equipment on the Project site, the Chief Surveyor shall verify that the equipment is in a sound and workable condition.

[13.6.11.] Selection of Additional Survey Personnel

The Chief Surveyor shall, if required (and in consultation with the Project Manager and the SSS), arrange additional personnel for the survey activities on the Project. All such personnel shall be briefed by the Chief Surveyor and the Project Manager, before they start with any of their survey activities. These briefings shall be noted in the survey diary and clearly indicate all survey requirements and further particulars discussed.

[13.6.12.] Operations, Quality Control and Reporting

[13.6.12.1.] Equipment

During the execution of the Project, the Chief Surveyor shall ensure that:

All survey equipment remains in a sound and working condition;

Adequate spares are available;

Mutations, maintenance and repairs are recorded on the Daily Survey Logs and the Survey Equipment List.

[13.6.12.2.] Filing

The Chief Surveyor is responsible for the filing of all survey documents, in a safe and protected place. To this extent he shall ensure that:

- A register is in place to record incoming correspondence and outgoing drawings/submittals to the Client;
- Transmittal forms (in the standard format) are used for data transfer;
- Data storage media are clearly annotated with the relevant information;
- All electronic data are recoverable;
- Echo sounder rolls are clearly annotated at both ends, to ensure easy reference.

All information relevant for as-built documentation is to be filed in such a way that it can be easily identified, retrieved and referred to in RBW-553a Final Survey Report.

Important as-built documentation such as survey results, calibration- and test sheets and the like are to be included in the Project Master File and archived according RBW-536 Control & Archiving of Quality Records.

[13.6.12.3.] Handover

The Chief Surveyor shall ensure that at any stage of the work the survey activities can be handed over in a controlled manner. The Chief Surveyor shall appoint a deputy Chief

Surveyor who will take over the function of Chief Surveyor in his absence. An electronic copy of the handover notes should be forwarded to the SSS and the Project Manager.

[13.6.12.4.] Reporting

During execution the Chief Surveyor shall prepare, or arrange preparation of, the following reports:

Report of Pre Contract Survey (for standard format see RBW-551);

4-Weekly Survey Report (for standard format see RBW-552).

The Pre Contract Survey shall be forwarded to the Project Manager for approval and further issuing to the Specialist Survey System. The 4-Weekly Survey Report will be forwarded to the Project Manager and Specialist Survey System for their perusal. Reporting of survey data to the Client shall be done in consultation with the Project Manager.

[13.6.13.] Instrument Calibration and Verification

Once the equipment has arrived on site, all instruments (including back-up instrumentation) under supervision of the Chief Surveyor following the Field check procedures (RBW-557) will be subject to full pre-survey and post-survey verification calibration and testing to ensure that they are functioning correctly and are operating according to the manufacturer's specifications. The results of the calibrations and tests shall be documented in a format indicated in the supporting document RBW-554 Survey Equipment Test Sheets.

Calibration or conformity certificates for all survey instruments will be submitted to the Authority at least one (1) week prior to the commencement of survey activities, unless otherwise stated. It is acknowledged that failure to do so could result in a delay to the start of the survey.

During the Project, interim calibrations and/or in-situ checks, using a higher order calibrated instrument or standard, will be carried out during the project (e.g. Bar check, Patch test, etc.). These will be carried out both periodically (no greater than fortnightly) and following changes that are likely to effect the geometry of the vessel. as described in the Survey Method Statement.

The calibration and in-situ check documents will be submitted to the Authority at the time of submitting all interim and final reports. The most recent calibration will also be available for inspection on request at any time throughout the survey operations.

The GPS based survey-navigation system installed aboard the vessel(s) (RTK GPS) will be calibrated against a higher order system, or as an offset (bearing and distance) from a known location or benchmark. This calibration check will be carried out at the start and end of each day of site works e.g. when the survey vessel(s) is alongside the berth in the local port of operations. Full records, and comprehensive station descriptions of any "offsets", will be provided in all interim and final reports.

Any instruments and/or sensors found to be or suspected to be malfunctioning will be quarantined and not be used for deployment/re-deployment until they have been repaired and/or re-calibrated and a new calibration certificate issued and copied to the Authority.

The relationship between the vertical land survey datum for orthometric heights, local Mean Sea Level (MSL) and local Chart Datum (CD), and any other relevant datum, will be defined

and documented and shown on all bathymetric charts, data tabulations, as well as being clearly identified in all interim and final reports.

After calibration and testing, the Chief Surveyor shall ensure that all equipment is installed in compliance with the manufacturer's instructions. If required, the SSS ensures that the equipment is accompanied with an up-to-date copy of such instructions. The actual installation of the equipment on shore and on vessels shall be carried out by qualified personnel only (e.g. an Electronic Engineer).

[13.6.14.] Back-up Instruments, Manuals and Spares

BWL will provide sufficient spares and/or back-up instrumentation, including but not limited to: GPS equipment, PCs, hydrographic survey equipment etc and other "consumable" spares to ensure that any failures and/or malfunctions encountered do not jeopardise the data collection program.

BWL will maintain on site and/or also on the survey vessels at sea, a full set of all manufacturer's manuals and software for all required survey related instrumentation.

[13.6.15.] Data Validation and Processing

Initial validation checks will be applied to gathered data prior to any editing or further analysis in order to identify any erroneous or spurious data.

Any gaps in the data will be identified and discussed in the reporting of the results.
Final quality control and validation of the data will include an assessment of the data quality. Consideration will be given to expected patterns or trends in the data and to comparisons with any other available data sets.

All data validation and correction procedures will be documented both in BWL's Execution Plan and in the Final Hydrographic Survey Report.

When Geospatial data is collected to demonstrate progress for payment, the survey will be witnessed by a representative of the Authority as specified in Clause 4.8 of the ITPD.

An Authority representative may also witness Pre-dredge surveys, Interim surveys, Post-dredge surveys, and the installation or translocation of base stations or tide gauges. Invitation to witness surveys will be extended to the Authority at least 7 days in advance of survey where possible.

[13.6.16.] Instrumentation Security

Onshore installations required to support survey operations will be suitably located in an area inaccessible to the general public. Installations will be checked weekly and where possible monitored remotely by a telemetry system. During the execution of the Project, the Chief Surveyor shall ensure that:

All survey equipment remains in a sound and working condition;

Adequate spares are available;

Mutations, maintenance and repairs are recorded on the Daily Survey Logs and the Survey Equipment List.

[13.6.17.] Registrations

The Chief Surveyor shall ensure that each survey that has been executed:
Is registered by an unique identification number;

All log sheets, lists, indexes and registers are adequately completed, filed and distributed;

[13.6.18.] Survey Reporting

During execution the Chief Surveyor shall prepare, or arrange preparation of, the following reports:

Report of Pre Contract Survey (for standard format see RBW-551);

4-Weekly Survey Report (for standard format see RBW-552).

The Pre Contract Survey shall be forwarded to the Project Manager for approval and further issuing to the Specialist Survey System. The 4-Weekly Survey Report will be forwarded to the Project Manager and Specialist Survey System for their perusal. Reporting of survey data to the Client shall be done in consultation with the Project Manager.

BWL will prepare and submit to the Authority for review and comment interim survey reports within 48 hours of completing surveys associated with either completion of sections of the Works or interim surveys undertaken on the instruction of the DIO PM.

The reports will contain all field data in a completed format, evaluations and interpretations of all survey data and supporting text. The reports will use SI units throughout and contain a summary of all geodetic parameters applied.

Upon completion of all survey operations the Chief Surveyor shall prepare a Final Survey Report in the standard format as given in Supporting Document RBW-553.

The interim reports and Final Report will, where relevant for each aspect of the survey(s), contain the following as a minimum:

A full factual account of the survey activities,

Times and dates of the activities reported in UTC for the duration of the survey operations and post-processing activities,

Description of the methodologies adopted and equipment used,
the Grid System used and whether or not this is based upon existing survey control.

Details of vessels, plant and equipment used,

Name and title of all project field and office personnel,

Comments on factors affecting the survey(s) including any problems encountered, particularly those which might have affected the quality of the results,

Presentations of the gathered data,

A discussion of the results,

Log reports of checks made (including position checks, survey checks and patch test results).

A summary of accuracy achieved and validation undertaken with reference to his Quality System. A schedule of calibration and confidence checks undertaken to control and check dimensional accuracy, their frequency and results will be detailed.

BWL will ensure that footer details and the table of contents are correct prior to delivery of the report.

The Chief Surveyor shall handover the Final Survey Report to the Project Manager and an electronic copy to SSS. The Project Manager shall include the approved Final Survey Report in the Project End Report.

BWL will prepare and submit to the Authority for review and comment a Final Report compiling the results of all post-dredge surveys within 48 hours of completing the final post-dredge survey.

Whilst outside the scope of works for this contact, BWL are able to undertake pre and post dredge surveys of the Nab Marine Disposal Area, which would be instructed by the DIO PM via a change notification. The timing of these surveys would be dependent on suitable survey craft being on site and a suitable weather forecast. From these surveys the volume of material deposited on the seabed can be calculated as support for the client's Baseline Documentation.

BWL will submit to the Authority within 14 days of receiving comments from the DIO PM, final copies of all reports addressing to the satisfaction of the DIO PM all comments raised.

[13.6.19.] Data

Deliverables will clearly display the scale and geodetic parameters applied, along with all necessary supplemental information.

For both Single Beam and Multi Beam Surveys, data will be provided in RAW format along with its accompanying metadata.

Data will also be provided in a reduced format such as Grid models, TIN models and/or X, Y, Z point files with its accompanying metadata. Unless prohibited by the file size, these files will have a cell size no greater than 0.5m x 0.5m.

In the interest of consistency, all depths below Chart Datum will be provided as negative values and all heights above Chart Datum will be recorded as positive.

Metadata will include:

Collection date/time,
Equipment,
Weather/Sea State Conditions,
Surveyor,
Horizontal and vertical datum applied.

[13.6.20.] Charts

Charts provided to the Authority will be issued in both electronic .pdf and hardcopy formats and will outline:

a. The horizontal and vertical geodetic parameters used,
b. The shift between Chart Datum and ODN,
c. The scale of the drawing,
d. The method of reduction to Chart Datum,
e. The main equipment used.

[13.6.21.] Profiles

Where required, profiles will be issued relative to a given centreline and Chart Datum at intervals of 50m. Profiles will be drawn for:

a. Design Level,
b. Over Dredge Tolerance,
c. Survey Level.

If necessary, a distinction will be made between Multi Beam and Single Beam data used to draw the profiles.

[13.6.22.] Volumes

Where Interim surveys are conducted for payment, BWL will provide volume information in addition to other required reporting and which will be included within the survey reporting included within Section 13.6.18.

These volumes may be calculated using either a gridded or profiling method however the procedure will be consistent throughout the duration of the survey operations and documented within BWL's Execution Plan.

Volumes will be given as:

a. Volume dredged since Pre-dredge survey above design,
b. Volume dredged since Pre-dredge survey below design,
c. Volume filled since Pre-dredge survey above design and,
d. Volume filled since Pre-dredge survey below design.

These volumes will be calculated and issued independently for each separate area of the works.

[13.6.23.] Demobilisation of Equipment

Upon completion of the works and acceptance by the Client of the Post Contract Survey, the Chief Surveyor shall ensure that all equipment is adequately prepared, packed for shipment and demobilised to a location as agreed with the Specialist Survey Systems and according the procedures described in document RBW-556 Survey Equipment Order and Shipment.

Defective equipment will be labelled with a defective survey equipment label (RBW-555k).

The Specialist Survey Systems shall take further relevant action to prepare the survey equipment for future use.

[13.6.24.] Finalisation of Survey Activities

Upon completion of all survey operations the Chief Surveyor shall prepare a Final Survey Report in the standard format as given in Supporting Document RBW-553.

The Chief Surveyor shall handover the Final Survey Report to the Project Manager and an electronic copy to SSS. The Project Manager shall include the approved Final Survey Report in the Project End Report.