Date: 18/06/20 **Survey No:** SHL-JN2003 **Ref:** SHL_JN2003_ROS_v1	SouthernHydrographic # SURVEY SUMMARY REPORT	**Client:** Christchurch City Council

Port	Survey Dates	Survey Area	Survey Order
AKAROA / FRENCH BAY	7-8 June 2020	• French Bay • Childrens Bay	**SO**

Hydrographic Surveyor (Supervising)	Certification
Dave Mundy Southern Hydrographic Ltd PO Box 61 Mapua 7048	IHO Category A AHSCP Level 1

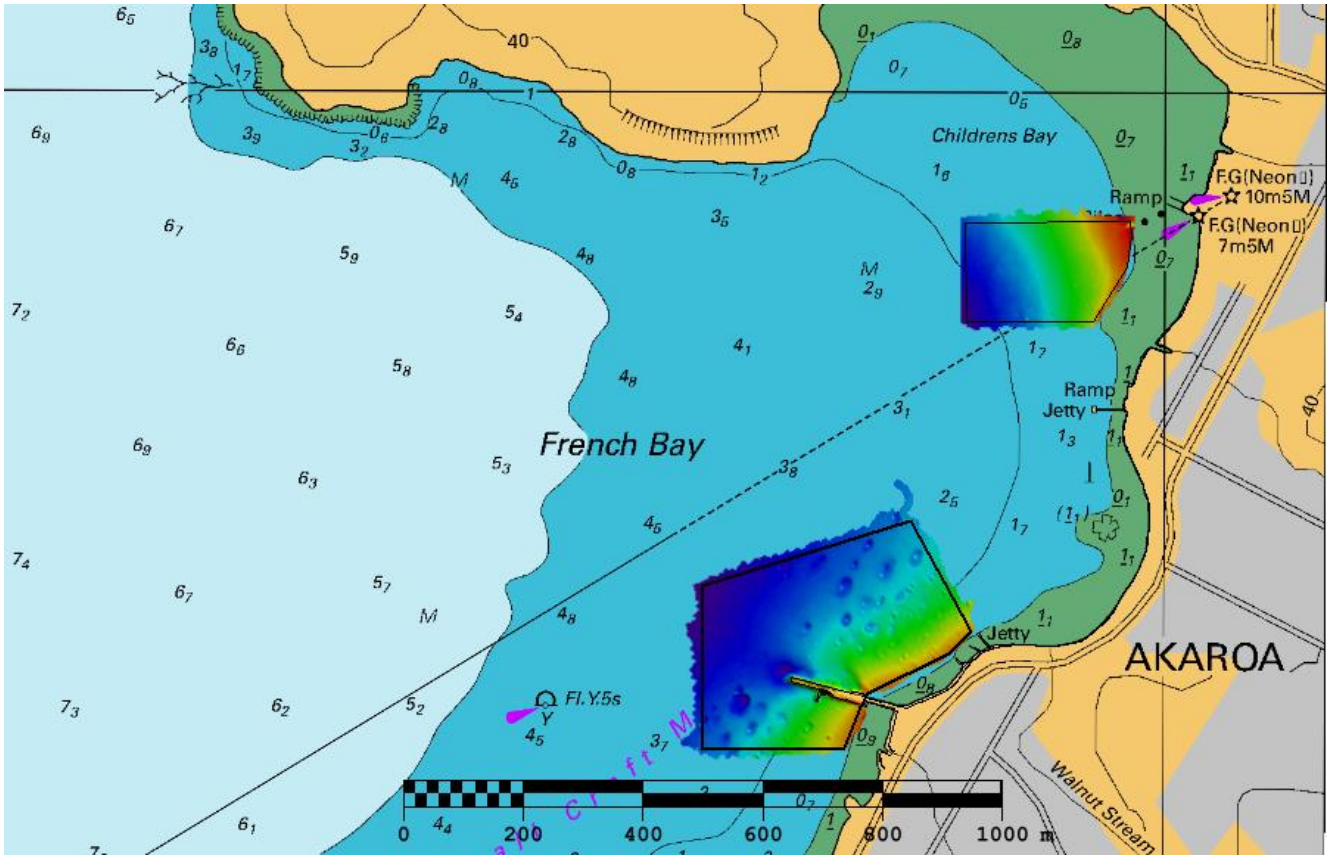
Purpose of Survey

Purpose of Survey	• Bathymetry data in support of engineering design for new wharf.

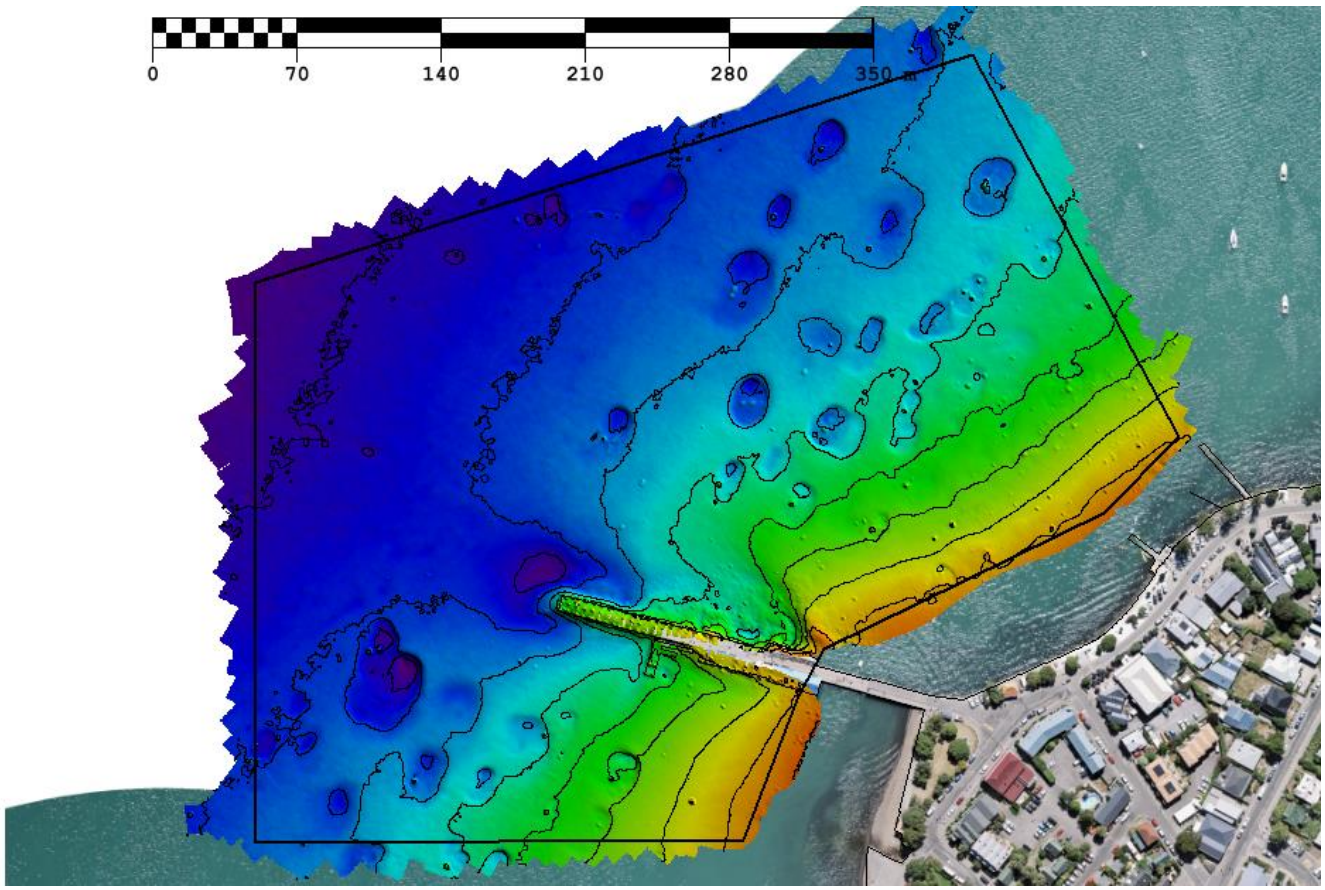
General Location Plots

General Description	MBES survey of proposed location options for new wharf: 1. Childrens Bay – S of main boat ramp. 2. French Bay – Area surrounding existing main wharf.

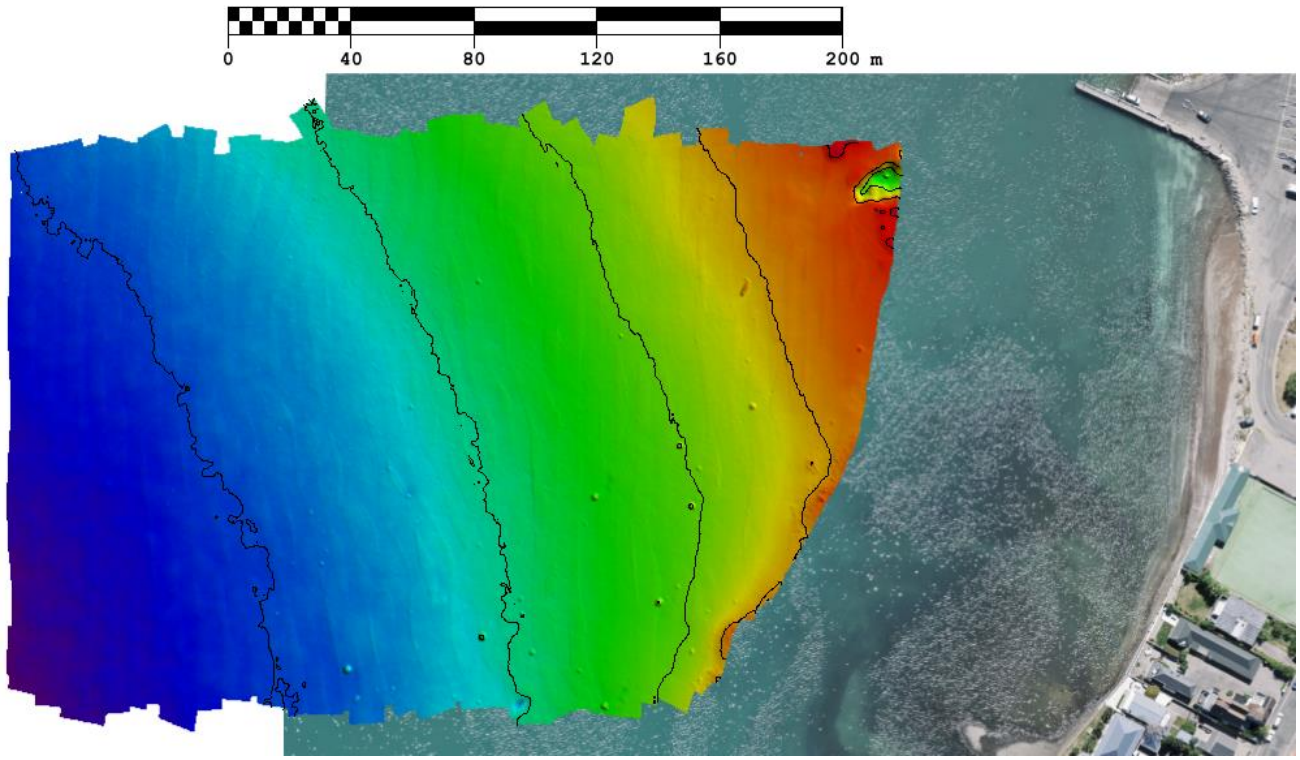
Ccc



French Bay (1:3000)



Childrens Bay (1:2000)



<table>
<tr><td colspan="2">Horizontal Positioning
Datum: NZGD2000
Projection: MTPLETM2000</td></tr>
<tr><td>Survey Geodesy</td><td>The datum/projection specified for this survey is <u>NZGD2000, Mount Pleasant Circuit</u>.</td></tr>
<tr><td>Connection to Horizontal Datum</td><td>Horizontal control for the survey was generated from an RTK Base Station occupying a local mark that was established to LINZ Order 5 standards using the LINZ PositioNZ PP service. Details of the local mark (named JN2003-BR) are tabulated below:
<table>
<tr><td>Parameter</td><td colspan="3">Detail</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Station Name</td><td colspan="3">JN2003-BR</td></tr>
<tr><td>LINZ PositoNZ Job ID</td><td colspan="3">PV678U</td></tr>
<tr><td>Date Established (Epoch)</td><td colspan="3">2020-06-05 (Epoch 2020.43)</td></tr>
<tr><td>Deformation Model</td><td colspan="3">Version 20180701</td></tr>
<tr><td>Reference Point</td><td colspan="3">SS pin set in rock on the N corner of the boad ramp S of Main Jetty on Beach Rd, Akaroa</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Coordinates</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Easting</td><td>Northing</td><td>Ellipsoid Height</td></tr>
<tr><td>Mt Pleasant Circuit</td><td>418814.875</td><td>775605.746</td><td>13.914</td></tr>
<tr><td></td><td>Latitude</td><td>Longitude</td><td>Ellipsoid Height</td></tr>
<tr><td>NZGD200 Geographic</td><td>43°48'35.54595"S</td><td>172°57'38.94338"E</td><td>13.914</td></tr>
</table></td></tr>
<tr><td>Methods of Obtaining Horizontal Position</td><td>Primary: Horizontal position will be obtained in real time on the survey vessel utilising RTK corrections generated from the RTK Base Station established at the local mark (per above).</td></tr>
<tr><td>Positioning checks</td><td>A check on the accuracy achieved by the horizontal and vertical coordinates derived using corrections from the RTK Base Station was carried out against existing Order 5 LINZ Geodetic Marks in the vicinity (specifically C82L).</td></tr>
<tr><td colspan="2">Vertical Datum
Datum: Chart Datum</td></tr>
<tr><td>Vertical Datum</td><td>The vertical datum for the survey is specified as Chart Datum, as described in on the LINZ official nautical chart NZ6324 and the Report of Survey (ROS) for the last hydrographic survey of the area – HS21 (2008), which is repeated below:

“Akaroa – 3.470 below LINZ BM C82L, a SS pin set 0.1m below ground level located in the footpath on Beach Road near the intersection with Rue Jolie.”</td></tr>
<tr><td>Method used to reduce soundings</td><td>Sounding data was reduced using RTK height data generated from an RTK Base Station established at a local geodetic mark “JN2003-BR”. Height data from the base station was referenced to the NZGD2000 ellipsoid, which was subsequently converted to vessel heights above CD by applying:

• A fixed offset of 11.778m to account for the separation between the NZGeoid2016 and the NZD2000 ellipsoid. This was determined using the LINZ online geodetic conversion facility, generated for the central position of the survey area.
• A fixed offset of 1.850m to bring the NZVD2016 height in terms of Chart Datum. This offset was derived by calculating the difference between the NZVD2016 height of BM C82L (as detailed in the LINZ Geodetic Database) and the published height of the BM above CD.</td></tr>
</table>

Validation of Vertical Height Solution	Validation of the vessel height calculated by the MBES Data Acquisition System in PANDORA II was carried out prior to survey works commencing. The height calculation included the application of the NZGeoid2016 offset together with the fixed offset to Chart Datum. Results are tabulated below:

Vertical Height Validation – Results:

Date	Reference Mark	Control			Observed			Delta		
		Easting (mE)	Northing (mN)	CD Height	Easting (mE)	Northing (mN)	CD Height	mE	mN	Height
RTK Base Station at Local Mark JN2003-BR										
7-Jun-20	**C82L**	**419086.147**	**775778.615**	**3.470**	419086.173	775778.629	3.488	-0.026	-0.014	-0.018

Dynamic Validation of Vertical Height Solution	Dynamic validation of the vertical height solution was achieved by comparing the real-time waterline height calculated on the vessel with the WL height generated by an independent source, in this case the height generated by an independent RTK receiver. Note this check was conducted with the vessel on the trailer, with the RTK zero (bottom of antenna pogo pole) held on the visible WL mark. The following table shows close agreement to within +/-2cm between the two, providing confidence that the vertical height solution being generated by the vessel is in accordance with expected uncertainty (+/- 3cm of CD).

Dynamic Validation of Vertical Height Solution – Results:

Date	Reference	Source		Max Delta
		QINSY (Vessel Waterline Node)	Trimble R8 RTK rover on WL	
06/06/2020 0926	Chart Datum	5.860	5.860	0.000

Depth Measurement

Survey Vessel Description (Length, Beam, Hull Type)

Vessel Details:

Survey Vessel Name:	SMB PANDORA II
Official No.	MNZ 135467
Owner:	Southern Hydrographic Limited
Hull Type:	Alloy Catamaran
Length Overall	7.1m
Beam:	2.5m
Draught (hull)	0.42m
Displacement	2.5Tonne
Engines	2 x Yamaha 115 four stoke
Electrical	12 VDC and 230VAC power

Method(s) to be used to Determine Least Depths

Multibeam Echosounder Specifications:

Multibeam Make/Model	Teledyne Reson T20-R
Frequency	200 to 400kHz (400kHz used)
Beam-width	1° x 1° at 400kHz, 2° x 2° at 200kHz
Maximum Ping Rate	50Hz
Number of Beams	1024 (equidistant) at 400kHz
Max swath angle	140° in equidistant mode; 165° in equiangle
Depth Resolution	0.006m

Echo Sounder Frequency(s)

The Reson T20-R MBES will be operated at 400kHz during the survey.

Method and Frequency of Echo Sounder Calibration

MBES patch tests are conducted during regular surveys in Lyttelton (March 2020). The angular bias of the MBES transducer with respect to the POS/MV IMU is derived using Caris HIPS calibration tool and set in the Qinsy Data Acquisition System and reapplied to raw ".s7K" files during post processing in Caris HIPS.

Vessel Offsets

The target mark on the POS/MV Inertial Measurement Unit (IMU) is designated the Common reference Point (CRP) for the Hydrographic Survey System. The lever arm distances between the CRP and various sensors have been measured as part of a Dimensional Control (DIMCON) carried out by Exodus Hydrographic Pty Ltd in September 2019. Reference Exodus HS016 dated 03 October 2019.

All vessel offsets are contained in both the online Data Acquisition System (Qinsy) and applied again to raw data during post-processing in Caris HIPS.

Bar Check

Shallow bar checks are conducted during regular surveys in Lyttelton (March 2020). MBES data is logged, post processed in HIPS and a comparison made between the processed depths (zero tide) and bar depths. Differences observed are typically less than 3cm.

Method to Compensate for Transducer Motion

Vessel attitude (heave, pitch, roll and heading) data is provided in real time by an integrated POS/MV Wavemaster II (Serial No. 10558) coupled with a Teledyne Type 20 Inertial Measurement Unit (IMU). Delayed heave was subsequently applied during post processing in Caris HIPS to reduce motion artefacts arising from settling time and long period swell.

Sound Velocity

The velocity of sound in water was continuously logged at the transducer head and employed for beam steering. Additionally, SV profile observations (SVP dips) were conducted before and after sounding and used in HIPS to correct for refraction errors during post processing in Caris HIPS.

Limiting Sea Conditions affecting Survey Quality	Poor weather / sea conditions on Saturday 6 June delayed the start of MBES survey operations until the following day when conditions were considerably better with light airs and nil swell.
Limiting Tide Conditions	The survey areas are very shallow for typical MBES operations and due to the low seabed gradient and range of tide (2.5m) it is not considered safe or practical to conduct MBES operations in depths less than 2.5m. MBES coverage was obtained to the drying line (0m at CD) were possible and safe to do so. Accordingly, MBES sounding along the inshore limit was conducted at HW springs to achieve maximum coverage.
Squat of Transducers at Sounding Speed	Any settlement and squat on the survey vessel is included in the vertical height component derived during "GPS Tide" processing in Caris HIPS.

Seabed Coverage

Method to Ensure Seabed Coverage Criteria is met	MBES sounding lines will be run at 200% coverage at all times.
Echo Sounder Pulse Repetition Rate	Maximum ping rate of the Teledyne Reson T20-R is 50Hz; typically ping rates of between 40-50Hz were achieved in the shallow depths during the survey (<5m). This resulted in very high sounding density, as seen in the Sounding Density Plots (refer Seabed Coverage).
Beam Widths - Along Track and Across Travel	The following beam widths will be achieved (at 400kHz): • Along Track = 1° • Across Track = 1°
Survey Vessel Speed	Survey vessel speed during the survey was 3-4kn in open areas but for majority of the time it was less than 3kn in and around the numerous small craft moorings.
Sounding Line Spacing and Orientation	MBES survey lines were run at variable spacing to ensure 200% coverage. This was achieved by running along the edge of the previous line (also known as "half-stepping). The horizontal distance between lines was typically 10m or less. Survey lines were generally orientated parallel with the depth contours, with the exception of those lines run in the vicinity of the jetty at French Bay, which were run parallel with the jetty.
Process for sounding inshore lines	Beam steering was employed in the MBES system to ensure the maximum swathe width was achieved along the inshore line and under wharfs/moored vessels where possible. The inshore strip was sounded at high water, enabling the drying line (0.0m) contour to be achieved along a significant part of the coastline. The presence of numerous mooring buoys, most occupied by vessels, required careful manoeuvring to ensure full seabed coverage was achieved, particularly along the inshore strip, where the shallow depth limited how close the survey vessel could safely work to the coastline.

Data Presentation

Principle and Method used in Sounding Selection	Soundings shown on survey plots were generated from bathymetric surface produced for each area using Combined Uncertainty Best Estimate (CUBE) employed by Caris HIPS. NOTE – bathymetric surfaces used for the generation of soundings have been clipped to exclude surface lines or wharf piles detected by the MBES that would otherwise will be shown as shoal soundings that are not representative of the general seabed depths. This is particularly relevant for the area under the jetty at French Bay. The following table details the relevant parameters used in the generation of plotted soundings:
Method of Contour Generation	Contours were generated in Caris HIPS at 0.5m intervals
Wharf Infrastructure and Topography	All wharf infrastructure and adjacent coastline shown on survey sheets has been digitized from aerial imagery sourced from the LINZ Data Service, and should be considered indicative only.

		French Bay	Childrens Bay
Bathymetric Surface	**Source File:**	JN2003_FB_50cm_v1.csar	JN2003_CB_50cm_v1.csar
	Type:	CUBE	CUBE
	Grid Size	0.5m	0.5m
Sounding Selection	**Plot Scale**	1:1000	1:1000
	Sounding Size	1.45mm	1.45mm
	Overplot Removal	Shoal bias	Shoal bias
	Sounding Rounding	Truncated	Truncated

Data Quality

The Method(s) used to Derive the Quality of the Data and Ability to meet the Depth Tolerance as Required in the Standards

In lieu of a specified standard, the LINZ Special Order standard is adopted as a minimum standard for this survey. The requirements for this order of survey are detailed in LINZ Contract Specifications for Hydrographic Surveys Version 1.3; the key parameters are repeated below:

LINZ Order	Description of Area	Max Allowable THU	Max Allowable TVU	Feature Detection
Special	Areas where under-keel clearance is critical	2 metres	a = 0.25m b = 0.075	Cubic features > 1 metre

The combined Total Propagated Uncertainty estimate of the horizontal and vertical components of the survey data has been calculated and is produced in the following section.

Total Propagated Uncertainty (TPU)

To demonstrate LINZ Special Order standard will be met, individual sources of uncertainty (commonly referred to as errors) have been identified and assessed as part of a combined model or Total Propagated Uncertainty (TPU).

Separate TPU models have been produced for both the depth (TVU) and position (THU) components. Both are reproduced below:

MBES Vertical TPU	Swath Width		3 X WD	Note	Depth (m)	Depth (m)	Depth (m)
Source of Uncertainty	Depth Independent Uncertainty		Depth Dependent Uncertainty		2	5	10
Vessel Draught Setting	0.00			a	0.00	0.00	0.00
Variation of Vessel Draught Setting	0.00			b	0.00	0.00	0.00
Vessel Settlement and Squat	0.00			c	0.00	0.00	0.00
MBES Instrument Accuracy	0.05	±	0.50% d	d	0.05	0.06	0.07
Roll Uncertainty			0.0013 d	e	0.00	0.01	0.01
Heave Uncertainty	0.05			f	0.05	0.05	0.05
Sound Velocity Measurement			0.0021 d	g	0.00	0.01	0.02
Sound Velocity Spatial Variation			0.0013 d	h	0.00	0.01	0.01
Sound Velocity Temporal Variation			0.0013 d	i	0.00	0.01	0.01
Tide Data Accuracy	0.03			j	0.03	0.03	0.03
Co-Tidal Uncertainty	0.07			k	0.07	0.07	0.07
Combined Total	**0.10**	**±**	**0.0059 d**		**0.10**	**0.11**	**0.12**
Requirement IHO/LINZ Special Order	**0.25**	**±**	**0.0075 d**		**0.25**	**0.25**	**0.26**
Standard Met					**YES**	**YES**	**YES**

Comments

a. Draught error eliminated with use of RTK Heighting methodolgy
b. Varaition of draught error eliiminated with use of RTK Heighting methodolgy
c. Squat/Settlement error eliminated with use of RTK Heighting methodolgy
d. Determined from manufacturers specifications of 1cm resolution and experience from previous surveys using the Reson "T" series MBES systems. An accuracy of 5cm + 0.5% of depth conservative estimate of the depth accuracy.
e. Maximum depth error in outer beams. Based on roll error used in position error TPU, ie +/- 0.05°.
f. Applanix POS/MV specifications state equipment real-time accuracy of 5% of heave experienced (heave experienced less than 0.1 metres during survey). Application of delayed heave during post-processing reduced residual heave artefact in worst case to 0.05m.
g. Manufacturers estimate of sound velocity sensor accuracy (+/-1%)
h. Spatial variation in sound velocity solution estimated to be better than 2m/s (0.0013d).
i. Temporal variation in sound velocity solution estimated to be better than 2m/s 0.0013d).
j Estimated accuracy of tidal observations at the gauge. Tides not used in this instance but figure retained as representing vertical height uncertainty using RTK heighting methodology.
k Not a co-tidal error as such, but representative of NZGeoid16 uncertainty when used in conjunction with RTK heighting.

MBES Position TPU	Swath Width	3 X WD	Note	Depth (m)	Depth (m)	Depth (m)
Source of Uncertainty	Depth Independent Uncertainty	Depth Dependent Uncertainty	300.00%	2	5	10
Positioning System	0.10		a	0.10	0.10	0.10
Positioning System Latency	0.01		b	0.01	0.01	0.01
Vessel Heading		0.05 ° 0.0013 d	c	0.00	0.01	0.01
Vessel Heading Offset		0.10 ° 0.0026 d	d	0.01	0.01	0.03
Offsets and Lever Arm Measurements	0.05		e	0.05	0.05	0.05
Vessel Roll		0.05 ° 0.0013 d	f	0.00	0.01	0.01
Vessel Roll Offset		0.10 ° 0.0026 d	g	0.01	0.01	0.03
Vessel Pitch		0.05 ° 0.0017 d	h	0.00	0.01	0.02
Vessel Pitch Offset		0.10 ° 0.0035 d	i	0.01	0.02	0.03
Combined Total	**0.11**	**±** **0.0057 d**		**0.11**	**0.12**	**0.13**
Requirement IHO/LINZ Special Order	**2.00**	**±** **0% d**		**2.00**	**2.00**	**2.00**
Standard Met				**YES**	**YES**	**YES**

Comments

a Maximum error estimate from static check. Worst case used.

b 1PPS used - negligible latency residual error present.

c Manufacturers stated accuracy for POS/MV.

d Heading offset uncertainty of MBES patch test methodology, ie estimated residual error after bias applied.

e Estimated accuracy of offset measurements.

f Manufacturers stated accuracy for POS/MV.

g Heading bias uncertainty of MBES patch test methodology, ie estimated residual error after bias applied.

h Manufacturers stated accuracy for POS/MV.

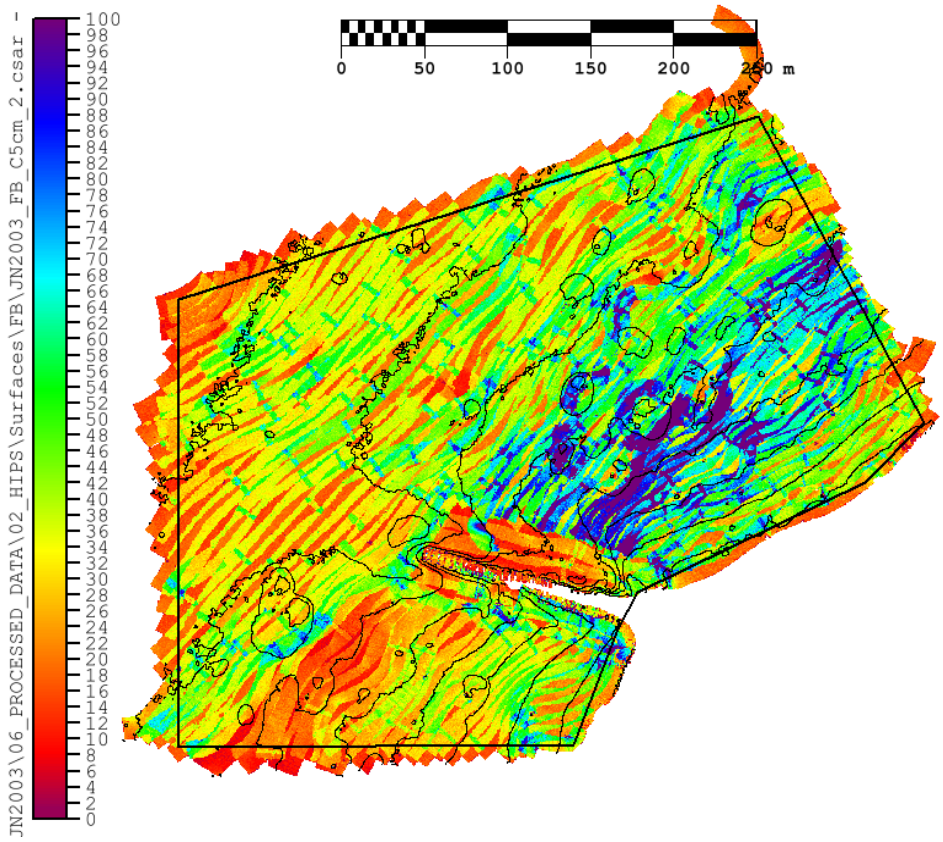
i Pitch bias uncertainty of MBES patch test methodology, ie estimated residual error after bias applied.

Seabed Coverage

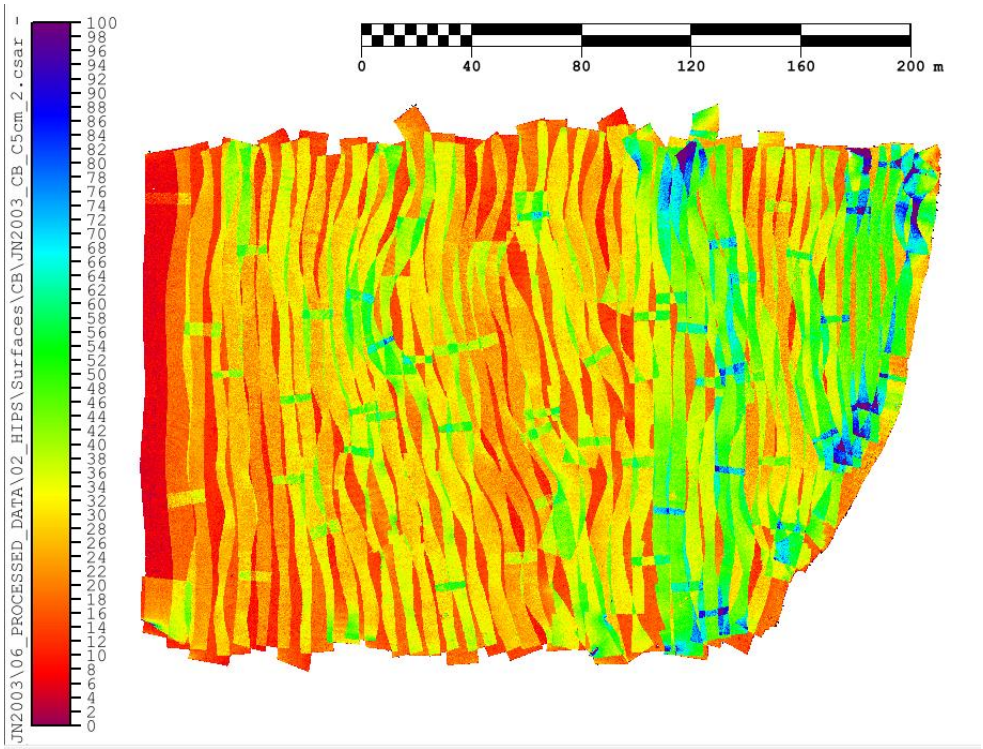
Method to Ensure Seabed Coverage Criteria is met	MBES sounding lines were run to ensure 200% coverage was achieved at all times.
Echo Sounder Pulse Repetition Rate	Maximum ping rate of the Reson 7125 is 50Hz; typically ping rates of between 20-30Hz were achieved during the survey.
Beam Widths - Along Track and Across Travel	The following beam widths were achieved (at 400kHz) • Along Track = 1° • Across Track = 0.5°
Survey Vessel Speed	Survey vessel speed was typically 4-5kn during the survey.
Sounding Line Spacing and Orientation	MBES survey lines were run at variable spacing to ensure 200% coverage. This was achieved by running along the edge of the previous line (also known as “half-stepping).
Process for sounding along Berths/Jetties	MBES lines were run parallel with the line of the main wharf with MBES beams steered at the maximum angle to achieve the greatest coverage under the wharf as possible. This enabled full seabed coverage under the wharf at the eastern end. Most of the wharf piles were detected and have been retained in the processed dataset, but not shown on the bathymetric sheet (refer Data Presentation).

Sounding Density – plot of soundings per 5cm grid	Due to the shallow nature of the survey, the MBES pulse repetition rate was very high, enabling excellent detection and resolution of small objects. The plots below provide a graphical representation of the sounding density, with the number of soundings shown every 5cm^2 per the colour legend.

French Bay



Childrens Bay:



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Sounding Selection	**Plot Scale**	1:1000	1:1000
	Sounding Size	1.45mm	1.45mm
	Overplot Removal	Shoal bias	Shoal bias
	Sounding Rounding	Truncated	Truncated

Deliverables

Digital Deliverables	The table below details the Digital Deliverables accompany this Summary Report of Survey.

Deliverable	Description	Format	File	Rendered
01 - Sounding Data	Processed, 5cm CUBE - French Bay Survey Area	ASCII XYZ	JN2003_Akaroa_French_Bay_MTPLEAT_CUBE_5cm_v1.xyz	25/06/2020
	Processed, 50cm, CUBE - French Bay Survey Area	ASCII XYZ	JN2003_Akaroa_French_Bay_MTPLEAT_CUBE_50cm_v1.xyz	24/06/2020
	Processed, 5cm CUBE - Childrens Bay Survey Area	ASCII XYZ	JN2003_Akaroa_Childrens_Bay_MTPLEAT_CUBE_5cm_v1.xyz	25/06/2020
	Processed, 50cm, CUBE - Childrens Bay Survey Area	ASCII XYZ	JN2003_Akaroa_Childrens_Bay_MTPLEAT_CUBE_50cm_v1.xyz	24/06/2020
02 - Contours	Depth Contours - 0.5m intervals - French Bay	DXF	JN2003_Akaroa_French_Bay_MTPLEAT_Contours_50cm_v1.dxf	25/06/2020
	Depth Contours - 0.5m intervals - Childrens Bay	DXF	JN2003_Akaroa_Chailrens_Bay_MTPLEAT_Contours_50cm_v1.dxf	25/06/2020
03 - Bathymetric Surface	CUBE Surface, 5cm resolution - French Bay Survey Area	Caris .csar	JN2003_Akaroa_French_Bay_CUBE_C5cm_1.csar	25/06/2020
	CUBE Surface, 5cm resolution - Childrens Bay Survey Area	Caris .csar	JN2003_Akaroa_Childrens_Bay_CUBE_C5cm_1.csar	25/06/2020
04 - Raster Files	KMZ, 5cm resolution - French Bay Survey Area	KMZ	JN2003_Akaroa_French_Bay_5cm_v1.kmz	25/06/2020
	KMZ, 5cm resolution - Childrens Bay Survey Area	KMZ	JN2003_Akaroa_Childrens_Bay_5cm_v1.kmz	25/06/2020
	Geo TIFF, 5cm resolution - French Bay Survey Area	TIFF	JN2003_Akaroa_French_Bay_5cm_v1.tif	25/06/2020
	Geo TIFF, 5cm resolution - Childrens Bay Survey Area	TIFF	JN2003_Akaroa_Childrens_Bay_5cm_v1.tif	25/06/2020
05 -Survey Sheets	Bathymetry Sheet, French Bay 1:1000	PDF	JN2003_Sheet_FB_A1-1K-BTY_v1.pdf	25/06/2020
	Bathymetric Surface, French Bay, 5cm	PDF	JN2003_Sheet_FB_A1-1K-SUR_v1.pdf	25/06/2020
	Bathymetry Sheet, Childrens Bay 1:1000	PDF	JN2003_Sheet_CB_A1-1K-BTY_v1.pdf	25/06/2020
	Bathymetric Surface, Childrens Bay, 5cm	PDF	JN2003_Sheet_CB_A1-1K-SUR_v1.pdf	25/06/2020
06 - Report	Survey Summary Report - SHL-JN2003-Akaroa	PDF	SHL_JN2003_Akaroa_ROS_v1	25/06/2020

I certify that this Method Statement described herein conform to the hydrographic survey meeting the Survey Standard.

D.L. MUNDY
Supervising Surveyor

25 June 2020

Certified Practitioner Hydrography Level 1 (AHSCP)
IHO Cat A
PGDip (Hydrography)