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Bathymetric Report
for
Magheroraty Approaches



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1. Summary

This report is intended to fulfil the requirements for bathymetric survey as specified in the tender documents "Magheraroarty Approach Channel Survey", October 2019. It is one of a family of four reports.

1. Final/Interpretative Report
2. Bathymetric Report for Magheraroraty Approaches (this report)
3. Side Scan Report for Magheraroraty Approaches
4. Magnetometry Report for Magheraroraty Approaches

This report is a summary only and is accompanied by high resolution copies of all figures and data extracts as specified below.

Donegal County Council requirements were specified as:

1. A Digital Terrain Model (DTM).
2. Raw bathymetric data for further processing.

The following deliverables were specified:

1. A summary and interpretive report.
2. Georeferenced contour charts with features indicated and labelled.
3. Georeferenced soundings charts.
4. CSV file with:
    a. Time/date stamp per data point
    b. XYZ data
    c. GNSS accuracy validation per data point
    d. Tidal compensation value per data point, to MSL Malin Head

The following standards were specified

1. Survey standards generally to IHO S44 order 1b.
2. Line spacing, 10m North-South, 10m East-West.
3. Sample spacing ≤ 2m.
    a. Survey speed was maintained at c. 3 knots and one sample was taken per second.

The measurements specified above are carried out in the context of the Works Requirements, Description of Works for this project.

"*Access to Magheraroarty pier has ever more been challenging due to the shallow approach and continuous siltation within the berthing area of the pier. Annual dredging is required to maintain navigable depths at the pier, however, there is also a difficulty on the final approach to the pier where Donegal Co. Council would now like to obtain an accurate profile of the approach channel.*

It is proposed to carry out a number of surveys to determine the most suitable approach route and from this provide Aids to Navigation. Donegal Co. Council would also like to determine the profile and make-up of the sea bed in this area to establish whether or not it is possible to dredge the access channel to make the pier accessible at all levels of tide".

2. Tidal Correction

Although it was planned to install a permanent tidal station at the pier through the Marine Institute, it was not possible for this project to go ahead prior to the survey. Subject to travel restrictions, this work should be completed in November 2020.

Tidal calculations for navigation in Ireland have historically been calculated by the UKHO. For tidal calculations, the standard port in this region is Galway, however only limited information is available for Inishbofin Bay. The following data was extracted from UKHO/Admiralty documents [1, 2].

Port	**Time Differences**				**Height Differences**			
	High Water		**Low Water**		**MHWS**	**MHWN**	**MLWN**	**MLWS**
Galway	0200 and 1400	0900 and 2100	0200 and 1400	0800 and 2000	5.1	3.9	2.0	0.6
Inishbofin Bay	+0040	+0026	+0032	+0046	3.9	3		

Other sources quote Bofin Harbour (Inishbofin) tides. This is an error as the cited tables refer to Inishbofin, Co. Galway.

Given the absence of data relating to low water in [1, 2] and the unavailability of tidal height for low water in Inishbofin Bay [3], a simple cosine model was used for tide prediction.

All compensation for tidal heights is by direct measurement and referenced to MSL Malin.

Tidal compensation was performed using:

1. Floating Sensor platform
    a. RTK GPS
    b. Depth Sounder for cross-check only

    Logging rate was one second and a one-minute moving average was used to minimise the effect of waves and disturbances.

2. Survey Vessel
    a. RTK GPS

    Logging rate was one second.

3. Tide levels were cross-checked at the start and end of survey by physical measurement from a temporary benchmark at the pier deck adjacent to the slipway.

3. Fixed data relating to Coordinate Reference Systems (CRS)

In section 1.3 of [1], the contractor is required to provide all data to Irish Grid (IG) and the Malin Head Vertical Datum (MSL).

The contractor must also provide:

1. Offsets values to CD from VORF or similar authoritative sources.
2. Offsets to MSL Belfast Lough.
3. Offset to the reference ellipsoid.

The following summary values are used for this survey.

ETRF to MSL	57.387	
ETRF to CD	55.3078	MSL -2.0792
ETRF to LAT	55.1824	MSL -2.2046
ETRF to Poolbeg	54.775	MSL -2.612
MSL Belfast	0.037m above MSL Malin	

This is based on the Vertical Offshore Reference Frame (VORF) model produced by the United Kingdom Hydrographic Office (UKHO).

It is important to clarify these values. For example, the original engineering drawings for the pier show the deck as +6m to OD Poolbeg. Modern survey shows the pier deck to be c. +3.1m to MSL Malin. Adding the 2.612m difference reconciles the two values +/- 0.29m. An explanatory sketch is given in Figure 1.

It is presumed that the remaining error relates to historical survey and actual build. The raised walkway against the west wall of the pier is c. 0.3m above the pier deck, it does not show on the original engineering drawings but is at c. +6m to OD Poolbeg.

This survey data was taken using Leica GS08+ RTK GPS with CS10 controller but is intended for guidance only. A benchmark survey of the pier is scheduled for late 2020, this should be considered the authoritative reference.

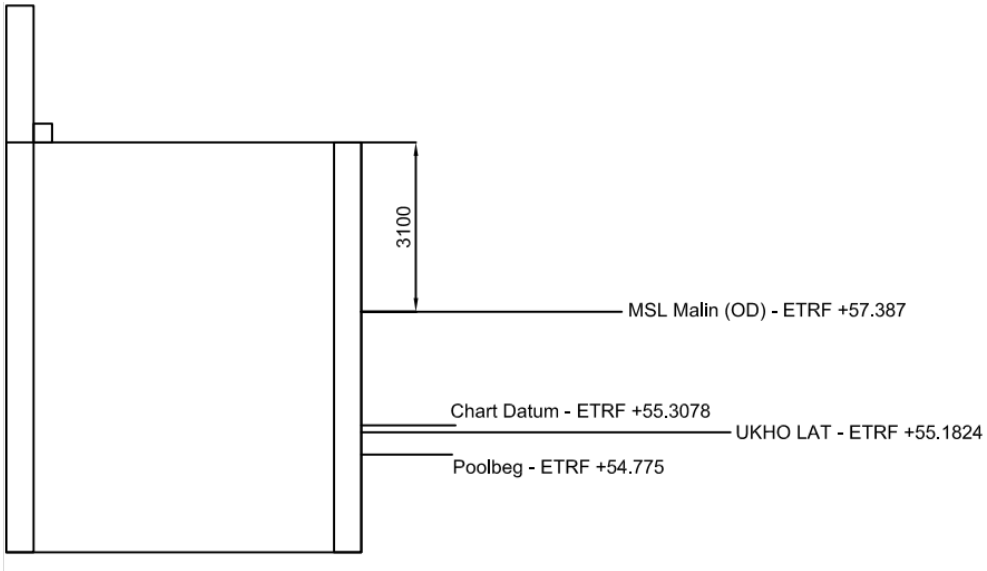


Figure 1. Significant Height References

4. Terrestrial Survey

4.1 Pier Level Survey

The survey in Figure 2 shows points along the west wall on the plinth, c. 0.3m above the pier deck. Points on the east side are at the pier deck level. As the installation of a tidal gauge is imminent, no permanent control points were created. All heights are to MSL Malin.

For conversion to Chart Datum (CD), add c. 2m, the exact offsets are given in section 3.

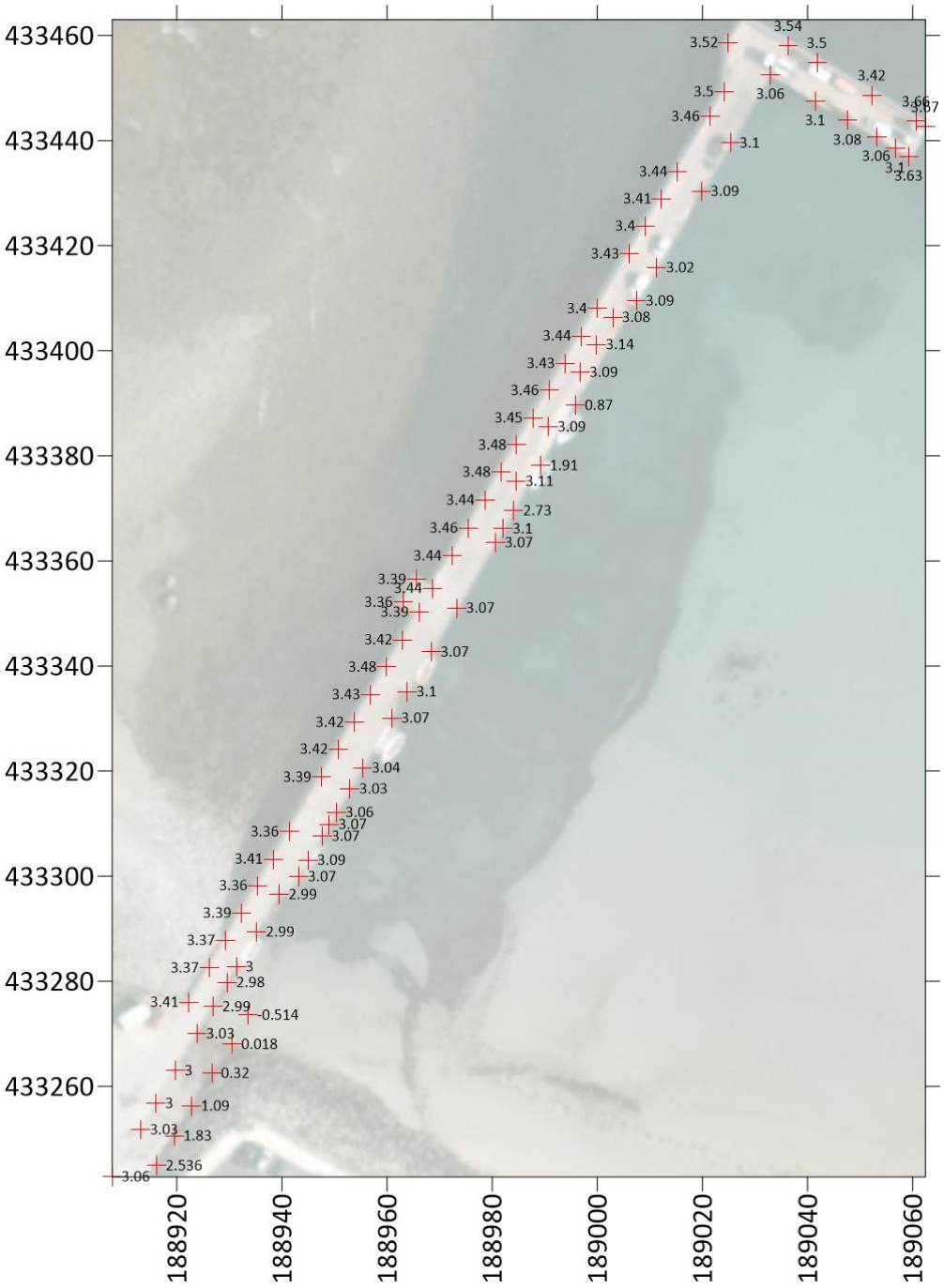


Figure 2. Pier Level Survey

4.2 Reef Level Survey

The survey data in Figure 3 was taken in area of the survey box which was safely accessible at low spring tide. An indicative sample of spot depths are provided. For conversion to Chart Datum, add c. 2m, the exact offsets are given in section 3.

For example, the -1m contour to MSL approximately equates to +1m to Chart Datum.

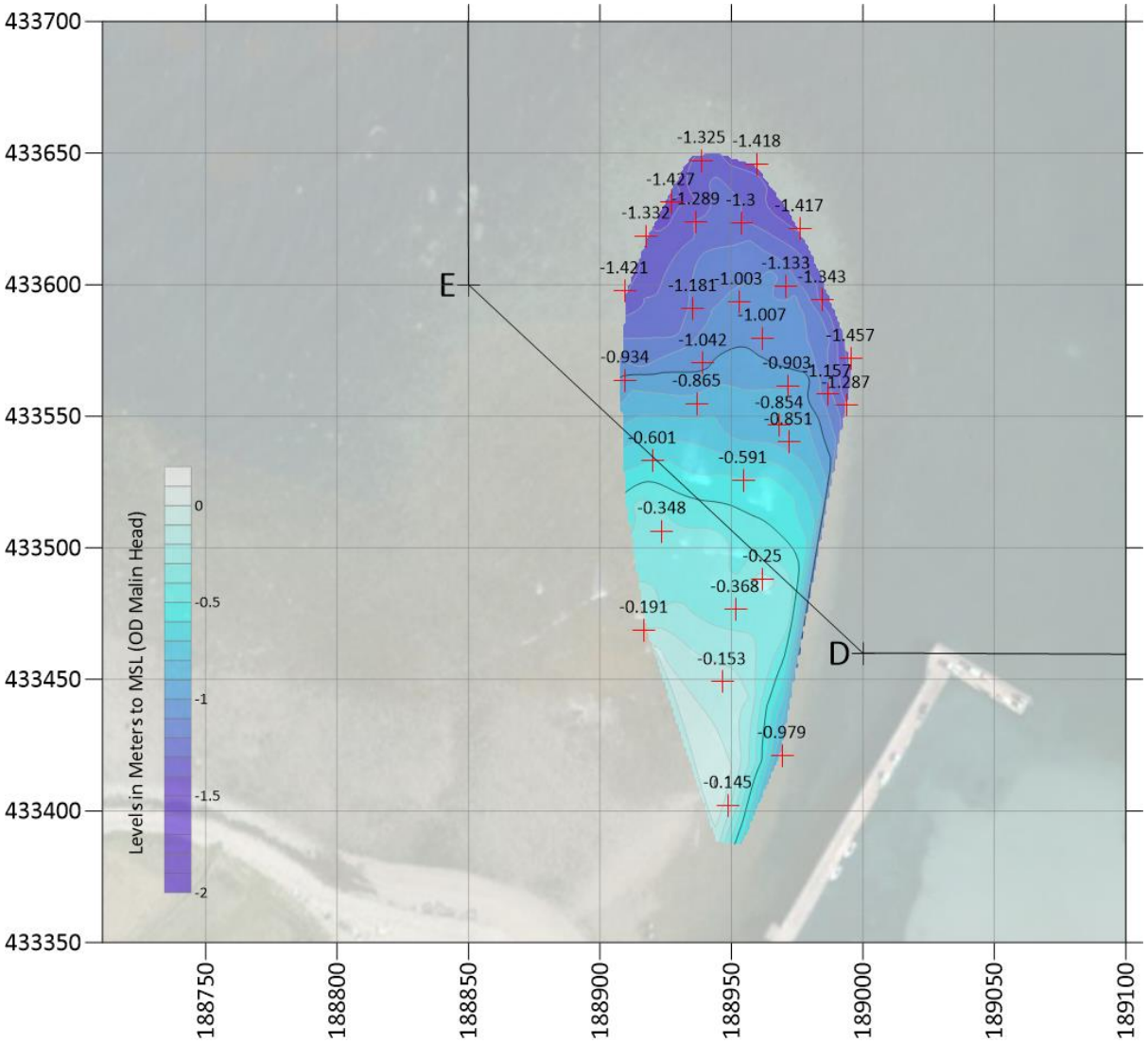


Figure 3. Reef Level Survey to MSL

5. Single Beam Echo Sounding (SBES) survey

The survey sounder was:

Airmar SS510 with 0.03m resolution and a 6° beam at 235kHz.

The survey positioning was via an RTK GPS utilizing:

U-Blox C94-MP8 base and rover

Only data points with an RTK or RTK float fix have been included for processing. The survey sounder and antenna are mounted on a carbon-fibre monopole.

Two GPS/sounder systems using different technologies and frequencies are used for all SBES, one sounder for survey and one for cross-check. The cross-check equipment was:

Garmin Echomap Chirp 75dv with GT20TM transducer (77/200kHz and 455/800kHz).

SBES survey was carried out around high water on 18th August 2020.

The outputs of both surveys were processed independently, and results are consistent. Bathymetric survey results were compared with results gathered independently from the reef level survey and were found to be consistent.

Additional data on indicative bottom hardness is included which was derived from:

Hummingbird XM 9 HW MSI T transducer, Dual Spectrum CHIRP 150-220 kHz, Narrow: 180-240 kHz, Wide: 140-200 kHz.

5.1 Bathymetry Contours

Figure 4 presents 1m contours to MSL for the survey area. For conversion to CD/LAT, add c. 2m. For example, the -2m contour to MSL approximately equates to 0m CD/LAT. The typical approach channel is c. 50m wide immediately west of 189100. The channel corresponds to the -5m contour area from c. 433475 running northwards. A bar can be seen at c. 433580 and -5m is attained again at c. 433670.

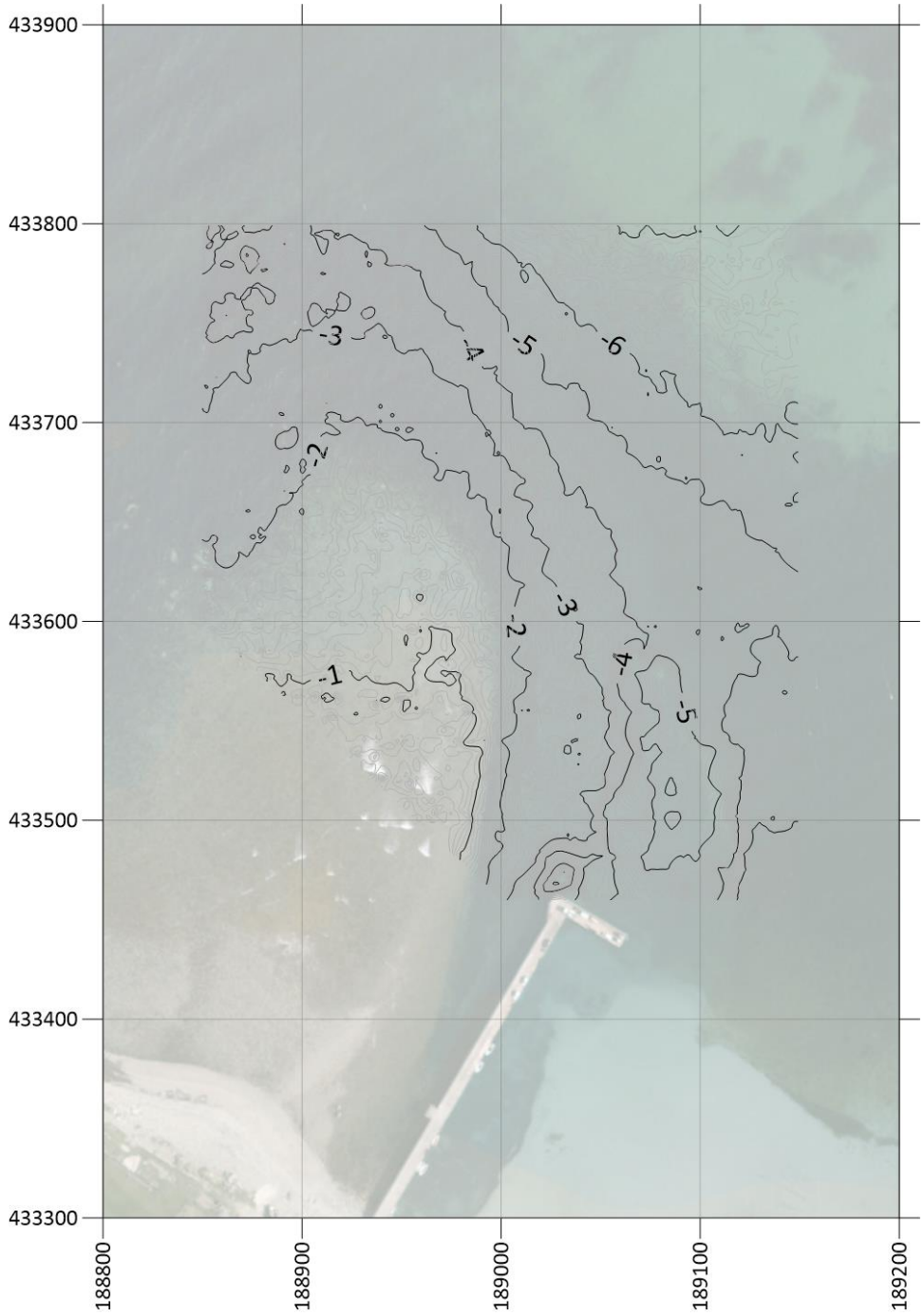


Figure 4. The 1m contours to MSL overlaid on aerial photography

5.2 Bathymetry Colour Contours

Figure 5 presents 1m contours to MSL for the survey area. For conversion to Chart Datum, add c. 2m, the exact offsets are given in section 3.

For example, the -2m contour to MSL approximately equates to Chart Datum.

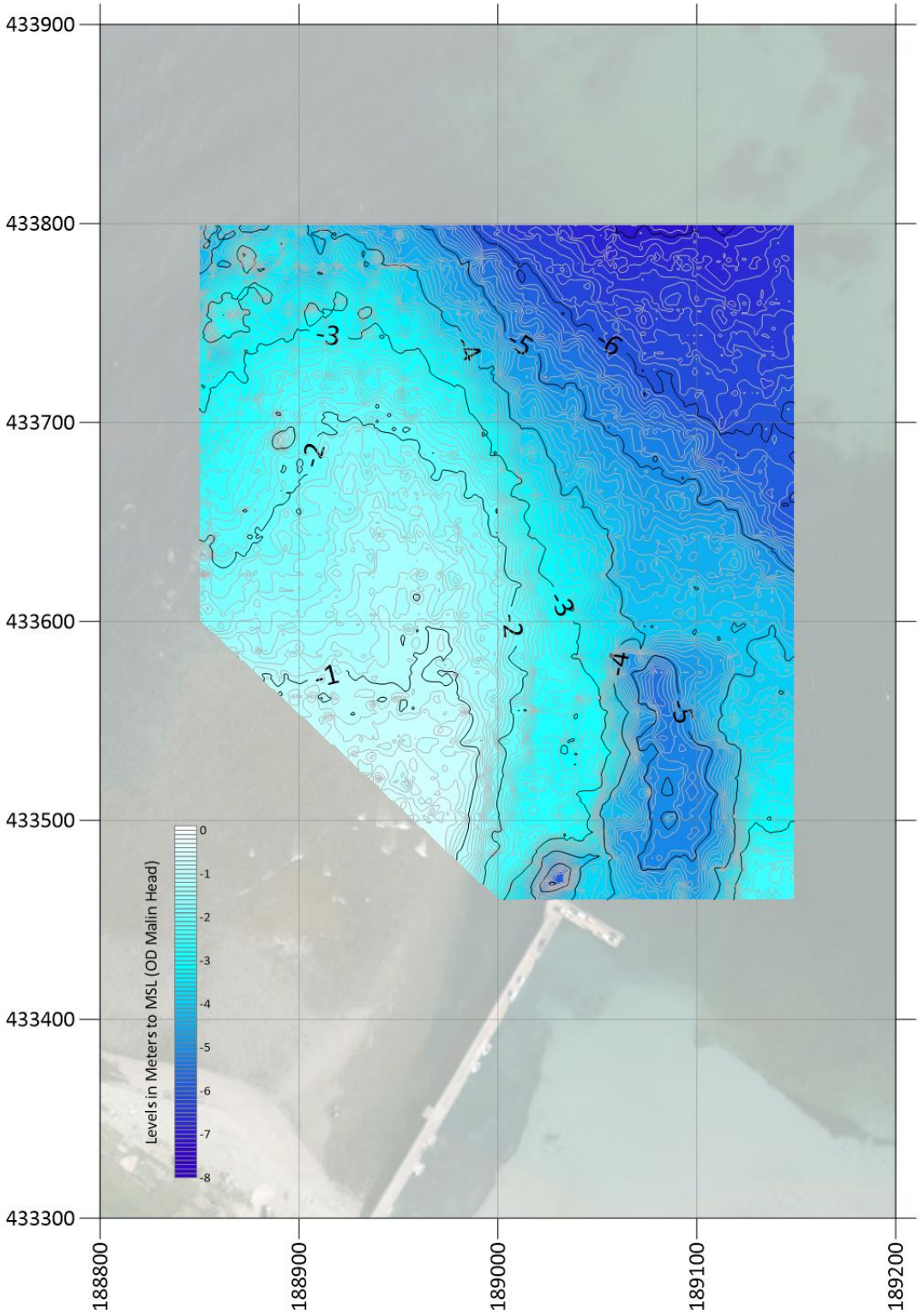


Figure 5. The 1m colour contours to MSL overlaid on aerial photography

5.3 Profile of the approaces

Figure 6 presents 1m contours to MSL for the survey area, with:

1. An arbitrary north-south profile (red) following the approximate centre of the channel. Figure 7 shows a profile along this line.
2. An arbitrary east-west profile (green) as a cross-section of the channel. Figure 8 shows a profile along this line.

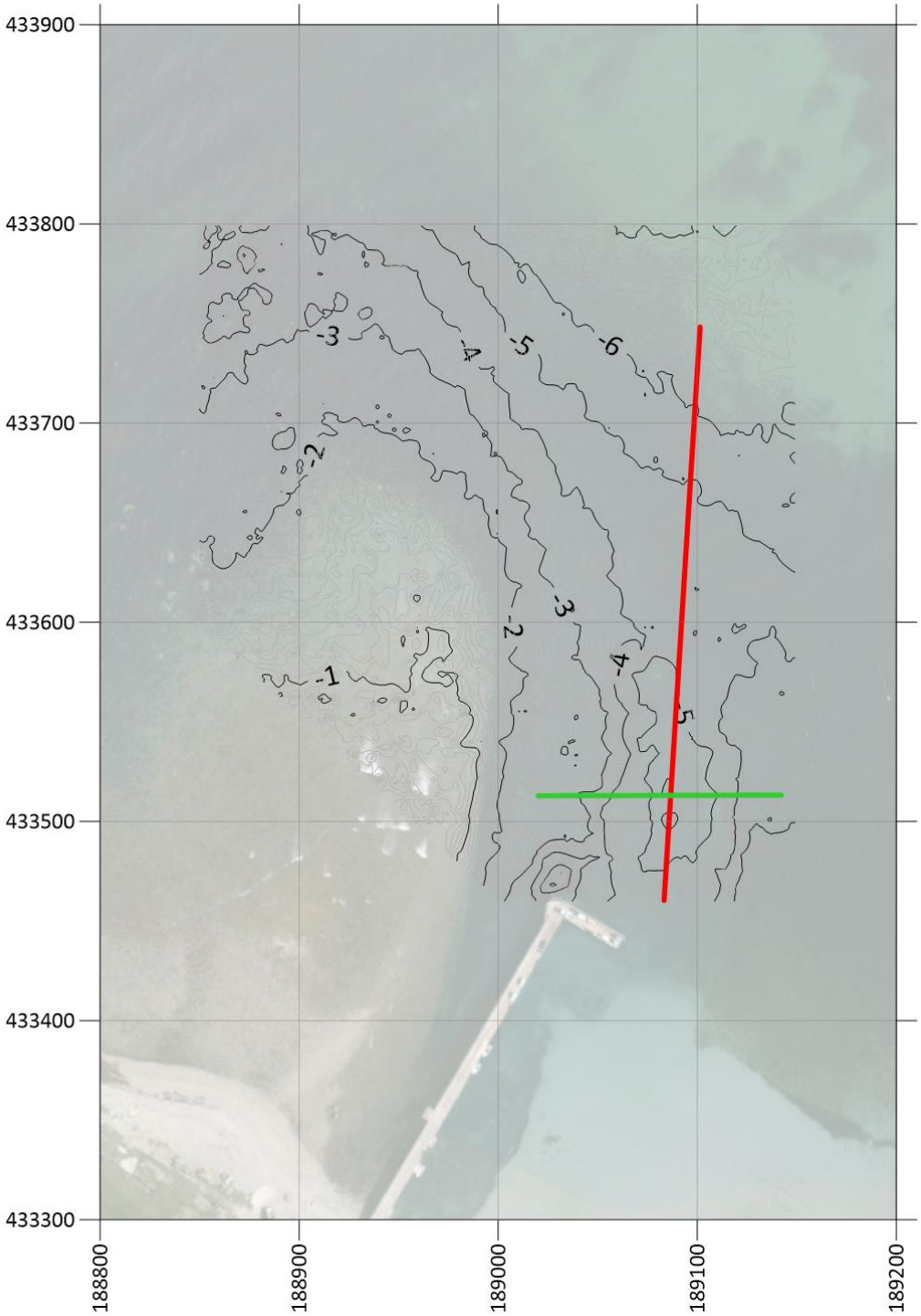


Figure 6. Arbitrary egress route

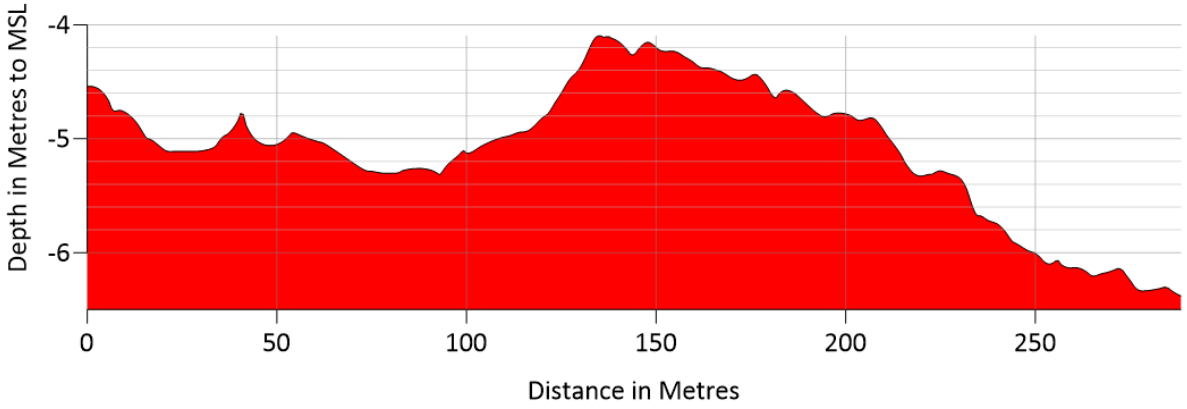


Figure 7. North-south profile following optimal egress route

As shown in Figure 7, the approach channel is generally better than -5m to MSL for 100m north of the pier. This shallows abruptly at c. 433580 to c. -4m to MSL for c. 100m further north.

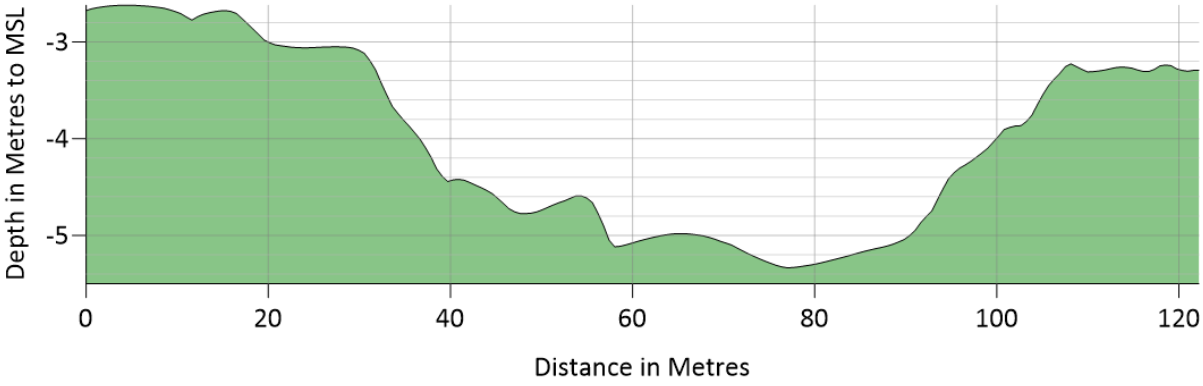


Figure 8. East-west profile showing an arbitrary cross section.

As shown in Figure 8, the approach channel is generally better than 50m in width to c. 433580.

A family of profiles is provided along the length of the survey area in the accompany Side-Scan Survey Report.

5.4 Bottom hardness

Figure 9 details the bottom hardness, and it is indicative rather than definitive. Bottom hardness assessment is a percentage value from minimum to peak based on:

- SV, the strength of the sonar return as it is reflected off the bottom.
- E1 derived from the sonar returns that immediately follow the peak return of the first echo return. This value is commonly referred to as roughness or rugosity and is a measure of the roughness of the bottom.
- E2 is derived from the full second echo return of the bottom.

The yellow contours mark areas of hardness above 80% and generally correspond to areas of rock, boulders, cobbles and gravel, red contours are typically sand or silt. These areas will be definitively zoned in the accompanying side scan survey report.

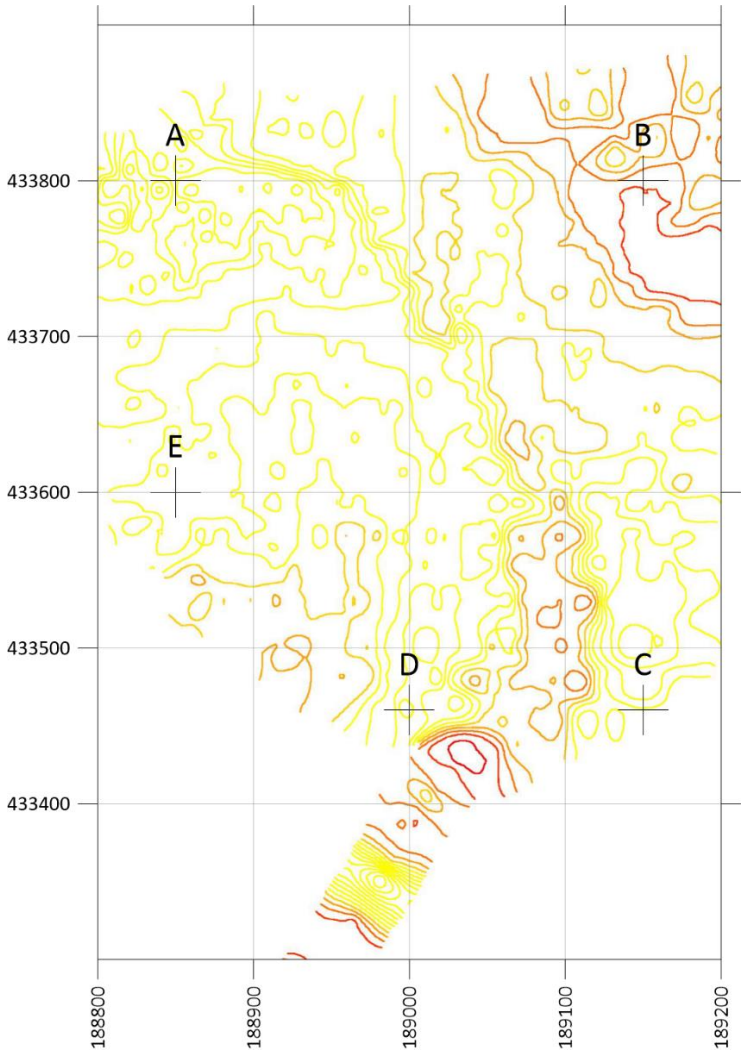


Figure 9. Bottom hardness contours

Between survey area posts C and D, a soft area is presented with relative hardness c. 70%, broken by a bar at 433500, 189100, this closely corresponds to the -5m contour of Fig. 4 and 5, which correspond with the approach channel.

Around survey area post B, a soft area is presented with relative hardness c. 50-70%.

5.5 Three-dimensional view

The topography of the area may better be presented using a three-dimensional view as shown in Figure 10. This view is looking into the approach channel from the south east. The natural approach channel is clearly visible c. 160m north of the pier.

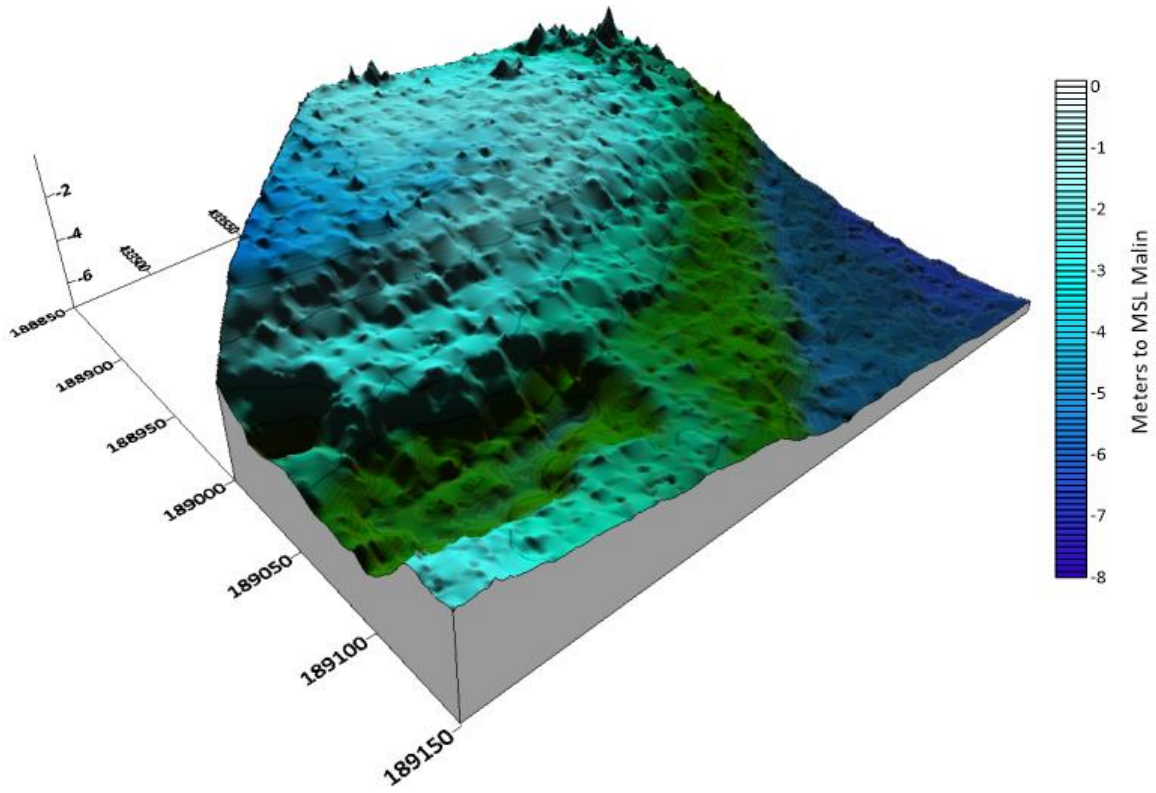


Figure 10. A 3D view from south-east with Z axis exaggerated

References

[1] Admiralty Tide Tables NP201-03

[2] Admiralty Chart 2752