



**REGULATIONS OF GEOMATICS
(WORK INSTRUCTIONS)
PART V (HYDROGRAPHY)**

**SURVEY DEPARTMENT
MINISTRY OF DEVELOPMENT
BRUNEI DARUSSALAM**

ABBREVIATIONS

1	DGPS	Differential Global Positioning System
2	N	North
3	E	East
4	S	South
5	W	West
6	IHO	International Hydrographic Organization
7	m	Meter
8	SBES	Singlebeam Echo Sounder
9	MBES	Multibeam Echo Sounder
10	PPS	Pulse Per Second
11	WGS84	World Geodetic System 84
12	GDBD2009	Geocentric Datum Brunei Darussalam 2009
13	LLS	Licensed Land Surveyor
14	UTM	Universal Transverse Mercator
15	SVP	Sound Velocity Profile
16	CD	Chart Datum
17	BM	Bench Mark
18	PDOP	Position Dilution of Precision
19	RTK	Real Time Kinematic
20	MRU	Motion Reference Unit
21	BSD	Brunei State Datum

PART III - HYDROGRAPHY

1. Introduction

These specifications shall refer to the conduct of hydrographic surveys for plan production and reporting. It does not relate to the production of Navigation Charts and shall include surveys for:-

- 1.1 Foreshore construction in related to shore protection works, retaining walls and outfall/intake structures and land reclamation.
- 1.2 Residential and commercial properties / facilities/ structures located along the foreshore and internal rivers.
- 1.3 Soil investigation

Any departure from these specifications must be agreed to, in writing, by the Surveyor General, Brunei Darussalam, before being implemented.

2. General Instructions For The Conduct Of Hydrographic Surveys

2.1 Engagement of Surveyor/ Hydrographic Surveyor

The hydrographic survey must be undertaken under the direction of a professionally qualified surveyor/hydrographic surveyor who shall be responsible for all survey works carried out and for the submission of hydrographic plan/chart and reports.

2.2 Standard of Survey

All hydrographic works are to comply with the International Hydrographic Organization (IHO) standard and meet the minimum standard for hydrographic survey in accordance with IHO Standard for Hydrographic Survey SP 44, 5th Edition, February 2008, Order 1B (as shown Table 1)

ORDER	Special	1	2	3
Horizontal accuracy (95% Confidence Level)	2m	5m +5% of depth	20m +5% of depth	150m +5% of depth
Depth accuracy for reduced depths (95% Confidence Level) ¹	a = 0.25m b = 0.0075	a = 0.5m b = 0.013	a = 1.0m b = 0.023	Same as Order 2
100% Bottom search	Compulsory ²	Required in selected areas ²	May be required in selected areas	Not applicable
System detection capability	Cubic features >1m	Cubic features >2m in depths up to 40m; 10% of depth beyond 40m ³	Same as Order 1	Not applicable
Maximum line spacing ⁴	Not applicable, as 100% search compulsory	3 x average depth or 25m, whichever is greater	3 -4 x average depth or 200m, whichever is greater	4 x average depth

Notes:

- To calculate the error limits for depth accuracy the corresponding values of a and b have to be introduced into the formula $(a^2 + (b \times depth)^2)^{1/2}$
with:
 - a constant depth error, ie the sum of all constant errors
 - b*d depth dependent error, ie the sum of all depth dependent errors
 - b factor of depth dependent error
 - d depth
- For safety of navigation purposes, the use of an accurately specified mechanical sweep to guarantee a minimum safe clearance depth throughout an area may be considered sufficient for Special Order and Order 1 surveys;
- The value of 40m has been chosen considering the maximum expected draught of vessels;
- The line spacing can be expanded if procedures for ensuring an adequate sounding density are used.

Table 1 : IHO Categories (IHO Standards for Hydrographic Surveys 5th Edition, February 2008. Special Publication No. 44. Soediono 1989) page 8

2.3 Engagement with Local Authorities

The contractor/Licensed Land Surveyor/ Hydrographers shall to contact and inform relevant national and local authorities e.g. Marine Department, Ports Department, Fisheries Department and Royal Brunei Navy well in advance of any intended survey work ashore and afloat prior to commencing the work from Marine Department. Marine Department shall produce 'Notice To Mariners' regarding the scope of work and location of the survey area.

3. Scope of Work

This Scope of Works for hydrographic survey shall cover a complete process of survey operation from the planning phase to the submission of the result, which are as follows:

- 3.1** Determine the Survey Area;
- 3.2** Define the scope and specification for the hydrographic survey;
- 3.3** Provide details of survey planning including equipment used, survey platform and methodologies for data acquisition and processing used in the hydrographic survey
- 3.4** Determine the conduct of the hydrographic survey, commencement date, survey lines and others
- 3.5** Agree on the terms and conditions for data format, sharing and exchange
- 3.6** Provide competency of person (s) responsible for the surveys

4. Planning

It is the responsibility of the Licensed Land Surveyor/ Hydrographers to provide appropriate hydrographic books/logs and records for use throughout the survey to ensure an audit trail exists for all data collected. Daily or regular back-up of data and storage shall be carried out at the survey platform.

4.1 Positioning Fixing

The position of a boat or vessel shall be fixed by means of one or more positions. (See diagram 1The fix can be obtained in a variety ways and can be referred to terrestrial or celestial object)

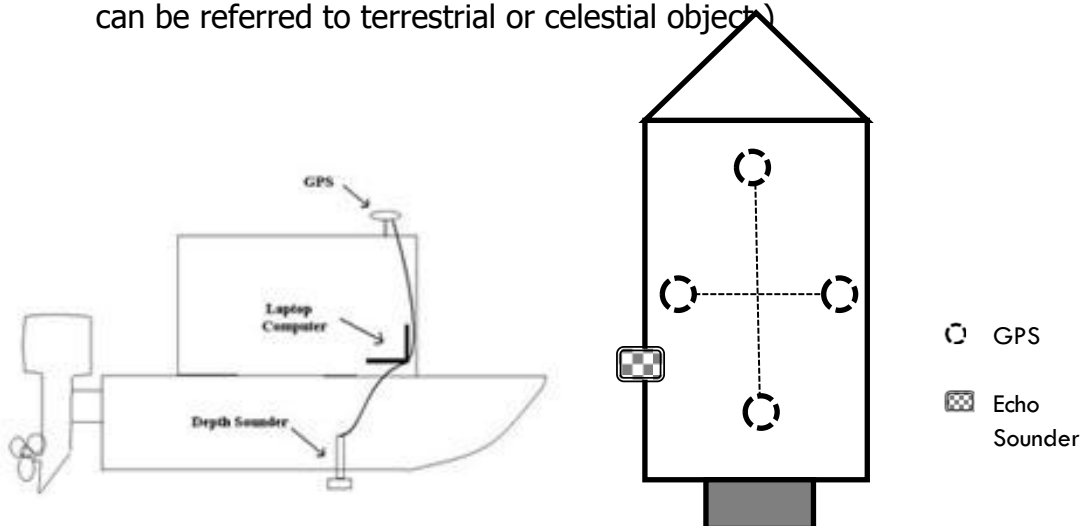


Diagram 1 : Position of GPS

4.2 Soundings

4.2.1 A plan of operations shall be prepared before commencing to sound. The plan shall provide for the delineation of topography of the seabed in the most economical and expedient manner

4.2.2 The line of sounding shall be run 5mm apart on the sheet, for example, on scale of 1 : 12500, lines are run 62.5 metres apart on the ground

Scale of Survey	Standard Line Spacing
1 : 5 000	25m
1 : 10 000	50m
1 : 25 000	125m
1 : 50 000	250m
1 : 100 000	500m

4.2.3 Cross-lines are to be run at angles of 60° or 90° to the main track-lines. A statistical comparison of raw data between the main survey track and the cross-line is to be undertaken to ensure that the accuracy requirements of the order of the survey are met.

4.2.4 For multibeam echosounder shall perform sounding at slower speeds and greater swath overlaps than for standard survey line.

5. Survey Limits

5.1 The survey limits shall extend to at least 25 metre beyond the perimeter of the required working limit or up to the adjacent sea-wall, wharf, coastline, etc.

5.2 Hydrographic survey must cover up to High Water Mark (Line) which is the Mean High High Water (MHHW) mark or Coastline where applicable. Low Water Mark or drying lines shall be shown in details symbolised in accordance with "Hydrographic Plan drafting Specification".

6. **Method and Execution of Survey**

The method and execution of survey shall conform to accepted standards of good survey practice. Where maximum standards of accuracy have to be achieved, these will be laid down in the Schedule to the Specification. Periodical system checks and monitoring shall be conducted to ensure validity of the data.

7. **Survey Equipment and Accuracy**

7.1 Calibration: Survey equipment that are to be used shall be properly calibrated before they are used in any survey. Calibration records shall maintain and submitted to Surveyor General or his representative for inspection.

7.2 Single Beam Echo Sounder (SBES): A dual frequency echo-sounder (viz. about 30 KHz and 210 KHz), providing depth accuracy of +/- 0.1 metre, shall be used for sounding surveys. The echo-sounder shall be calibrated daily by Bar Checks, up to the maximum depth of the survey area and on the working phase of the echo sounder, before and after sounding depending on the water depth at location. The records of such Bar Checks shall be marked on the same echo roll used for the particular day's sounding and shall be subject to inspection by Surveyor General or his representative.

SBES shall must be calibrated precisely and adjusted for draught setting, index error and sound velocity. Allowance must be made for ship squat. If bar check is impossible, Sound Velocity (SV) should be used to determine by probe alone.

Heave may be determined by inspection of the echo sounder trace. The surveyor must assess what portion of the trace is due to heave and what error this has produced. The use of a heave compensator device will remove much of the error introduced by vessel movement.

Transducer motion or heave can be compensated by a variety of methods which typically include a Motion Reference Unit (MRU), RTK or manual heave reduction.

MRUs should be used within the manufacturers stated limitations. Daily check lines run into the swell over a smooth seabed should be carried out to ensure correct settings and operation. Where RTK is used the motion should be sufficiently slow enough to be able to differentiate between heave and high frequency noise. Manual heave reduction should be limited to values less than twice the allowable depth tolerance of the class of survey (eg depth tolerance 0.15, transducer motion should be less than 0.30m) care should also be taken as to direction of lines in relation to the wave direction.

In all cases the method of heave correction should be confirmed over a flat sea floor

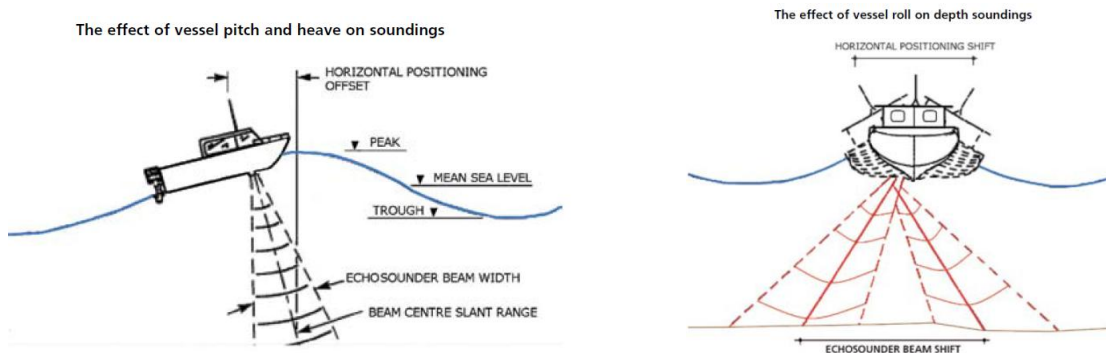


Diagram 2 : Effects on Motion Reference Unit (MRU)
(Extract from *Fishing harbour planning construction and management*)

7.3 Multi Beam Echo Sounder (MBES): 'Patch Test' shall preform prior to commencement of the survey in the 'patch test area' at site. Brief

7.3.1 Roll – Run two lines in opposite directions, at the same speed, over an area of flat seabed. Maximise the line spacing whilst an overlap in the outer beams

7.3.2 Pitch – Run two lines in opposite directions, at the same speed over an area of sloping sea bed.

7.3.3 Yaw – Run two parallel lines, with an offset of 15m, at the same speed in opposite directions over slope area with the same heading as the first line. Two parallel lines being separated by such a distance as to have 50% swath overlap.

7.3.4 Latency – Run two lines in same directions, one runs being twice the speed of the other, over a sloping seabed: A PPS correction is applied for compensating the latency.

7.3.5 Corrections – The corrections for pitch, roll, heading and latency were applied into multi-beam software.

7.3.6 Sound Velocity Profile - Real time corrections for steering angle of the flat transducer during data logging

7.4 Horizontal Positioning System

The horizontal positioning is to be controlled by Differential Global Positioning System (DGPS) or electronic positioning system such as Total Station providing an accuracy of +/- 1m or better. The DGPS shall be checked against a known coordinated position before and after survey each day. DGPS Integrity shall preform daily to detect any degradation of the accuracy/performance.

7.5 Geodetic Datum

Shored-based geodetic hydrographic control surveys in Brunei Darussalam are to be carried out in terms of Geocentric Datum Brunei Darussalam (GDBD2009). Note that for practical purposes, WGS84 and GDBD2009 can be regarded as the same at the decimetre level. All hydrographic survey work at sea is to utilise WGS84 datum

Ellipsoid	: WGS84
Semi Major Axis (a)	: 6378137.0 m
Flattening (f)	: 1/298.25722
Projection	: Universal Transverse Mercator (UTM)
Zone	: 50
False Northing	: 0.0m
False Easting	: 500000.0 m
Scale Factor at Central Meridian	: 0.9996
Central Meridian	: Centre of Zone 50

At least 3 GPS stations shall be established from the observations known as RTK GPS. These stations shall be used and check as DGPS Integrity check. Control stations to be used shall be at least 2nd Class or better. The Surveyor shall submit to Surveyor General a plan at the survey scale showing all the control stations used for the surveys and a list of their respective co-ordinates and station descriptions. If additional control point established, full reports and processing shall be verified by the Surveyor General.

7.6 Vertical Datum

The datum used during the survey shall be Lowest Astronomical Tide (LAT), or Mean Sea Level (MSL) which is the lowest water plane to which soundings are reduced and above which drying height are shown in the Fair Sheet and other survey records. LAT shall be determined by harmonic analysis from continuous tidal observations of at least 29 days tidal data collection.

Tidal station shall be located in the area of the hydrographic survey being conducted. Tides shall be observed with the tide gauge and tide pole tied to the established Geodetic Control Station. To obtain reliable data for datum transfer and sounding reduction, tides are observed simultaneous at interval of 10 minutes at this station continuously over a spring tide period.

For engineering purposes, the Sounding Datum to be used for the reduction of soundings shall be the Brunei State Datum 88 (BSD88) which is equivalent to the Mean Sea Level, MSL. This is normally referred to height of Bench Mark in the vicinity of the sounding area.

Care should be taken to ensure that geodetic heights used throughout the survey are related to the correct datum. This shall be specified on the plan and survey report.

7.7 Digital Surveying System

Appropriate Hydrographic package software (Caris, ArcGIS, Fleadermaus and etc) for survey preparations in the field data editing and data control survey shall be used to integrate with several survey equipments and to carry out various purpose surveys.

8. Field Survey Records

The field records shall be maintained for inspection at any time by Surveyor General or his representative. The care and attention devoted to work in the field must be extended to all aspects of preparing the fair data, and to the careful and legible annotation of all original material. The following records must be duly certified and submitted to the Surveyor General :-

- 8.1** Name of Surveyor;
- 8.2** Digital or hard copy of daily echo trace and bar-check records, date and time, fix numbers shall be annotated;
- 8.3** All Bathymetric and position data recorded digitally in real time. The raw data comprising date, time, x,y,z coordinates shall be presented in ASCII format;
- 8.4** Digital record in ASCII format of daily tidal height measurement if applicable
- 8.5** Hard copy record of field equipment calibration;
- 8.6** Digital and hard copy plots of the actual tracks travelled by the survey boat;
- 8.7** Digital and hard copy of sounding plots; and,
- 8.8** Any other relevant records is required by the Surveyor General from time to time.

9. Hydrographic Plan Drafting Specification (Fairsheet or Plan)

Depth and position data collected in the field shall be transferred to a computer for data processing and plan plotting. Hydrographic processing software shall be used for the purpose.

- 9.1** The Survey Plan / Fair Sheets will be drawn at scale of 1:1000 or any suitable scale agreed by client for general bathymetric information of surrounding waters in Universal Transverse Mercator Zone 50 projection and WGS84 ellipsoid.

- 9.2** The plotting scale shall be at the scale that is normally used by Survey Department (1:500, 1:1000, 1:1250, 1:2500, 1:5000 and 1:10000)
- 9.3** Soundings shall be plotted at intervals of not more than 10 -15mm on plan along the entire sounding line.
- 9.4** Main sounding lines shall be plotted at intervals of not more than 5 mm on plan at survey scale.
- 9.5** All symbols, abbreviations and terms depicted on the plan shall be in accordance with the "Survey plan drafting instruction". Depths shown on plans shall be clear, legible and free from over plotting. Any heights of isolated features shall be shown.
- 9.6** Where cross-sectional plans are to be drawn, the vertical and horizontal scales will be determined by requirements of the client or consultant.
- 9.7** Results of seabed sampling for post dredging survey shall be plotted on a separate plan at the same survey scale.
- 9.8** Depth Contour
Standard drying lines and depth contour will be set-out in the "Schedule to the Specification" and shall be drawn on all relevant survey plans. The contours depicting the approved dredging/or dumping depth shall also be drawn on the relevant survey plans where applicable.

9.9 Survey Grid

The survey results shall be plotted in Geocentric Coordinate grid. The grid will be shown by crosses at 100m intervals in Northings and Eastings. Full grid values will be given alongside the grids outside neat line.

10. Submission

10.1 Certification

All plans, field records, reports, data sheet, equipment calibration records, sounding plots, etc shall be certified by surveyors before submitting them to the Surveyor general.

10.2 Survey Plans

The surveyors in charge shall submit:

10.2.1. One transparent polyester base, in black and white

10.2.2. Two paper prints of the survey plans, not larger than AO size, to the Surveyor General.

10.3 Survey Report

The Surveyors in charge shall submit a comprehensive survey report (2 copies) to Surveyor General giving details on Outline of Operation, Field Operation, Data Processing, Finding, List of Accompanying Documents, and any other relevant information of each survey carried out by the Surveyor.

10.4 Digital Data File:

The LLS & Hydrographers shall submit a set of all digital survey record mentioned in clause 8, and store the soft copy in CD together with an index chart let showing the surveyed areas covered by each data file and the co-ordinates for those points defining the surveyed areas.

11. References

- Edition 1/04 2004 *Hydrographic Quality Assurance Instructions for Admiralty Surveys* - UK Hydrographic Office
- 17th Edition 1996 *General Instructions for Hydrographic Surveys* – UK Hydrographic Office
- 11th Section 1968 *Admiralty Manual of Hydrographic Surveying Volume 1* – UK Hydrographic Office
- 1969 to 1973 *Admiralty Manual of Hydrographic Surveying Volume 2* – UK Hydrographic Office
- 5th Edition – 1994 *"Hydrographic Dictionary" S-32* – International Hydrographic Organization, Monaco
- 4th Edition – 1998 *"IHO Standards for Hydrographic Survey" S-44* - International Hydrographic Organization, Monaco
- 29th April 1998 *"IHO Standards for Hydrographic Survey" Supplement to S-44*
Draft enclosed in letter IHB N.S3/7198
- 1st January 2002 EM1110-2-1003 *"Hydrographic Surveying"* – U.S. Army Corps of Engineers, Department of the Army, Washington.
- 1st June 2002 EM1110-1-1004 *"Geodetic and Control Surveying"* - U.S. Army Corps of Engineers, Department of the Army, Washington.
- Fourth Edition *"Hydrographic Manual"* – Melvin J. Umbach Rockville, Md. U.S Department of Commerce National Oceanic and Atmospheric Administration (NOAA) National Ocean Services (NOS)
- March 2003 NOS Hydrographic Surveys *"Specification and Deliverables"* - U.S Department of Commerce National Oceanic and Atmospheric Administration (NOAA) National Ocean Services (NOS)
- July 1974 *"Sea Surveying"* – Alan E. Ingham, John Wiley & Sons, Inc New York