Titan Environmental Surveys Limited
A GARDLINE COMPANY

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Titan Environmental Surveys Limited

A GARDLINE COMPANY

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ABBREVIATIONS

DGPS	Differential Global Positioning System
DPR	Daily Progress Report
ETRS89	European Terrestrial Reference System 1989
GPS	Global Positioning System
HW	High Water
IHO	International Hydrographic Organisation
kHz	Kilohertz
MBES	Multibeam Echosounder
MCA	Maritime and Coastgaurd Agency
ODN	Ordnance Datum Newlyn
OSGB36	Ordnance Survey Great Britain 1936
OSTN15	Ordnance Survey Transformation 2015
PPK	Post-Processed Kinematic
QA	Quality Assurance
QC	Quality Control
RMS	Route Mean Square
RTK	Real Time Kinematic
SBAS	Satellite-based Augmentation System
SBP	Sub-Bottom Profiler
SSS	Sidescan Sonar
SVP	Sound Velocity Profiler
SVS	Sound Velocity Sensor
TBC	Trimble Business Centre
TPA	Thermal Protective Aid
TQA	Titan Quality Assurance
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
VDU	Visual Display Unit
VRS	Virtual Reference Station

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1. Executive Summary

This report, *CS0590_Aberaeron_Geophysical_V1*, details the results of the survey operations undertaken by MV Titan Surveyor from 26th – 29th November as part of an investigation covering the site for a potential breakwater. The Titan Surveyor was tasked with collecting bathymetry, side scan sonar, boomer, and magnetometer data across the site subject to vessel manoeuvrability, as well as over the proposed breakwater location. Full data coverage was achieved in the nearshore area and each instrument was run on every line, except the crosslines which did not include magnetometer. Within the entrance to the inner harbour, just multibeam, side scan and boomer were collected as it was not safe or practical to tow the magnetometer. Further within the inner harbour, only multibeam was collected due to the close proximity of mooring buoys. From the collected data a 1.0m multibeam xyz was produced as well as sonar and magnetometer contact lists. Five different charts were created to display bathymetry contours, shaded relief, seabed features and an interpreted geological profile of the breakwater location. Seabed sediments are interpreted to comprise of gravel and cobbles associated with glacial till across much of the offshore section in the west of the site. Within the vicinity of the harbour and proposed breakwater, seabed sediments are interpreted to predominantly comprise of gravels and silty sand. A total of fourteen objects are interpreted at the seabed on the side scan sonar data; thirteen of these are interpreted as boulders and one as linear debris. Across much of the survey area, an intermittent veneer of fine sand is present and underlying this surficial veneer, glacial till is interpreted comprising clay, sand, gravel, and boulders. Acoustically the till is seismically chaotic with numerous internal events. Penetration into this till is limited, assumed to be because of the consolidated nature of the material.

2. Introduction

2.1 General

In October, Titan Environmental Surveys Ltd (Titan) was commissioned by Quantum Geotechnics to conduct a geophysical survey at the entrance to Aberaeron harbour and the tidal basin within the inner harbour. The survey is part of an investigation covering the site for a potential breakwater intended to protect the installation of a possible lock gate.

2.2 Scope of Work

Under the conditions set out by Quantum Geotechnics the following tasks were requested to be carried out:

- Full Bathymetry coverage – MBES Interferometric
- Full Sonar coverage - SSS (Subject to vessel manoeuvrability and safe working)
- Sub-bottom Profiles (Subject to ground conditions)
- Magnetometer (Subject to vessel manoeuvrability and safe working)
- Breakwater SBP Profile (Subject to ground conditions)

The survey area defined by Atkins (in document *5182114-ATK-MAR-GEN-DR-GE-2122.pdf*) is provided in Table 2.1.

Table 2.1 Survey Area Co-ordinates provided in Ordnance Survey

	Easting	Northing
A	245245	262776
B	245010	262940
C	245524	263543
D	245839	263357
E	245480	263121
F	245688	262873
G	245648	262832

2.3 Survey Achievement

To complete the survey within the boundary provided by the client the area was divided into two sections, the inner harbour and nearshore area as defined in Figure 2.1.

Figure 2.1 Overview of nearshore area, inner harbour area and line plans

2.3.1 Nearshore Area

Titan achieved full data coverage of the survey area where it was safe to do so.

- Mainlines - 50m line spacing with an orientation of 40° (Shore parallel) - Full Geophysical setup (MBES, SSS, SBP and Magnetometer) with an orientation of 40°
- Infill lines - 25m line spacing with an orientation of 40° (Shore parallel) – Surveyed with MBES and SSS to ensure coverage
- Additional MBES Infill - Additional MBES lines were run to achieve full bathymetry coverage due to the shallow water depths, North of the Aberaeron harbour entrance
- Crosslines (100m line spacing at an orientation of 130°). Surveyed with MBES, SSS and SBP

Crosslines were run without the magnetometer deployed. To avoid magnetic interference with the vessel it is necessary to tow the magnetometer 30m aft of the vessel therefore, this significantly reduces the vessel's turning circle. During operations onsite it was deemed unsafe to approach the shoreline with the reduced turning circle, so the crosslines were collected with MBES, SSS and SBP only.

2.3.2 Inner harbour

Titan achieved full data coverage of the survey area where it was safe to do so but this was limited in the inner harbour.

The survey area around the entrance and inner harbour was too tight to be able to safely perform line turns whilst towing a magnetometer with a minimum tow length of 30m. Therefore, only one line with the magnetometer deployed was run into the inner harbour. The magnetometer was recovered as quickly and safely as possible once inside the harbour to allow the vessel to turn.

With the magnetometer recovered, survey lines were run in and out of the inner harbour covering the entrance with MBES, SSS, and SBP until the safe working limit of the vessel had been reached.

The profile line along the proposed seawall was collected without the magnetometer. This allowed the vessel to collect more SBP data along the entire proposed sea wall route, without having to turn away early due to the constraints of towing a magnetometer.

To be able to safely carry out any data collection further into the harbour, adjacent to the mooring buoys the SSS and SBP were recovered. At the top of the spring tide, several attempts were made to survey further into the harbour with only the MBES deployed on a best endeavours approach. However, due to the spacing and density of the trot mooring buoys, the strong river flow making steerage difficult, and the very shallow depths (~2m on a HW spring), it was deemed unsafe to continue and limited additional coverage was achieved.

2.4 Reporting

This report details the operations and results of the survey carried out 11/11/2020 – 29/11/2020; including details of instruments and methods adopted for the survey, calibration/verification of equipment, processing techniques and an assessment of data quality. A full list of deliverables has been provided in Appendix A.

2.5 Personnel

The key personnel throughout the project have been outlined in Table 2.2.

Table 2.2 Key Personnel

Name	Proposed Position	Responsibilities
Management		
Malcolm Houston	Managing Director	• Commercial Contract Overseer
Matt Ireson	Project Manager/ Lead Surveyor	• Overall management of the project • Point of contact for employee personnel • Client liaison • Responsible for technical conduct of survey alongside the Party Chief • Detailed planning and preparation for fieldwork • Technical Support • Appointment of Party Chief and surveyors • Responsible for technical conduct of survey alongside the Party Chief/Project Manager
Office Staff		
Fred Dulley	Project Reporting Coordinator	• Overseer of data management • Finalisation of Interferometric MBES data • Final QC of data deliverables • Compilation of final reports
Mike Kingston	Principal Geophysicist	• QC of geophysical data
Field Staff		
Geraint Jones	Skipper	• Responsible of the overall safety of the vessel • Responsible for undertaking pre-sail vessel safety briefing and checks • Responsible for undertaking project safety meetings and toolbox talks • Responsible for ensuring all crew are aware of all relevant SSOW for the work in hand • Responsible for any decisions related to vessel safety, i.e., decide whether it is safe to work in current weather conditions
Matt Ireson	Party Chief	• On-site client liaison • Production and distribution of the DPRs • Oversee the performance, QC and management of vessel-based operations and onshore processing
Kyle Jones	Surveyor	• Responsible to undertake day-to-day surveying (under supervision of Party Chief)

3. Survey Operations

3.1 Vessel

Table 3.1 gives details of the MV Titan Surveyor.

Table 3.1 MV Titan Surveyor Vessel Specification

MV Titan Surveyor

Flag	British
Class	MCA Small Commercial Vessel (SCV) Cat 3: 20 miles from safe haven
Year Built	1998
Length	7.9m
Breadth	2m
Draught	0.8m
Speed	10 knots dependent on load
Survey	Over the side mounts Port and starboard tow arms Equipment towed alongside
GSM	+44 (0) 7884 068449
Email	Titan.Surveyor@titansurveys.com
Call Sign	MXIA7
MMSI	235000852

3.2 Summary of Operations

A summary of the principal survey activities is given in Table 3.2. A detailed description of the daily activities was presented as Daily Progress Reports during operations, copies of which were submitted to all relevant parties.

Table 3.2 Summary of Survey Activity

Survey Day	Date	Activity
1	11/11/2020	Travel to Aberystwyth. Commence mobilisation of Titan Surveyor.
2	12/11/2020	Continued survey mobilisation. Radar system replaced.
3	13/11/2020	Final mobilisation, full system check. Stand down, travel back to South Wales.
4	21/11/2020	Travel to Aberystwyth, standby port.
5	22/11/2020	Depart port but conditions found to still not be good enough. Decision to stand down and travel back to South Wales.
6	25/11/2020	Travel to Aberystwyth, standby port, project meeting.
7	26/11/2020	Operational
8	27/11/2020	Operational – Patch test (Roll lines), Survey operation at Aberaeron were cancelled due to the man overboard incident and the potential risk of Hypothermia.
9	28/11/2020	Operational – Infill
10	29/11/2020	Operational – Aberaeron survey work completed. Patch Test (Pitch Lines)

A summary for each code reflecting the final project timings as per the last DPR is presented in Table 3.3.

Table 3.3 Project Timings Summary

Project code	Time (hours)
Mobilisation	40:50
Full Geophysical Survey	25:11
Full Geophysical Survey – Infill	03:30
Full Geophysical Survey - Crossline	01:14
Stand down	19:00
Standby – Sea	02:50
Standby – Port	28:05
Total	120:40

3.3 Health, Safety and Environment

3.3.1 Health and Safety

All work was carried out in accordance with Titan's Health and Safety Policy. Prior to survey operations, all personnel joining the vessel were given a comprehensive safety briefing by the vessel skipper. This briefing included a detailed description of the survey work to be undertaken, all health and safety procedures aboard the vessel, and a demonstration of all safety equipment on board and its relevant location.

Health and safety toolbox meetings were conducted and recorded to discuss specific issues associated with the vessel or survey. There were twelve in total for the Titan Surveyor.

Any health and safety observations, incidents and technical faults are recorded on digital GL30a Observation Cards as part of Gardline Group's safety framework. Any safety incidents would be subsequently reviewed and assessed by Titan's management team and Gardline' Health and Safety department. Three GL30a cards were submitted during the project duration.

A brief description of each GL30 for vessel ops is in Table 3.4.

Table 3.4 GL30 summary - Vessel Operations

GL30 title	Date	Observation Type	What Happened?
Crew member overboard	27/11/2020	Health & Safety	Whilst trying to move to the bow of the vessel to recover the tangled hydrophone equipment. Crew member MI missed his footing while walking down the side of the vessel and slipped into the water. Life jacket automatically set off. Sea state was flat calm, and vessel was stationary at the time. Crew members instantly offered him support and helped pulled MI from the water using the MBES mount as a stepping platform. Clothes were removed and MI was placed in a TPA. It was then decided to place MI in an immersion suit. Plans for survey operations at Aberaeron were called off for the day in case hyperthermia. Vessel returned to Aberystwyth carrying out a recce of MBES patch location on the way.
Fishing line caught on Starboard Engine	27/11/2020	Vessel	Running one of our last Bathy lines very close to the shore, we failed to notice an angler fishing in close proximity. This resulted in his line getting caught by our vessel with a small amount later found to be wrapped around the starboard propeller. At the time of the incident, we came back around and apologised to the man for the inconvenience, and he allowed us to then complete our last nearshore line.
Surveyor elephant trunk detachment	29/11/2020	Vessel	During transit to the calibration site the starboard elephant trunk became detached. When we had got to site and slowed down this resulted in water ingress onto the back deck (about 4 inches). This had to be fixed to stop further water ingress, and the water had to be bailed out by hand.

3.3.2 Environment

Titan recognises the increasing importance of environmental issues. Consequently, great store is laid upon the protection of the environment with regard to all our operations. In addition to our Health and Safety Organisation, environmental considerations have been incorporated into our daily operations.

During this project:

- Field Staff complied with all relevant local, national, and international environmental legislation, which impinged on survey activities.

- All attempts were made to prevent / minimise pollution through; recycling of paper waste and printer cartridges; disposing of waste in a responsible manner; reducing energy use; encouraging the efficient use of transport fleet to both optimise the utilisation of fuel and minimise emissions to the environment.

4. Reference Control

4.1 General

All times quoted in this report are in Coordinated Universal Time (UTC), units of measurements refer to the metric system and all co-ordinates are referred to OSGB36 OSTN15. The vertical datum of acquired data is referred to OSGM15.

4.2 Horizontal Control

Primary positioning was achieved using a SPS751 operating in RTK mode with live corrections from NTRIP VRS Now. Data was received in ETRS89 and was transformed to OSGB36 using the OSTN15 transformation. For details on the geodetic parameters of the project, see Table 4.1 and Appendix B.1.

In addition, positioning of swathe data has been enhanced by post processing data using a PPK tide file to improve positional and attitude data.

A Hemisphere VS130 was used as a secondary navigation, operating in SBAS mode to provide real-time dynamic comparisons and quality control (QC) of the primary navigation.

Table 4.1 Project Geodetic Parameters

<table>
<tr><td rowspan="3">Navigation System Datum</td><td rowspan="3">ETRS89</td><td>Semi-major axis</td><td>6378137</td></tr>
<tr><td>Semi-minor axis</td><td>6356752.3142</td></tr>
<tr><td>Flattening (1/f)</td><td>298.25722356301</td></tr>
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<tr><td>Semi-minor axis</td><td>6356256.910</td></tr>
<tr><td>Flattening (1/f)</td><td>299.320</td></tr>
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<tr><td>Central Latitude</td><td colspan="2">49° North</td></tr>
<tr><td>Central Longitude</td><td colspan="2">2° West</td></tr>
<tr><td>False easting</td><td colspan="2">-100000</td></tr>
<tr><td>False northing</td><td colspan="2">400000</td></tr>
<tr><td>Scale factor</td><td colspan="2">0.9996</td></tr>
<tr><td rowspan="7">Datum Transformation</td><td>Rotation X (secs)</td><td colspan="2">0</td></tr>
<tr><td>Rotation Y (secs)</td><td colspan="2">0</td></tr>
<tr><td>Rotation Z (secs)</td><td colspan="2">0</td></tr>
<tr><td>Scale Factor (ppm)</td><td colspan="2">0</td></tr>
<tr><td>Translation X (m)</td><td colspan="2">0</td></tr>
<tr><td>Translation Y (m)</td><td colspan="2">0</td></tr>
<tr><td>Translation Z (m)</td><td colspan="2">0</td></tr>
</table>

4.3 Vertical Control

All bathymetry data has been reduced to ODN using the OSGM15 geoid.

5. Equipment Details and Methods

5.1 Geophysical Survey Spread Summary

Table 5.1 Summary of Navigation and Survey Equipment

Summary of Navigation and Survey Equipment		
Integrated Navigation Software		QPS QINSy 9
Primary Navigation		Trimble SPS 751 with RTK corrections from VRSNow
Secondary Navigation		Hemisphere VS130
Heading		Hemisphere VS130
Single Beam Echosounder		Odom Hydrotrac
Multibeam Echosounder		Kongsberg Geoswathe GS4
	Motion Sensor	Teledyne DMS-05
	Sound Velocity Sensor	Valeport Miniature Sound Velocity Sensor
	Sound Velocity Probe	Valeport SWiFT Sound Velocity Profiler
Sidescan Sonar		Edgetech FS4200 100/400kHz
Sub-Bottom Profiler		AA CSP300 Bang Box and Applied Acoustics 20 Element Hydrophone AA 202 Boomer Plate
Magnetometer		Geometrics G882 Caesium Vapour

5.2 Calibration and Verification

A series of calibration and verifications were undertaken during the mobilisation and during the survey, which have been summarised in Table 5.2. Full details on all tests can be seen in the relevant appendices.

Table 5.2 Calibration documents

Calibration/Verification	Date Undertaken	Reference Document	Appendix
Vessel Offset Diagram	12/11/2020	FRM_TQA042_Vessel Offset Diagram	B.2
Static Navigation Verification	12/11/2020	FRM_TQA017a_Navigation Verification	B.3
Survey Navigation Comparison	26/11/2020 – 29/11/2020	FRM_TQA017c_Survey Navigation Comparison	B.4
Heading Verification	12/11/2020	FRM_TQA038_Gyro Verification	B.5
MBES Patch Test	29/11/2020	FRM_TQA035b_GeoAcoustics Swathe Calibration	B.6

5.2.1 Sidescan Sonar Rub Test

An Edgetech FS4200 Dual Frequency 100/400kHz SSS was mobilised onto the MV Titan Surveyor for survey operations. SSS rub test was carried out on 13/11/2020 to ensure all transceivers were operational. The results of the rub test can be seen in Figure 5.1.

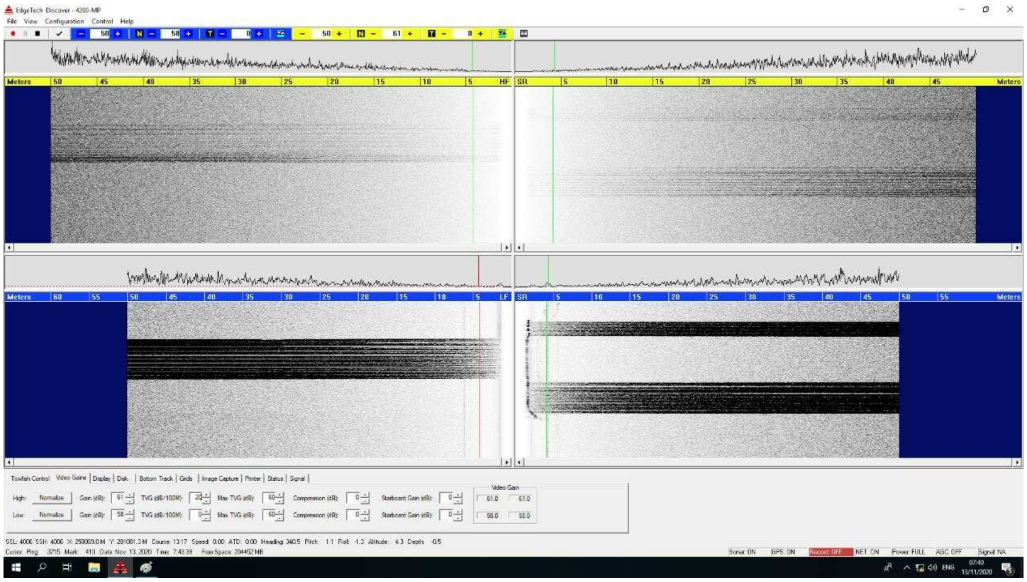


Figure 5.1 SSS rub test verification

5.2.2 Sub-bottom Profiler Verification

An SBP verification line was run offshore of the survey area to prove the system was operating correctly. The horizon below the surface horizon disappears the closer the vessel moves towards the shoreline where the seabed is formed by hard constituents. The results of the verification can be seen in Figure 5.2.

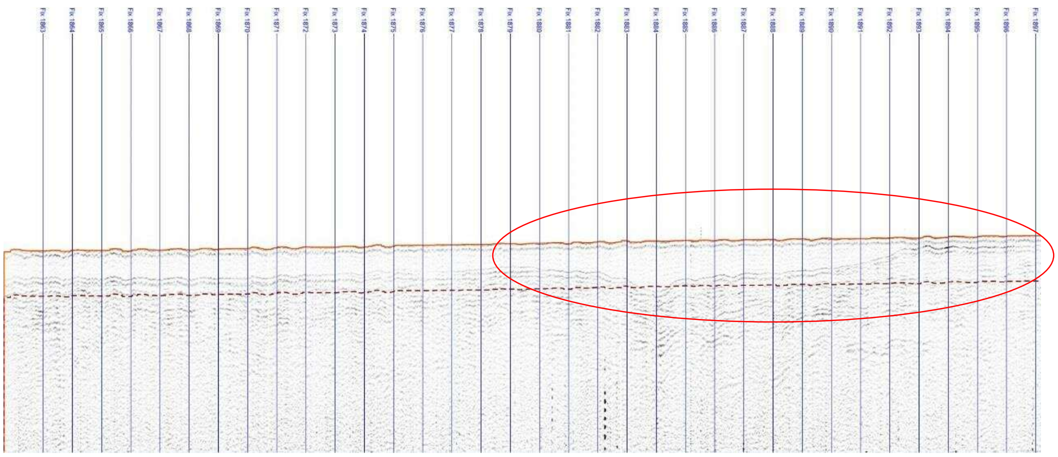


Figure 5.2 SBP Verification over a geological feature

5.3 Integrated Navigation and Data Acquisition System

Titan Surveys uses QPS QINSy for the acquisition and logging of position, heading, bathymetry, attitude, tide sources, quality control information and updating of real-time data and navigational displays. QINSy works with standard RS232 data transfer via NMEA. Real time navigation and event information can be exported to external sensors. All the raw and computed data is time tagged with a PPS signal to eliminate real time system latency.

The system is also able to graphically represent quality control information such as delta east, delta north, PDOP, HDOP, differential age and sensor profiles to allow the surveyor to monitor the incoming sensor information and review its quality for survey operations. System warnings can also be setup based on a traffic light system, to alert the surveyor to potential equipment problems.

QINSy has a Survey Manager tool which allows the user to create survey run lines, routes or targets and once combined with positional, heading and velocity information can display the vessels position relative to a pre-determined guidance object. Together with distance and track data on a helmsman's VDU for efficient vessel steering and guidance.

The system's flexible operation allows for multiple steer-by nodes, allowing guidance of several towed instruments to different guidance objects. All logged data within QINSy navigation can be subsequently accessed within the QPS Replay component for post survey analysis and exporting.

5.4 Primary Navigation

A SPS751 was used as the primary navigation system during survey operations. The system was configured to receive RTK corrections from NTRIP VRSNow for the duration of the survey. The system provided real-time comparisons with secondary navigation for QC purposes. Post processing of the data was available for a tidal elevation comparison.

Table 5.3 Trimble SPS751: Technical Specification

Channel	72 Channel L1 C/A code
Horizontal Accuracy	8 mm +0.5 ppm RMS (RTK VRS)
Vertical Accuracy	15 mm +0.5 ppm RMS (RTK VRS).
Precise Heading	0.09° (2 m antenna spacing)
Initialization time	Typically <10 seconds >99%

5.5 Heading and Secondary Navigation

A Hemisphere Crescent VS130 DGPS system was used as the secondary navigation system during survey operations. The system was configured to receive SBAS for the duration of the survey. The GPS differential antenna was in a separate housing linked to the receiver and was configured to receive differential corrections from a specific frequency within the high frequency band. The system provided real-time comparisons of the primary navigation for QC purposes.

Table 5.4 Hemisphere Crescent VS130 DGPS System: Technical Specification

Horizontal Accuracy	<0.60 m 95% confidence (DGPS)
Heading Accuracy	<0.15° RMS (1.0 m antenna separation)
Pitch/Roll Accuracy	<1.00° RMS (0.5 m antenna separation)

5.6 Multibeam Echosounder

The GeoSwath Plus system used to collect bathymetry data was operated at 250 kHz, meeting IHO Special Order specifications whilst using a swath width up to 6 times water depth. The system comprised of two transducers, a processing unit and an operating station. The transducers were mounted to -plate’ frame alongside a miniature sound velocity sensor (mini-SVS) and a miniature altimeter, which was then deployed through a central moon-pool on the vessel.

During acquisition, real-time swath bathymetry data was viewed as a plan display to show the extent of coverage. The GeoSwath Plus system is interfaced to a GeoSwath 4 acquisition system that records all swathe data collected in a RAW format, as well as navigation from the primary system, data from the mini-SVS and attitude data from the mini altimeter, all in real-time.

Table 5.5 Kongsberg GS+ MBES System

Frequency	250 kHz
Swathe Update Rate	30 swath/second
Resolution	0.003 m
Slant Range Resolution	0.05 m
Two-way Beam Width	0.75° Azimuth

The TSS Dynamic Motion Sensor MRU unit was mounted directly over the bathymetric system to reduce the offset for lever arm corrections. The heave, pitch and roll values were recorded within the bathymetric acquisition system and used in real-time to correct the swathe data. To improve dynamic performance, the unit was provided with position, heading and velocity data directly from the Hemisphere VS130 secondary positioning system.

5.6.1 Sound Velocity Sensor

A Valeport Miniature Sound Velocity Sensor was mounted onto the bathymetry system to record continuous real-time sound velocity. The values from the sensor were applied directly into the bathymetry user interface. Specifications for the unit can be found in Table 5.6.

Table 5.6 Valeport Miniature Sound Velocity Sensor: Technical Specifications

Velocity Range	1400 ms^{-1} – 1600 ms^{-1}
Velocity Resolution	0.001 ms^{-1}
Velocity Accuracy	±0.06 ms^{-1}

5.6.2 Sound Velocity Profiler

A Valeport SWiFT Sound Velocity Probe (SVP) was deployed to record vertical sound velocity profiles through the water column and as quality control against the transducer mounted mini-SVS. The unit was a self-recording/direct reading instrument, which allowed readings to be taken at set depth intervals of 0.25m. The data was downloaded as text files and uploaded into Geoswathe. The unit specifications can be seen in Table 5.7.

Table 5.7 Valeport SWiFT Sound Velocity Profiler: Technical Specifications

Velocity Range	1375 ms^{-1} – 1900 ms^{-1}
Velocity Resolution	0.001 ms^{-1}
Velocity Accuracy	±0.02 ms^{-1}
Pressure Range	200 dbar
Pressure Resolution	0.001% FS
Pressure Velocity Accuracy	±0.05% FS Range

5.7 Sidescan Sonar System

Seabed mapping was achieved using an Edgetech 4200-FS SSS, which provided both full spectrum and multi-pulse technologies into one unit. The system comprised of a portable topside processor running Edgetech Discover software, a communications cable and tow rope/data tow cable and a tow fish. The system operated dual simultaneous frequencies at both 100 kHz and 400 kHz in high-definition mode (HDM) and recorded the data for both frequencies simultaneously.

The SSS fish was towed on the starboard midship of the vessel. Layback was calculated manually with the real time nav being applied as an offset from QINSy. Digital data was recorded with a fish position provided via QINSy using the software towline estimation utility.

Annotations to the digital record were provided automatically from QINSy at 20 second intervals and included details of the fix number, time and line name. The dual frequency sonar data was recorded digitally in the 4200-FS data Discovery computer. SSS data was recorded in both JSF (Discovery Proprietary Software) and XTF formats.

Table 5.8 Edgetech 4200-FS SSS: Configuration

Frequency	100/400 kHz
Layback	Alongside Tow
Range	50 m

5.8 Sub-bottom Profiler

The AA Surface Tow Boomer system was used to collect sub-bottom profile data. The transmitter array comprised a capacitor bank, tow cable and catamaran containing the boomer plate. The receiving array consisted of a hydrophone that was input to the acquisition and processing module. The boomer and hydrophone were deployed in a catamaran float alongside the vessel, with no layback. Fix marks and navigation were input into the acquisition system from QINSy 9 in real-time. The data was recorded in RAW SEG-Y format within the sub-bottom acquisition system.

Table 5.9 AA Boomer: Configuration

Fire Rate	250 msec
Power	100 %
Frequency	0.9 – 4.5 kHz

5.9 Magnetometer

Titan operated a Geometrics G882 Magnetometer on the vessel, which is a self-oscillating split beam Caesium vapour magnetometer. The instrument was towed on a soft tow cable to avoid interference from the vessel and was positioned by manual layback. A magnetically inert surface float was added to the magnetometer so sufficient instrument layback could be maintained in shallow water.

The magnetometer system collected data through 4 channels; Channel 0, magnetometer data; Channel 1, signal strength; Channel 2, depth; Channel 3, altimeter. The data was recorded digitally by QINSy, which applied all offsets and layback as well as fixes and positioning data.

Table 5.10 Geometrics G-882 Caesium Magnetometer: Configuration

Operating Range	20,000 to 100,000 nT
Absolute Accuracy	<3 nT throughout range
Heading error	±1 nT (over entire 360˚ spin and tumble)
Layback	30 m

6. Data Processing

6.1 Post Processed Kinematic Tide

Titan processed observed tidal heights from the SPS system using Trimble Business Centre (TBC) to derive a PPK tide, which was later used to reduce bathymetry data to the specified vertical datum.

VRSNow Rinex Virtual Reference Station (VRS) for the survey day was downloaded for processing. VRS was downloaded for the following position:

- 52.2428°N, 4.26217°W

TBC was used to combine the VRS data with the rover location in post-processing, providing accurate co-ordinates of the survey vessel at 1 second intervals. The derived GPS antenna elevation data was to OSTN15 and reduced to OSGM15. The GPS antenna height above the water surface was accurately calculated by total station measurement.

Derived tidal elevations were smoothed using a spline smoothing routine within Titan' - house tidal processing software, Turtle. The tidal elevations were quality controlled through comparisons against predicted tides for the following locations:

- Aberporth
- Aberystwyth
- New Quay

The processing workflow is outlined in Figure 6.1.

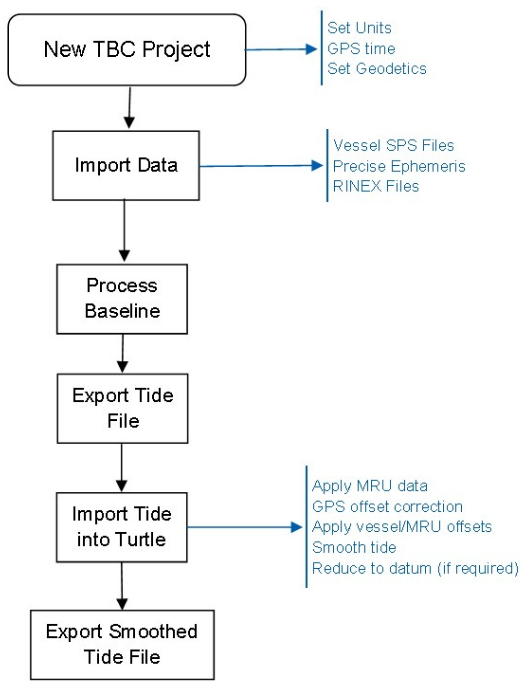


Figure 6.1 PPK Processing workflow

6.2 Bathymetry Processing

GeoSwath 4 (GS4) processing package was used to process the swathe bathymetry data collected. The package provided a complete project-based solution for the GeoSwath Plus sonar system, which allowed data acquisition, storage, calibration, data cleaning processing, and gridding for final exports.

Within GS4, the RAW bathymetry data had all offsets applied, as well as calibration values for heave, pitch and roll. 1PPS time correction was applied to remove any latency in the system. Sound velocity profiles taken throughout the survey day were imported, to correct for temporal and spatial changes in the water column.

The data was reduced to ODN by applying a smoothed tide export that was post-processed in TBC and Turtle.

Sound velocity profiles were applied to the data before processing to correct for changes in sound velocity within the water column. Sound velocity was largely uniform outside of the harbour but changed rapidly on entering the harbour due to freshwater input of the Afon Aeron. This had a significant effect on bathymetry data collected within the harbour which resulted in the characteristic 'smiles' in the data shown Figure 6.2. This was corrected for within GS4 software.

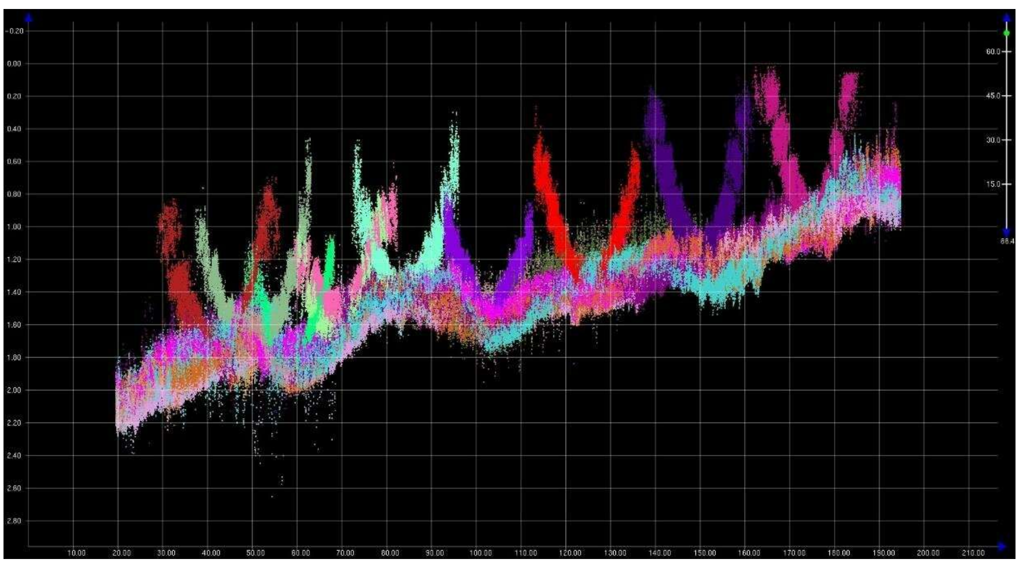


Figure 6.2 Inner harbour bathymetry data relative to the outer harbour bathymetry

A mixture of amplitude, limits, along and across track filters were applied to process the bathymetry data. The data was finalised and exported from GS4 processing software.

6.3 Sidescan Sonar Processing

GeoFusion software package was used to interpret and process the side scan sonar data.

Within GeoFusion the side scan sonar data had corrected seabed tracking, corrected navigation, heave, pitch, roll and time variable gains applied. These features aided the interpretation and exporting of seabed features, contacts and a sonar mosaic.

Each side scan sonar line is interpreted separately and added to a total project for final processing. GeoFusion allows the user to adjust line orientation, cross reference against external and internal data sets (such as geotechnical logs, known man made features) and apply filters for sonar mosaicking.

Upon completion data sets are exported as a combination of .csv, .xyz, .shp and .tiff files to the specified bin sizes required for charting.

Titan has a vigorous Quality Control (QC) and Quality Assurance (QA) process to ensure that at all stages of processing and charting the correct steps have been taken and key information is recorded. During data processing Titan Quality Assurance (TQA) forms are filled out as part of our workflow

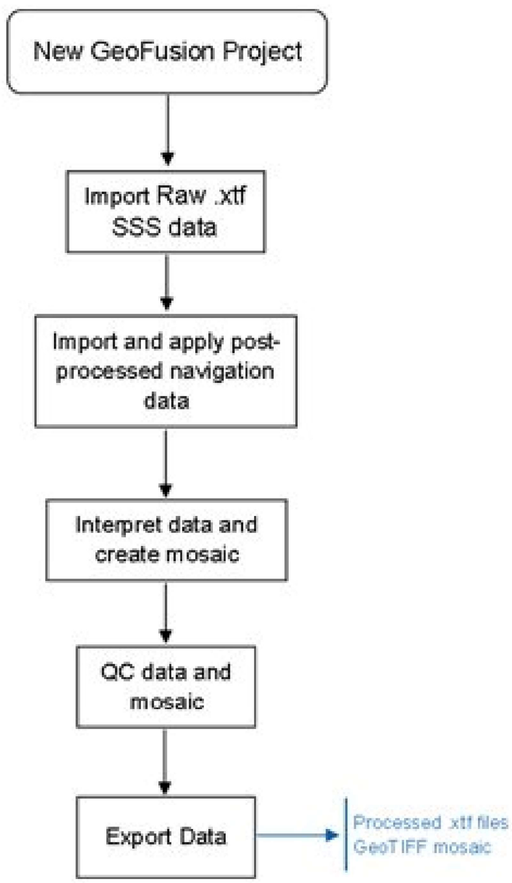


Figure 6.3 Sidescan sonar interpretation Workflow

6.4 Sub-Bottom Processing

GeoFusion software package was used to interpret and process the seismic data.

Within GeoFusion the seismic data had seabed tracking and time variable gains applied. These features aided the interpretation and exporting of sediment horizons, diffractions, and faults.

Each seismic line is interpreted separately and added to a total project for final processing. GeoFusion allows the user to adjust line orientation, cross reference against external and internal data sets (such as geotechnical logs, known man made features) and apply filters for sonar mosaicking.

Upon completion data sets are exported as a combination of .csv, .xyz, .shp and .tiff files to the specified bin sizes required for charting. Charting and visualisation of data is undertaken in a variety of software packages, including ArcGIS.

6.5 Magnetometer Processing

Magnetometer data was exported from QINSy and passed through an in-house macro to provide an initial QA/QC check on the data. The data imported into GeoSoft Oasis Montaj software where it was analysed and edited within following the workflow outlined in Figure 6.4. Targets were automatically picked using the Blakely method and then reviewed and edited accordingly. All targets were cross referenced with MBES and SSS targets to aid identification.

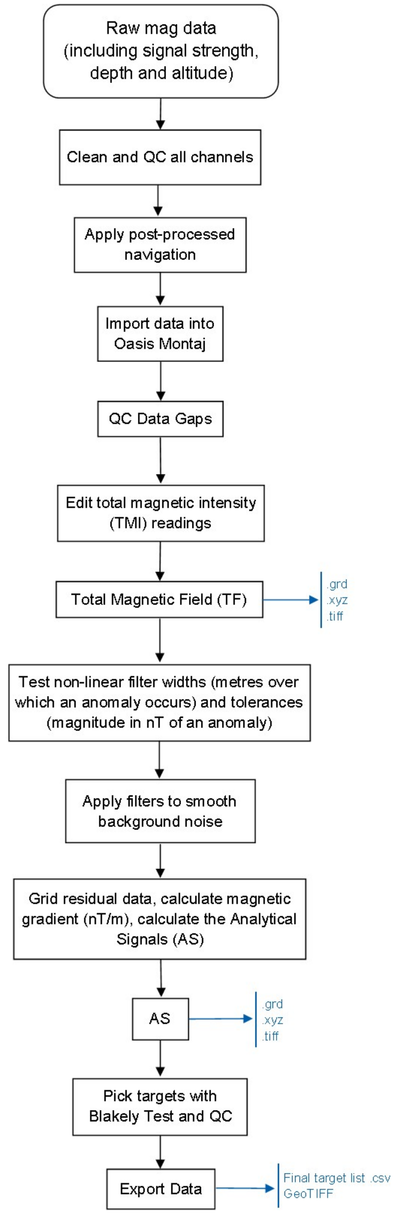


Figure 6.4 Magnetometer Processing Workflow

6.6 Anomaly Identification

6.6.1 Magnetometer

Magnetometer targets were manually picked within Oasis Montaj and using the Blakely test. A Blakely threshold of 0.5nT/m was chosen across the site. Targets were then manually removed or added if deemed appropriate based on their strength and correspondence to a MBES/SSS anomaly.

7. Results

7.1 Multibeam Bathymetry

Full MBES coverage was achieved up to the safe working limits of the vessel (around 2m in-situ water depth). Within the survey area, water depths vary from 6.6m ODN in the west to <0.2m ODN adjacent to the beach in the east. The seabed shoals towards the beach with a gradient generally <1°. More significant gradients are present, associated with both the interpreted till at seabed, as well as surficial accumulations of fine sand. Locally gradients exceed 15°. The proposed breakwater traverses these accumulations of fine sand; gradients on their flanks in the vicinity reach 10°.

Within the harbour water depths are in the order of 1m ODN.

Figure 7.1 shows the full extents of MBES coverage relative to the survey area, and to the shoreline/inner harbour.

Figure 7.1 Multibeam coverage overlay

Seabed features were picked up well by the Geoswathe system, further seen in Figure 7.1 and Figure 7.3, where nearshore groynes in the southern nearshore of the survey area, and a pipeline outfall can be seen to the northeast of the survey area respectively.

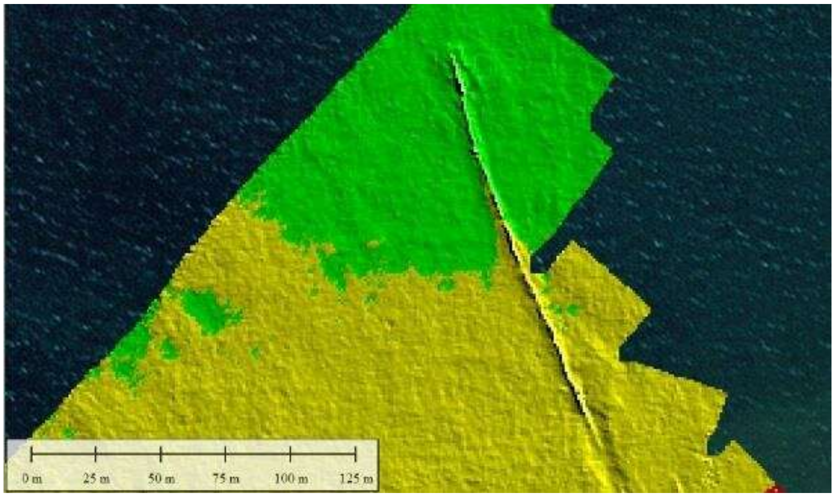


Figure 7.2 Pipe Outfall

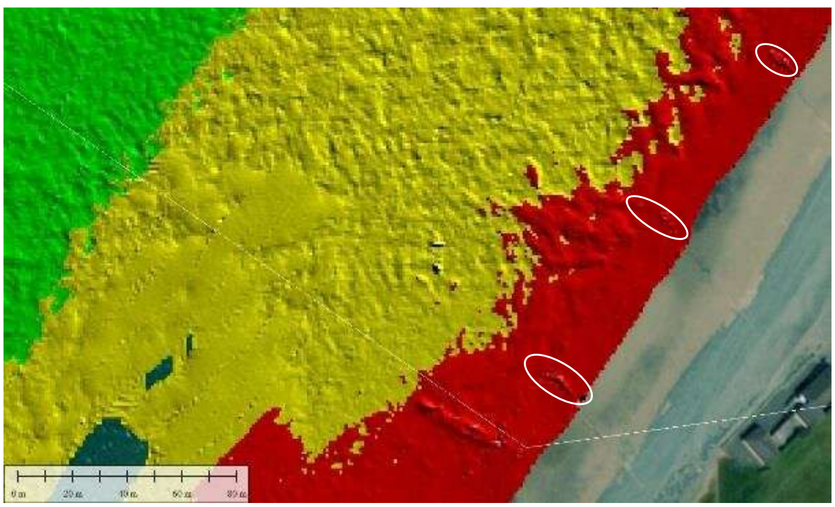


Figure 7.3 Groynes in the nearshore

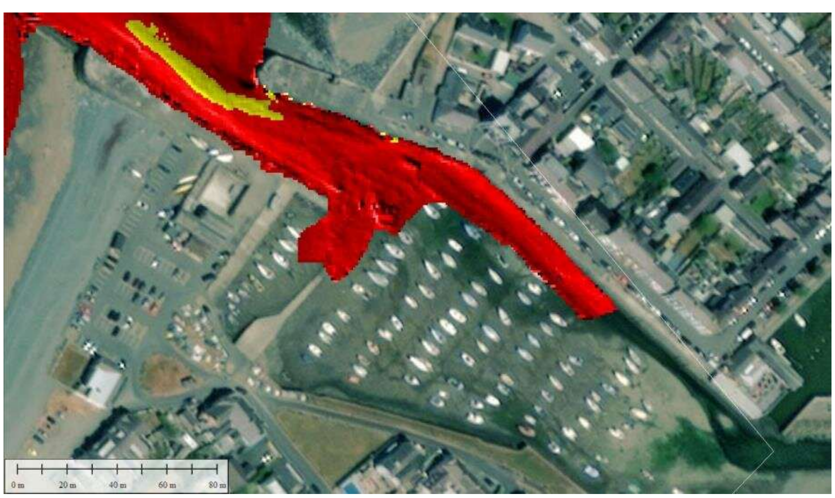


Figure 7.4 Multi-beam coverage of the inner harbour

Figure 7.4 illustrates the coverage achieved in the inner harbour. A slim strip of MBES data is sandwiched between the harbour wall and the mooring buoys. As mentioned previously, after this line was run, it was decided that the vessel could not safely collect any more data due to the close proximity of the buoys (denoted by the numerous sailing boats in the figure), the strong river flow and shallow water depths. No further data collection could be carried out around the boat launch also for these reasons.

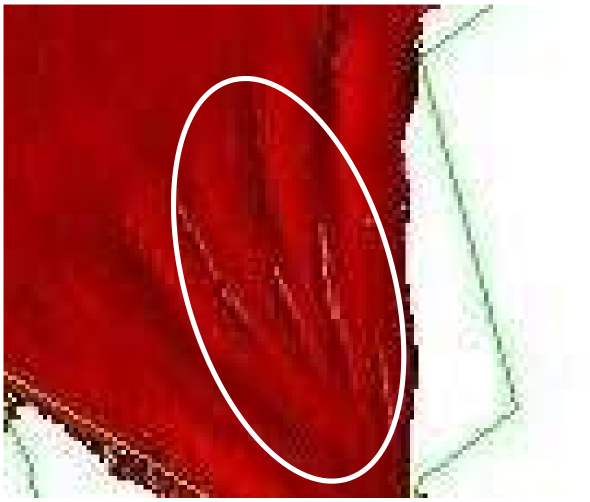


Figure 7.5 Seabed sound velocity artefacts

Figure 7.5 illustrates the strong effects of the freshwater input from the River Aeron on sound velocity in the water column. Taken from a raw MBES coverage chart and seen in the harbour entrance, the sound velocity changes rapidly from brackish to much more saline, which creates these false seabed features or 'smiles' that needed to be rectified during post processing.

7.2 Seabed Features

Seabed features are illustrated in Appendix D3, with a side scan sonar mosaic presented as Appendix D4. Seabed features have been interpreted by integrating all acquired survey data as well as referencing client supplied documents and imagery. Side scan sonar data is of adequate quality for the survey area.

Seabed sediments are interpreted to comprise gravel and cobbles associated with glacial till across much of the offshore section in the west of the site (Appendix C1). This has been ground-truthed during previous seabed imaging surveys (Atkins, 2020). Further inshore, accumulations of sand are clearly seen on both bathymetry and side scan sonar datasets as areas of low reflectivity forming a surficial veneer (Appendix C2). This is predominantly confined to the south of the site. In the north of the site, side scan sonar data shows reduced acoustic reflectivity with fewer discrete contacts, and as such is interpreted to comprise predominantly gravels. Within the vicinity of the harbour and proposed breakwater, seabed sediments are interpreted to predominantly comprise gravels and silty sand.

A series of groynes are observed on the data to the south of the site, orientated from southeast to northwest and are shown in Appendix C3. A linear contact identified on both the bathymetry and side scan sonar datasets is thought to represent a fish trap as detailed on client supplied infrastructure information (Appendix C4).

In the northeast of the site, two linear features are observed at seabed heading northwest from the beach as illustrated in Appendix C5. These are not included on the client supplied infrastructure information but are expected to represent outfall pipelines. The more significant interpreted pipeline measures some 200m long, with evidence of trenching associated with it. Both features have associated magnetometer anomalies.

The base of the existing harbour walls are imaged on the bathymetry data, and there is evidence on the side scan sonar of rock dumping associated with the existing breakwater exiting to the north of the northern harbour wall (Appendix C1).

A total of fourteen objects are interpreted at seabed on the side scan sonar data; thirteen of these are interpreted as boulders and one as linear debris. A list of all sonar contacts are included within the sonar contacts listing deliverable.

Of the boulders picked, the largest identified measures 0.9L x 0.8W x 0.8Hm. Marginal weather conditions throughout the duration of the survey has led to the potential for missed boulders across the site, as cable snatching effects may hide or result in low confidence measurements of seabed contacts. No side scan sonar contacts are interpreted in the vicinity of the proposed breakwater however.

The item of linear debris is interpreted in the west of the site as an item of wire or chain, and measures 16.5m in length and is illustrated in Appendix C6.

A total of 47 magnetometer anomalies not associated with existing infrastructure are interpreted within the survey area, with a higher proportion occurring in the nearshore or harbour areas. These may represent buried debris. A significant magnetometer anomaly measuring 33.3nT/m is interpreted in the vicinity of the proposed breakwater. A list of all magnetometer contacts are included within the magnetometer contacts listing deliverable.

7.3 Shallow Soils

A shallow geological profile along the proposed breakwater centre line (Boomer Line SB_20201129073830) is presented in Appendix D5. A Boomer data example along the same line is presented as Appendix C9.

Acquired Boomer data is of moderate quality on site during acquisition. The nature of the seabed within the survey area has also resulted in limited penetration into the underlying soils. An assumed seismic velocity of 1700m/s has been used to convert two-way time to depths.

Across the survey area, an intermittent veneer of fine sand is interpreted predominantly from bathymetry and side scan sonar datasets. Due to its' limited thickness, the base of these sediments are not seen on the boomer data and they are evident only as positive relief features at seabed (Appendix C7). The extents of these features which are expected to generally be <1m thick have been mapped and are presented in Appendix D4.

Underlying this surficial veneer, glacial till is interpreted comprising clay, sand, gravel and boulders. This is present at seabed across much of the survey area and ground-truthed during previous seabed imaging surveys (Atkins, 2020). Acoustically the till is seismically chaotic with numerous internal events (Appendix C8). Penetration into this till is limited, assumed to be because of the consolidated nature of the material.

Occasional intermittent reflectors are observed at depths of 10-12m below seabed on the boomer data, which may represent the top of the regional bedrock in the area. Background BGS, as well as Client-supplied information indicate the bedrock in the area to comprise lower Palaeozoic bedrock comprising mudstone, volcaniclastic igneous rock, siltstone and slate. Due to the lack of coherent reflectors the top of the bedrock has not been mapped and thus the Isopachs deliverable and Shallow Geology chart has not been done as there is very little to show.

In the vicinity of the harbour entrance, a faint reflector marking the base of Unit 1 is interpreted deepening gently towards the east (Appendix C9). Acoustically chaotic, the sediments comprising Unit 1 are interpreted to comprise silt, sand and gravel. These are typically 1.5m thick, deepening in the east to a maximum thickness of 2.5m. The base of Unit 1 has been mapped in Appendix D5.

APPENDIX A

DIGITAL DATA

Data

MBES

Gridded Soundings 1.0m XYZ	:	1 x .txt

Sonar Contacts

Sonar Contacts	:	1x .xlsx

Magnetometer

Magnetic Contacts	:	1x .xlsx

Charts

Bathymetry	:	1x .dwg/pdf
Shaded Relief	:	1x .dwg/pdf
Seabed Features	:	1x .dwg/pdf
SSS Mosaic	:	1x .dwg/pdf
Interpreted geological profiles	:	1x .dwg/pdf

Reports

Daily Progress Reports	:	10 x .pdf
Field Ops Report	:	1 x .pdf

APPENDIX B

TITAN QUALITY ASSURANCE

B.1 GEODETIC INFORMATION

Titan Environmental Surveys Limited

TQA004
Navigation & Geodesy

Client:	Quantum Geotechnics	**Issued By:**	SF
Project Name:	Aberaeron Geophysical Site Investi	**Checked By:**	MI
Project Code:	CS0590	**Approved By:**	

Geodetic Summary

Coordinate System Group:	OSGB36	**Vertical Datum:**	ODN
Zone:	N/A	**Reduction Method:**	OSGM15
Datum Transformation:	OSTN15 (From ETRS89)		

Navigation System Datum:	ETRS89	**Semi Major Axis**	6378137
		Semi Minor Axis	6356752.3142
		Flattening (1/f)	298.25722356301
Job Datum:	OSGB36 (AIRY1830)	**Semi Major Axis**	6377563.396
		Semi Minor Axis	6356256.910
		Inverse Flattening (1/f)	299.320
Projection:	Transverse Mercator	**Central Latitude**	49° North
		Central Longitude	2° West
		False Northing	-100000
		False Easting	400000
		Scale Factor	0.9996
Datum Transformation from Navigation System Datum to Job Datum:		**Rotation X (secs)**	0
		Rotation Y (secs)	0
		Rotation Z (secs)	0
		Scale Faction (ppm)	0
		Translation X (m)	0
		Translation Y (m)	0
		Translation Z (m)	0

Test Point Calculation from Navigation System Datum to Job Datum

Latitude	52 14 42.119 N	Easting	245410.960 E
Longitude	04 15 56.610 W	Northing	263178.780 N
Height	60	Height	5.8456

Primary Navigation System

GPS System:	SPS 751	
Differential Corrections:	RTK (VRSNow)	
Differential Base Station Operator/ network:	Internet	
Differential Base Station:	Site Name:	N/A
	Latitude:	N/A
	Longitude:	N/A
	Frequency:	N/A
	Nominal Range:	N/A

Secondary Navigation System

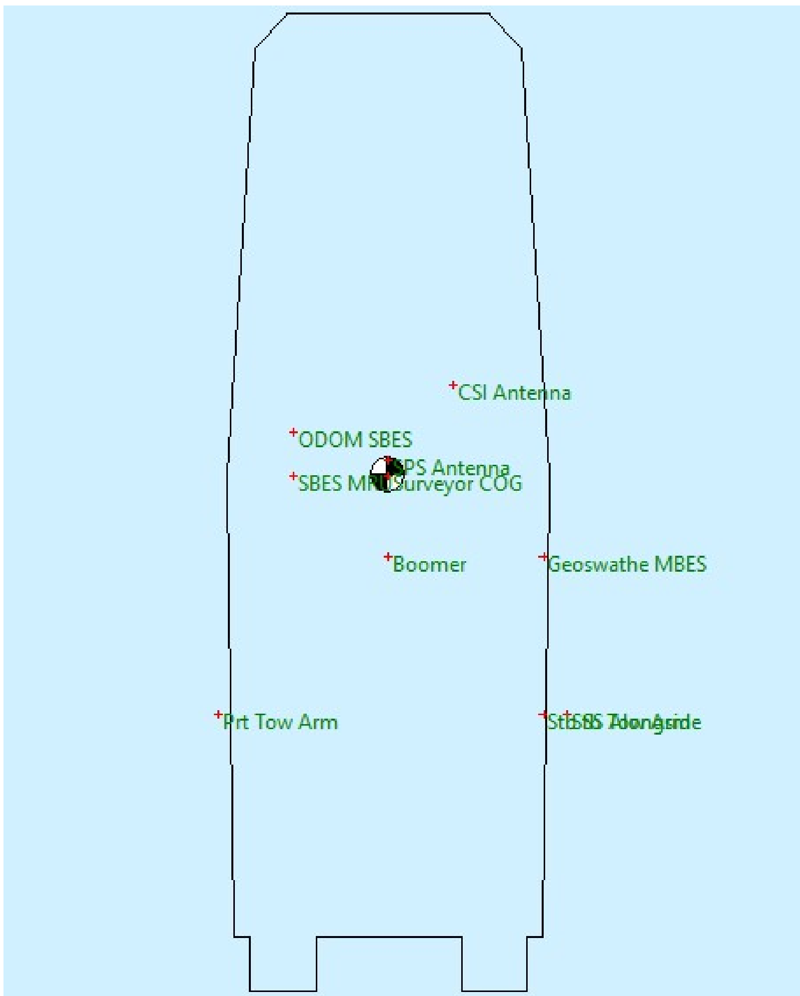
GPS System:	CSI VS130	
Differential Corrections:	DGPS	
Differential Base Station Operator/ network:	SBAS	
Differential Base Station:	Site Name:	N/A
	Latitude:	N/A
	Longitude:	N/A
	Frequency:	N/A
	Nominal Range:	N/A

B.2 VESSEL OFFSET DIAGRAM

TQA042 Vessel Offset Diagram

Client:	Quantum Geotechnic	**Project Name:**	Aberaeron Geophysical Site Investigation
Project Code:	CS0590	**Personnel:**	MI GJ KJ
Vessel:	Titan Surveyor		

Diagram:



Offsets	X (m)	Y (m)	Z (m)
Boomer	0.000	-0.753	0.000
CSI Antenna	0.610	0.852	2.151
Geoswathe MBES	1.440	-0.750	-0.840
ODOM SBES	-0.900	0.400	-0.300
Port Tow Arm	-1.598	-2.240	1.711
SBES MRU	-0.900	0.000	0.000
SPS Antenna	0.000	0.150	3.716
Stbd SSS Alongside	1.440	-2.240	0.500
Starboard Tow Arm	1.673	-2.240	1.711
Titan Surveyor CoG	0.000	0.000	0.000

B.3 STATIC NAVIGATION VERIFICATION

Titan Environmental Surveys Limited		**TQA017a Navigation Verification**	
Client:	Quantum Geotechnics	**Vessel:**	Titan Surveyor
Project Name:	Aberaeron Geophysical Site Investi	**Collected By:**	MI, GJ, KJ
Project Code:	CS0590	**Processed By:**	FD
Date Collected:	12/11/2020	**Date Processed:**	16/11/2020

Geodetic Summary

Occupied Station:	Titan Surveyor	**Coordinate System Group:**	British Grid
Station Code:		**Zone:**	OSGB36
Date Occupied:	12/11/2020	**Datum Transformation:**	OSTN15

Primary Equipment Used

GPS System:	SPS751	**Differential Correction:**	RTK (VRSNow)
Frequency:	1Hz	**Differential Base Station Operator/ Network:**	NTRIP/Internet

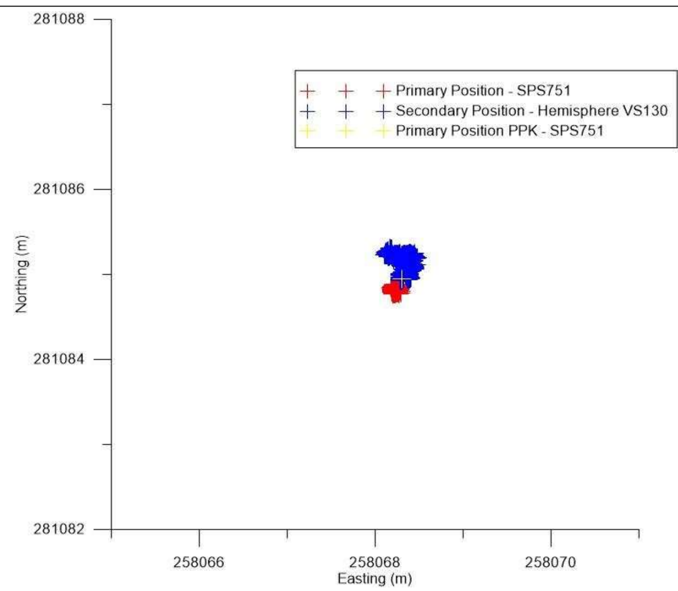
Secondary Equipment Used

GPS System:	Hemisphere VS130	**Differential Correction:**	DGPS
Frequency:	1Hz	**Differential Base Station Operator/ Network:**	SBAS

Results

Primary RTK vs Secondary DGPS:	dE:	-0.098	dN:	-0.317
Primary RPK vs Primary PPK:	dE:	-0.095	dN:	-0.221

Scatter Plot



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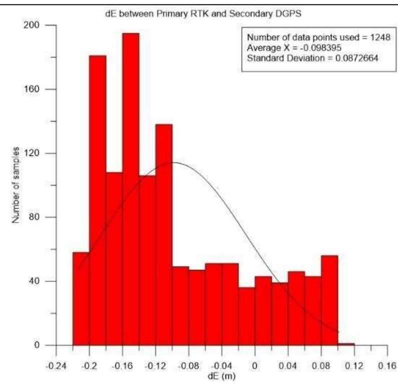
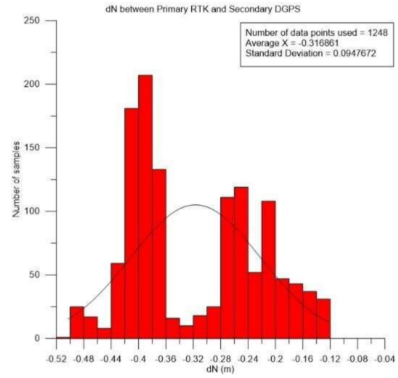
<tr><td>
</td><td>
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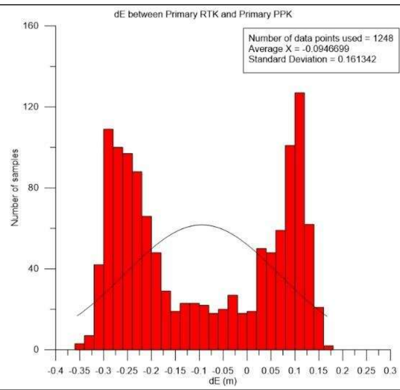
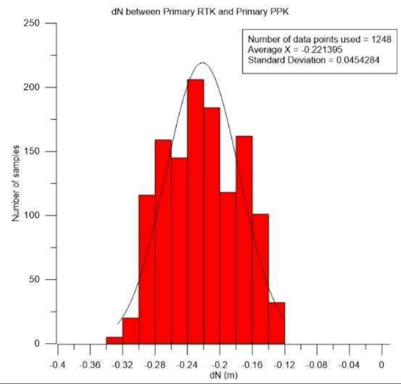
<tr><td>
</td><td>
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B.4 SURVEY NAVIGATION COMPARISON

Titan Environmental Surveys Limited	# TQA017c Survey Navigation Comparison		
Client:	Quantum Geotechnical	**Vessel:**	Titan Surveyor
Project Name:	Aberaeron Geophysical Site Investi(	**Processed By:**	GJ
Project Code:	CS0590	**Date Processed:**	15/12/2020
Dates Collected:	26/11/2020 to 29/11/2020		

Geodetic Summary

Occupied Station:	Titan Surveyor	**Coordinate System Group:**	Bitish Grid
Station Code:		**Zone:**	OSGB15
Date Occupied:	26/11/2020 - 29/11/2020	**Datum Transformation:**	OSTN15

Primary Equipment Used

GPS System:	Trimble SPS 751	**Differential Correction:**	RTK (VRSNow)
Frequency:	1 Hz	**Differential Base Station Operator/ Network:**	NTRIP/Internet

Secondary Equipment Used

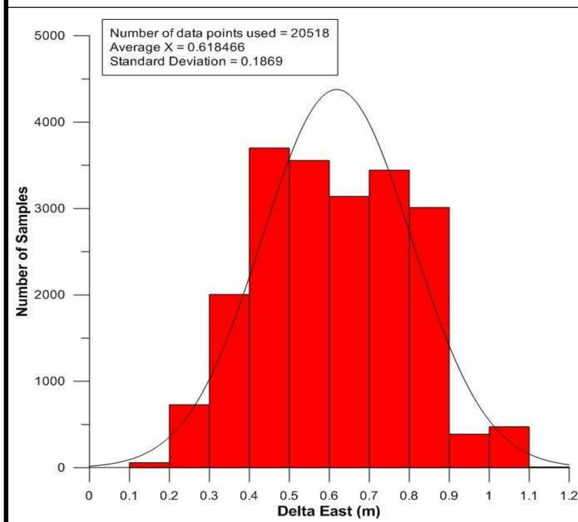
GPS System:	Hemisphere VS130	**Differential Correction:**	DGPS
Frequency:	1 Hz	**Differential Base Station Operator/ Network:**	SBAS

Results

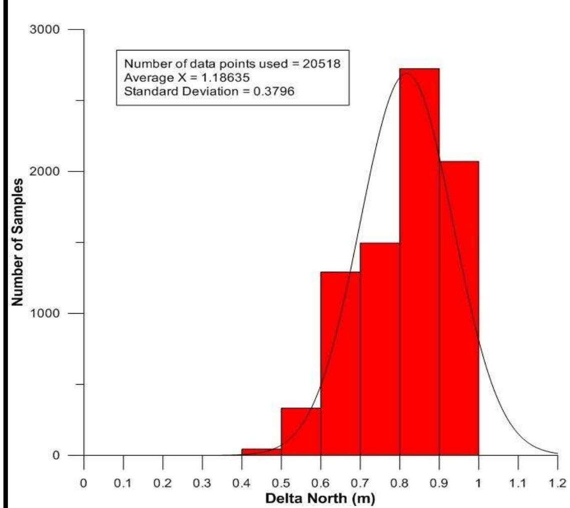
Primary RTK vs Secondary DGPS	dE:	**0.62**	dN:	**1.19**

Position Results

dE



dN



B.5 HEADING VERIFICATION

Titan Environmental Surveys Limited

TQA038
Gyro Verification

Client:	Quantum Geotechnics	**Vessel:**	Titan Surveyor
Project Name:	Aberaeron Geophysical Site Investi	**Collected By:**	MI, GJ, KJ
Project Code:	CS0590	**Processed By:**	FD
Date Collected:	12/11/2020	**Date Processed:**	16/11/2020

Geodetic Summary

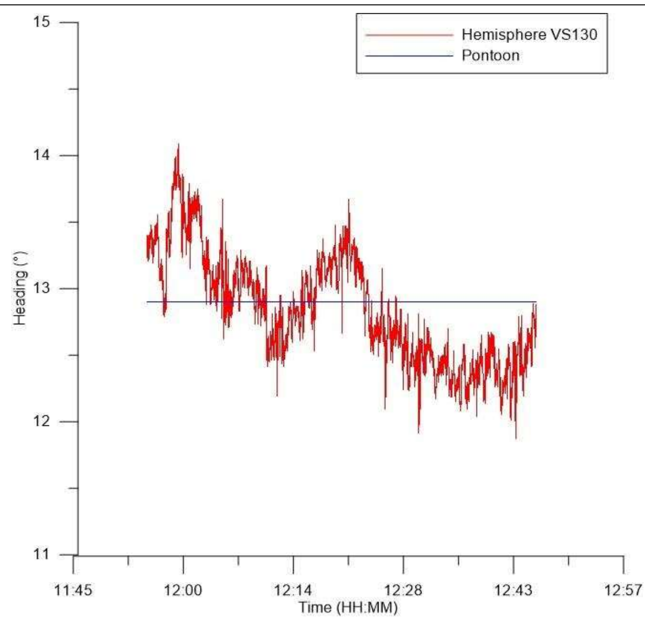
Occupied Station:	Titan Surveyor	**Coordinate System Group:**	British Grid
Station Code:		**Zone:**	OSGB36
Date Occupied:	12/11/2020	**Datum Transformation:**	OSTN15

Equipment Used

Primary:	Hemisphere VS130

Results

Time Series Plot



B.6 MBES PATCH TEST

Titan Environmental Surveys Limited (A GARDLINE COMPANY)	**TQA035b GeoAcoustics Swathe Calibration Summary**

Client:	Quantom Geotechonic Ltd	**Project Name:**	Aberaeron	**Project Code:**	CS0590
Date:	29/11/2020				
Information:	Geoacoustics Swathe Calibration				
Vessel:	MV Titan Surveyor				

Overview:
A patch test was completed on the 27/11/2020 (Roll Lines) and 29/11/2020(Pitch/Yaw Lines) to establish the correct motion sensor offset angles for the Geoswath Swathe system on board the MV Titan Surveyor. The patch test consisted of setting the motion sensor offset values in the Geoswath Plus acquisition software to 0.00, and running the standard set of patch test lines to acquire calibration values for latency, attitude latency, roll, pitch and yaw.

The Roll lines calibration site chosen was located at a North of Aberaeron over a flat area of seabed. (52°15'34.91271"N / 4°18'27.59228"W)

The Pitch lines calibration was located North West of Aberystwyth (52°26'12.5878"N/ 4°15'42.2495"W)

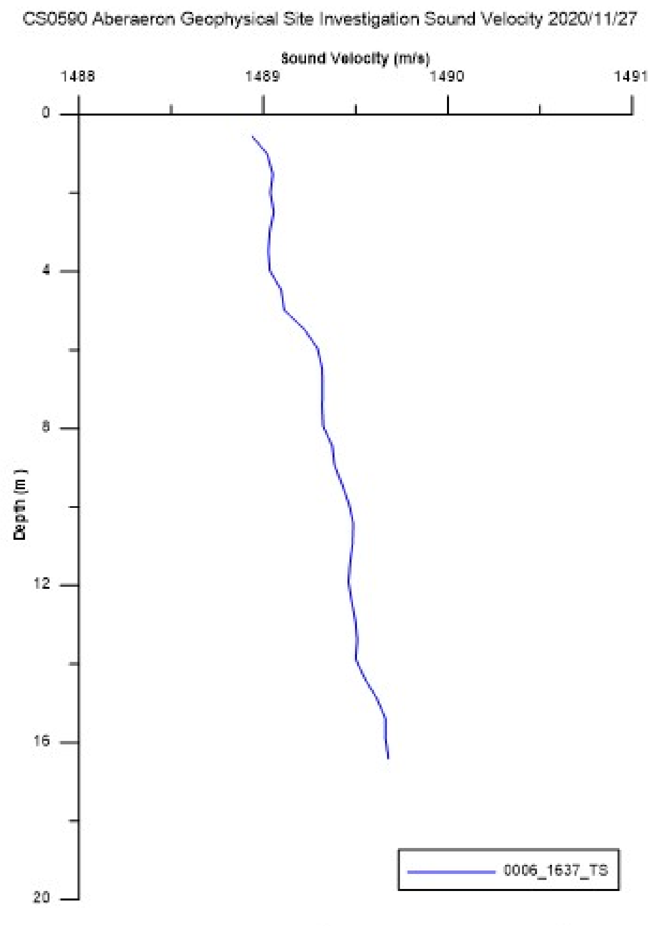
The calibration lines were planned using the online QPS QINSy Software, data was acquired using the GS4 acquisition software, and processed using GS4 processing Suite.

Summary and Results:

Date	**29/11/2020**
Job No.	**CS0590**
Latency	**0.000**
MRU Latency	**0.030**
Roll Port	**-0.16°**
Roll Stbd	**0.68°**
Pitch Port	**-1.27°**
Pitch Stbd	**0.27°**
Yaw Port	**5.08°**
Yaw Stbd	**3.36°**
Comments	

The calibration lines were created as advised by Kongsberg GeoAcoustics for the GS4 system; main lines were run parallel to each other in opposite directions across the selected patch test site for roll and pitch/yaw calculations. An additional line over a flat seabed was run perpendicular to the current/tide/wind (for maximum roll in the vessel) to calculate the MRU latency.

Sound Velocity Summary	
Downcast mean velocity:	1492.25 m/s
Surface velocity:	1491.17 m/s
Mini SVS:	1491.44 m/s
Surface temperature:	10.74 °C
Mean temperature:	11.11 °C



Sound Velocity Graph

A visual comparison was made between the data from the SVP and the value of the SVS positioned on the transducer head and both sets of data were found to agree to within 0.3 m/s.

Calibration Procedure

Latency

A latency correction value of 0.00s remained as no correction is required. This is due to the GS4 system on the MV Titan Surveyor receiving 1PPS directly from the GPS navigation system and therefore mitigating the need for a latency calibration.

Roll

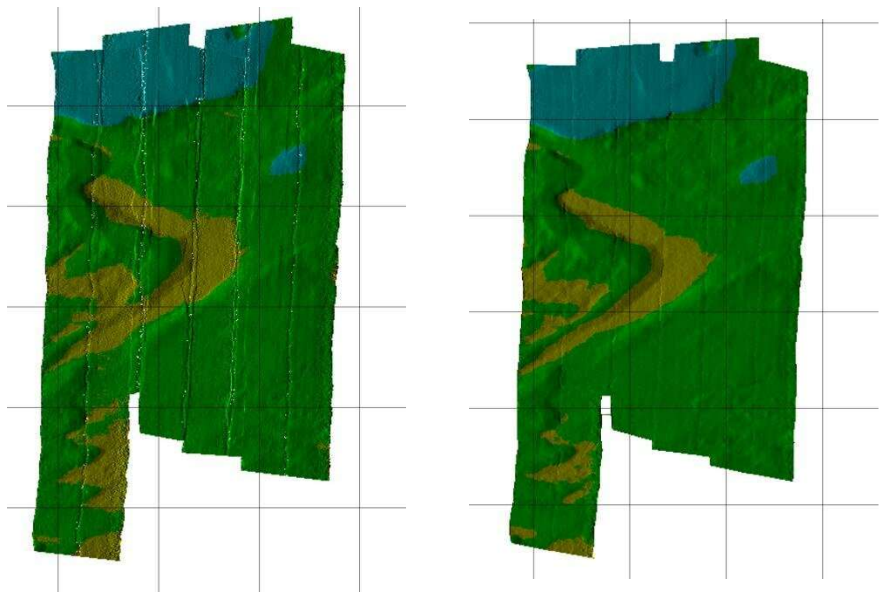
To determine the Roll correction, two lines were run parallel to each other over a flat seabed in opposite directions to determine the effect on the GS4 MBES head. Two parallel lines were run in order to achieve full overlap of the Port or Starboard transducers for best calculations to be achieved.

Pitch/Yaw

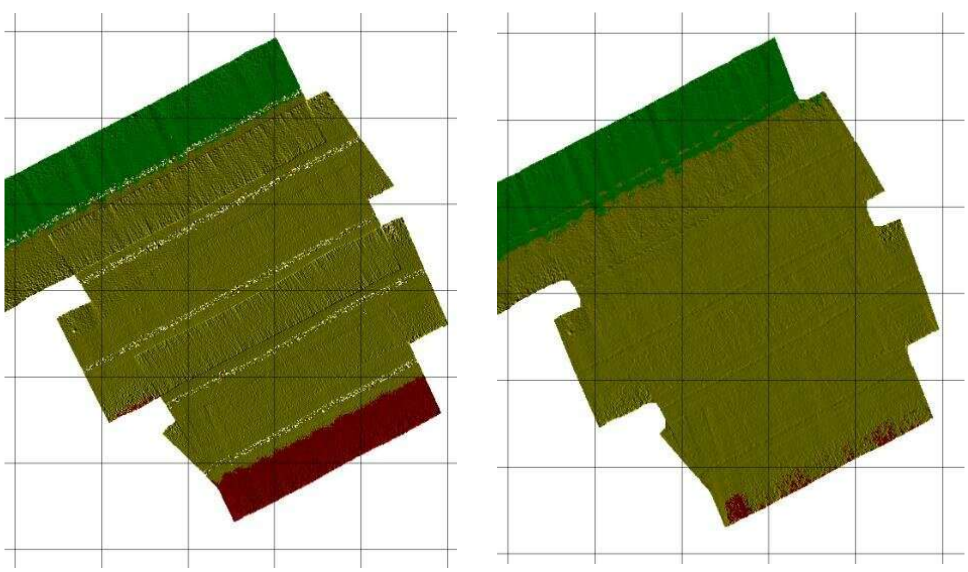
To determine the Pitch and Yaw correction, two lines were run parallel to each other over a seabed feature in opposite directions to determine the effect on the GS4 MBES head. Two parallel lines were run in order to achieve full overlap of the Port or Starboard transducers for the best calculations to be achieved.

Results

The patch test values were re-computed and applied to the Titan Surveyor GS4 MBES configuration. The GS4 MBES data collected during the patch test on 29/11/2020 was reprocessed with the patch test values with results shown below before and after application of the values.



Pitch and Yaw lines Pre-application and post application of the calibration results



Roll lines Pre-application and post application of the calibration results

Methodology

The calibration area were chosen to evaluate the different calibration factors using various criteria as follows:

1. Precise surface positioning.
2. Uniform water mass, avoiding areas with marked thermoclines.
3. Calibration performed in good survey weather.
4. Flat area for evaluation of roll error.
5. Significant seabed feature for evaluation of the pitch and heading error.

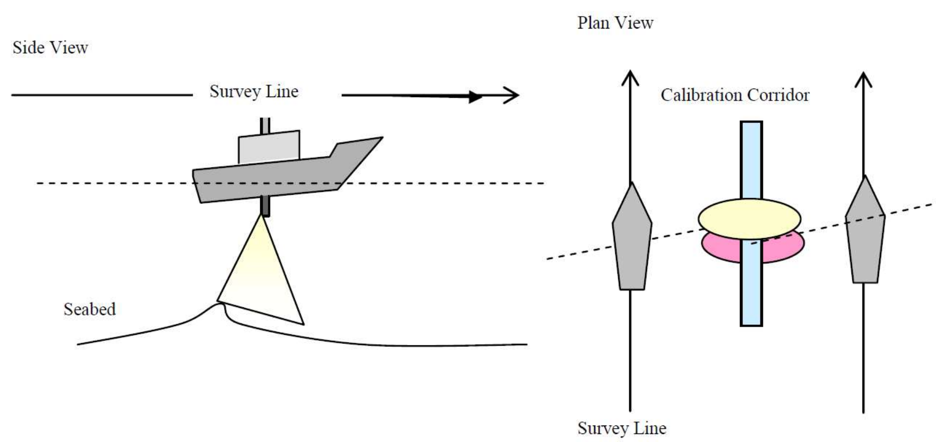
In the determination of angular errors, the greater the water depth, the more apparent the system errors become in the bathymetric data, and the easier they are to evaluate.

A significant linear feature, such as a wreck or ridge is desirable to evaluate any positioning delay. To reduce the effect of any angular errors it is preferable to find such a feature in shallower water.

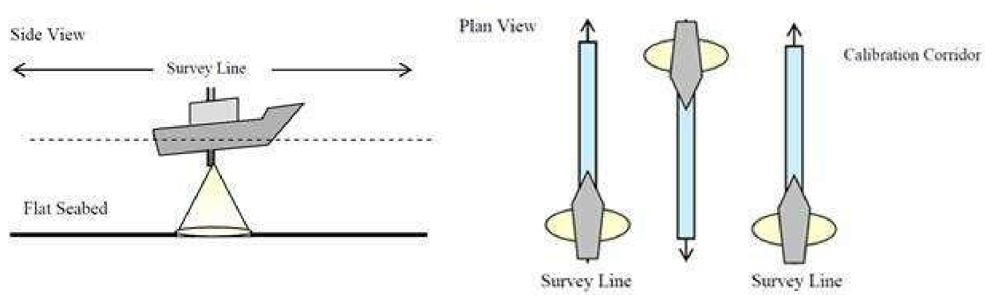
Below describes the methods used for determining each set of results.

Pitch Calibration

Pitch calibrations required the survey vessel to steam at constant speed along 3 to 5 parallel and adjacent lines over a well-defined feature to determine the effects on the transducer heads.

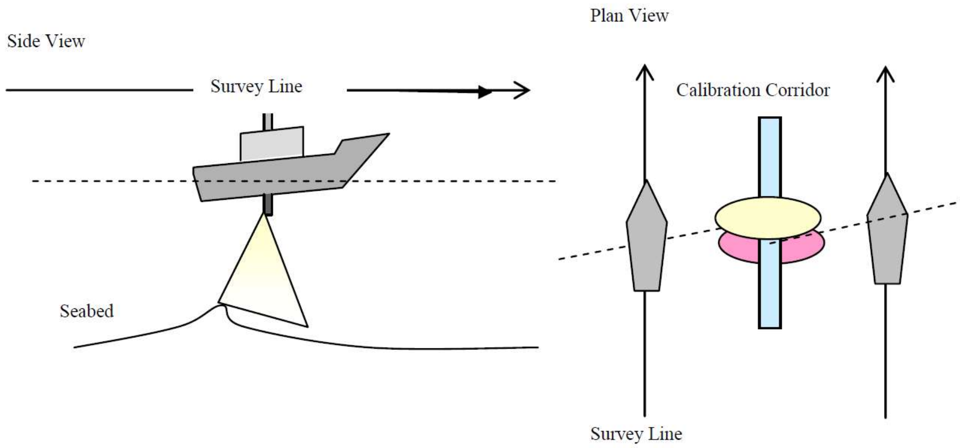


Roll Calibration



Horizontal Alignment Error (Yaw)

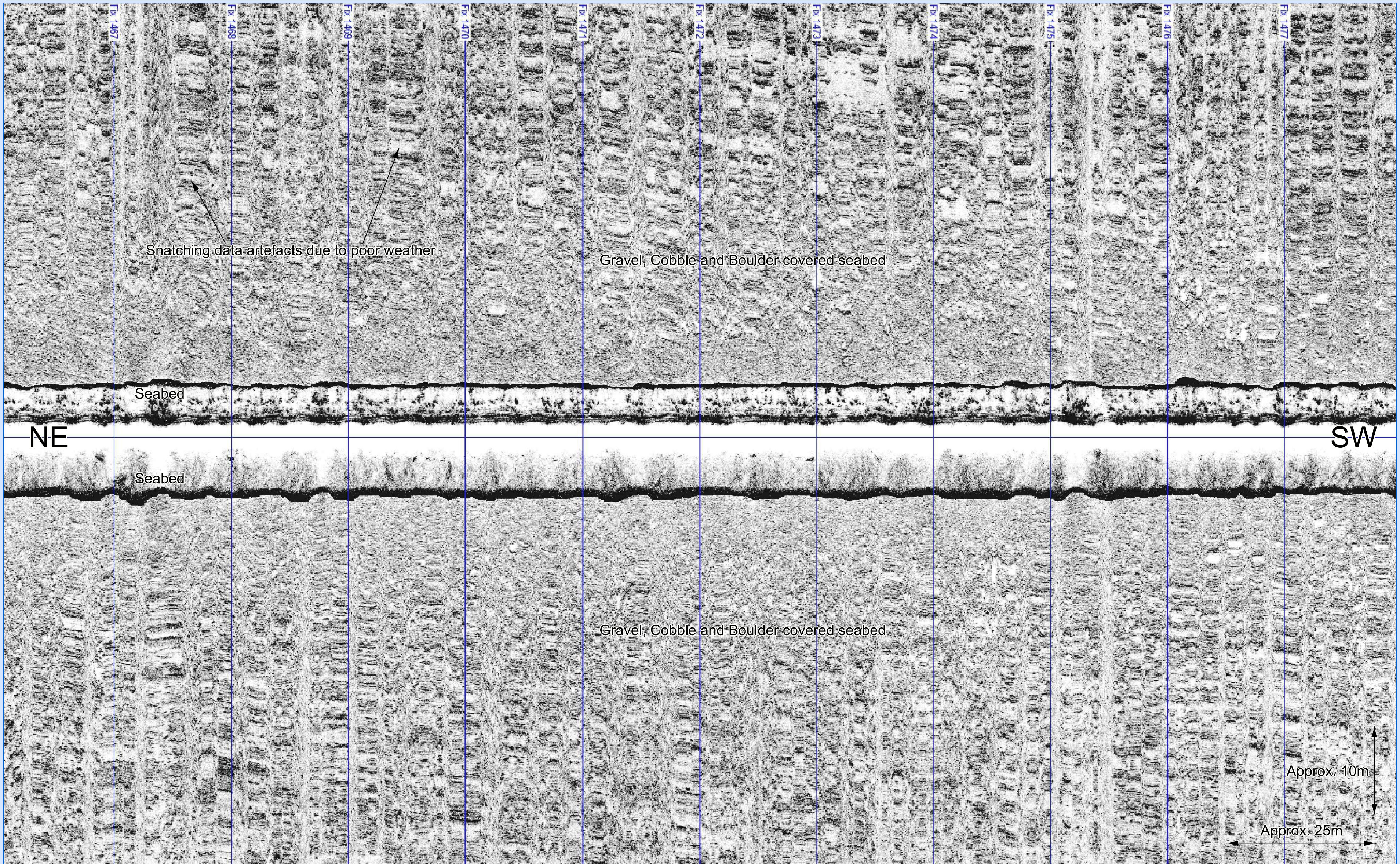
Yaw calibrations required the survey vessel to steam at constant speed along three parallel and adjacent lines over a well-defined feature to determine the effects on the transducer heads.



APPENDIX C

DATA EXAMPLES

C.1 SSS LINE. ILLUSTRATING GRAVELS, COBBLES AND BOULDERS



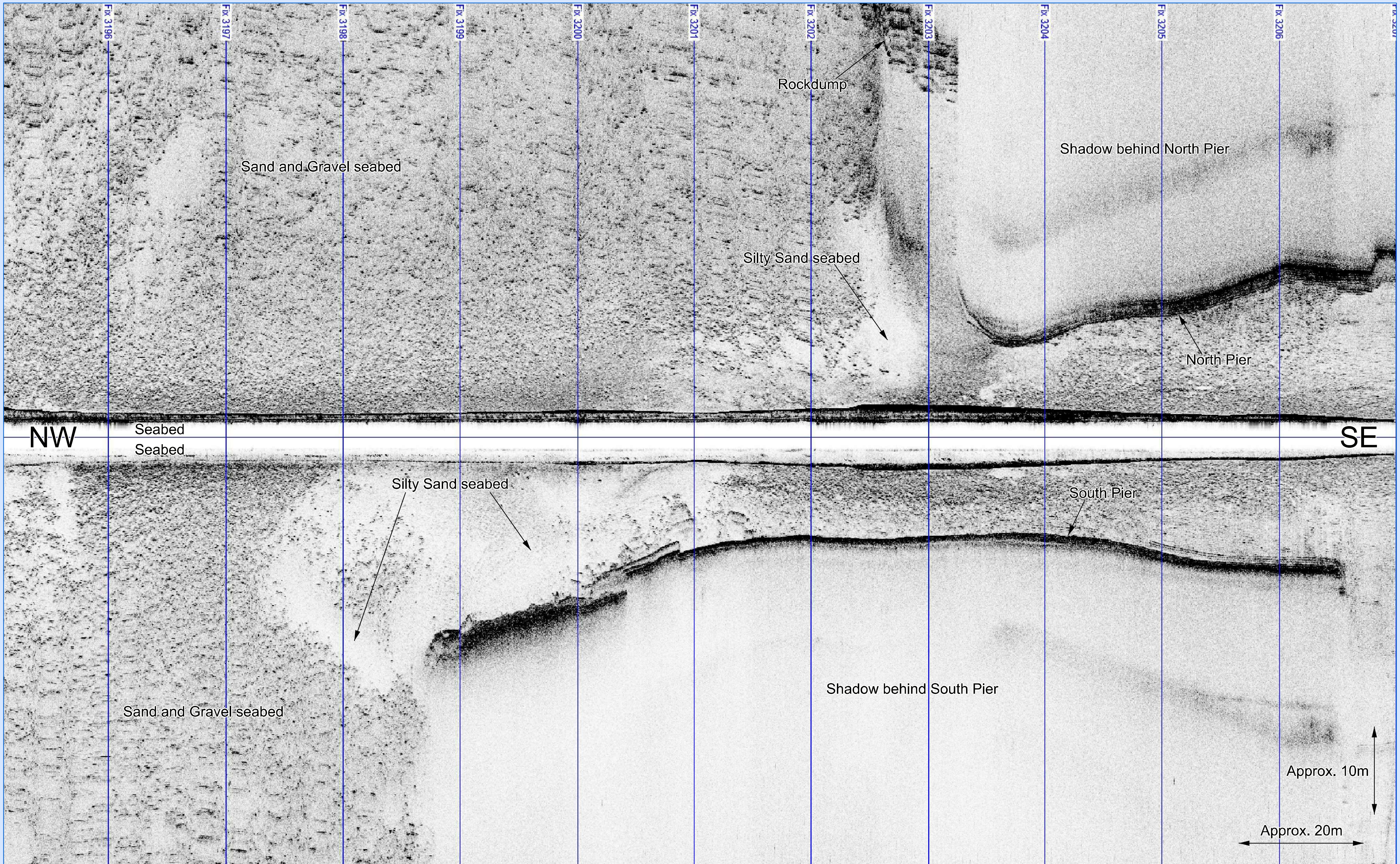
Line 20201126_M-1bH

SIDE SCAN SONAR
Illustrating Gravel, Cobble and Boulder sediments

Figure 1.1

Job No. 11557

C.2 SSS LINE. ILLUSTRATING SILTY SAND



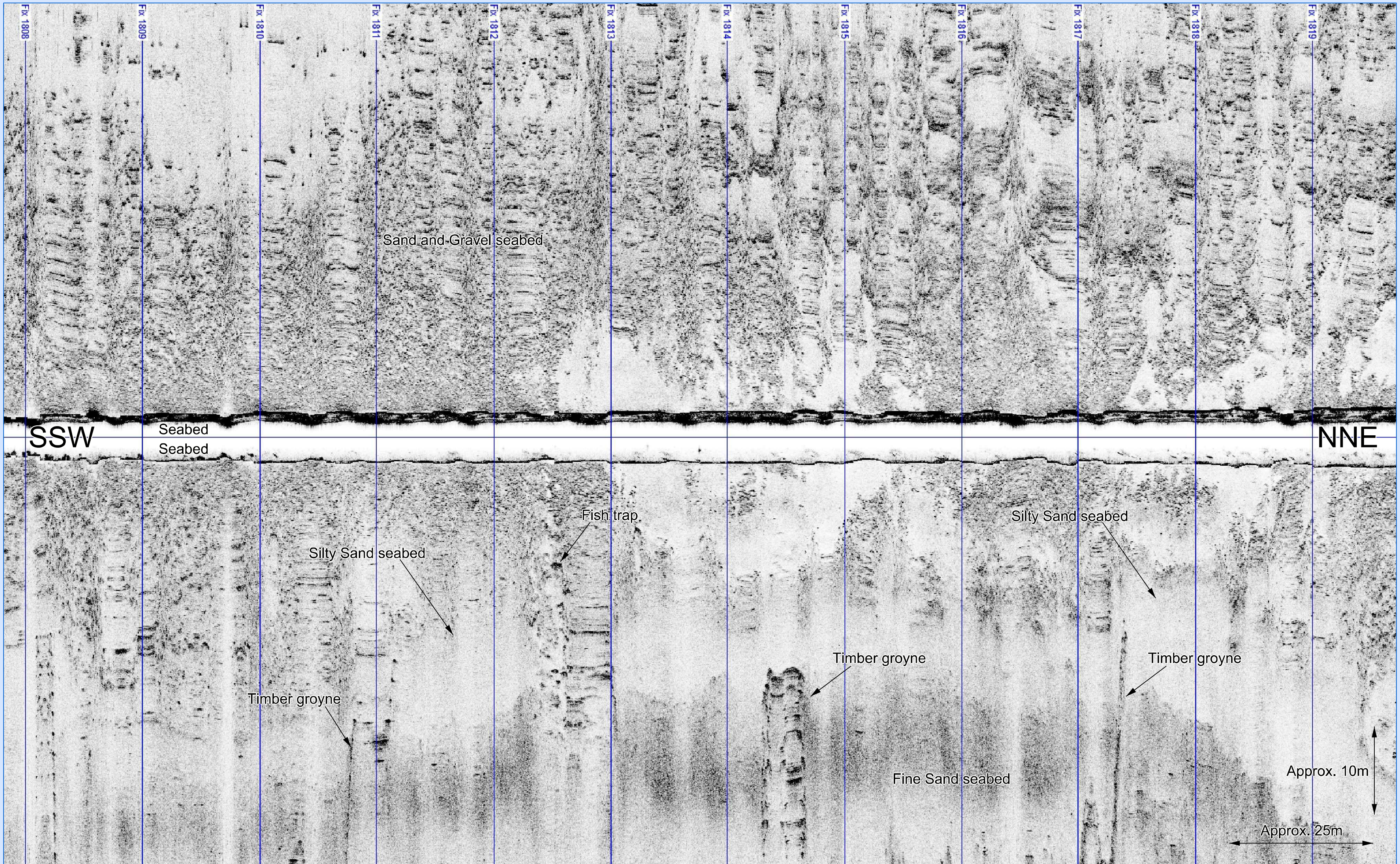
Line 20201129_HM-2aH

SIDE SCAN SONAR
Illustrating Silty Sand sediments

Figure 1.2

Job No. 11557

C.3 SSS LINE. ILLUSTRATING FISH TRAP AND GROYNES



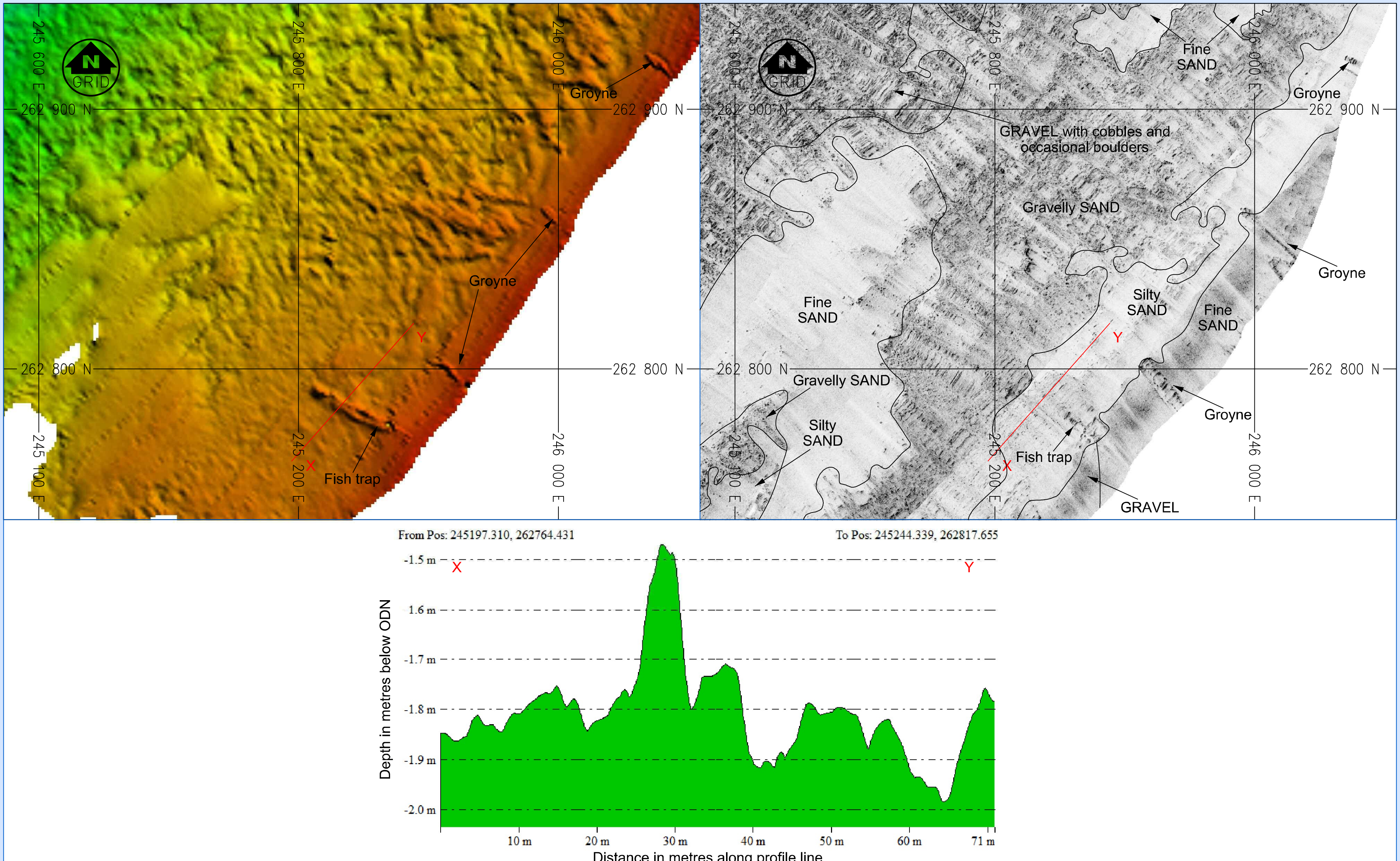
Line 20201126_M-5H

SIDE SCAN SONAR
Illustrating fish trap and groynes

Figure 1.3

Job No. 11557

C.4 DATA MONTAGE ILLUSTRATING FISH TRAP AND GROYNES



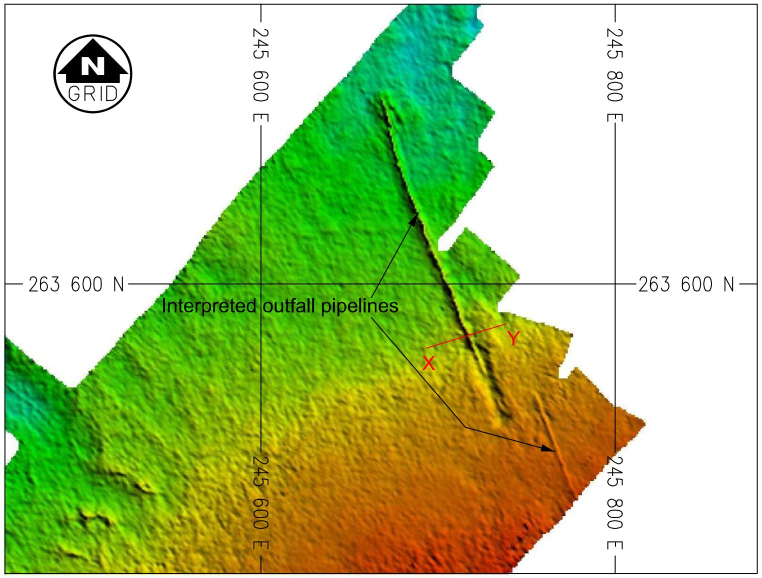
Scale 1 : 2000
Ordnance Survey OSTN15/British National Grid

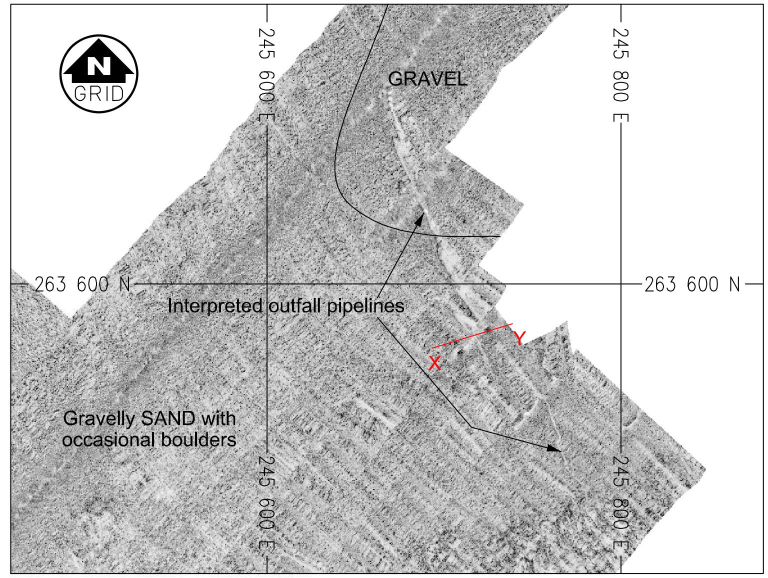
DATA MONTAGE
Illustrating fish trap and groynes

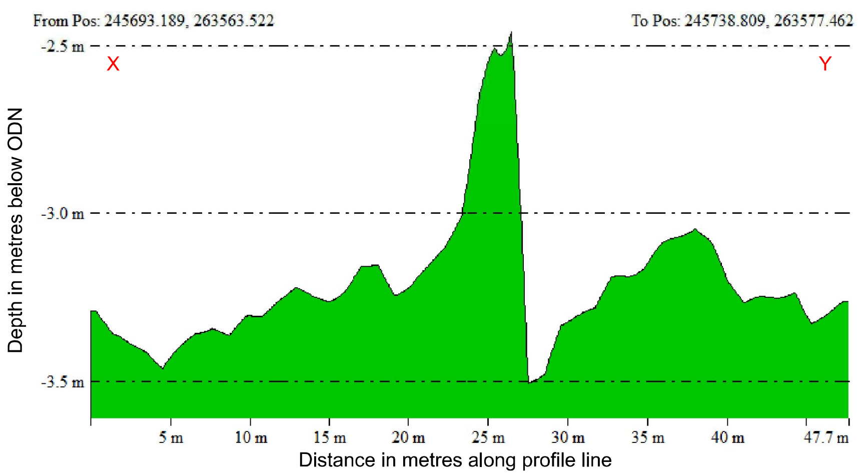
Figure 1.4

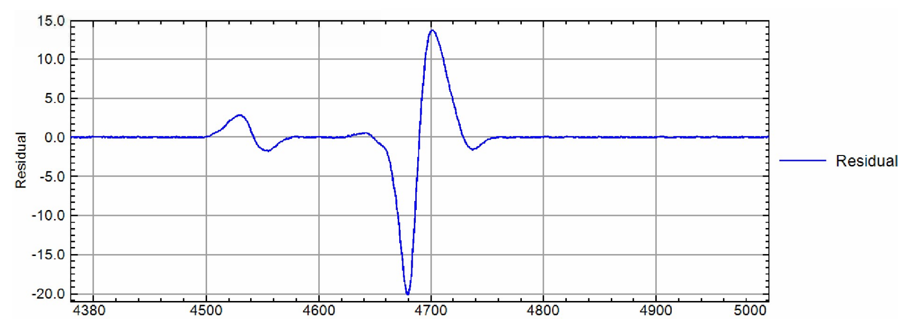
Job No. 11557

C.5 DATA MONTAGE ILLUSTRATING INTERPRETED OUTFALL PIPELINES









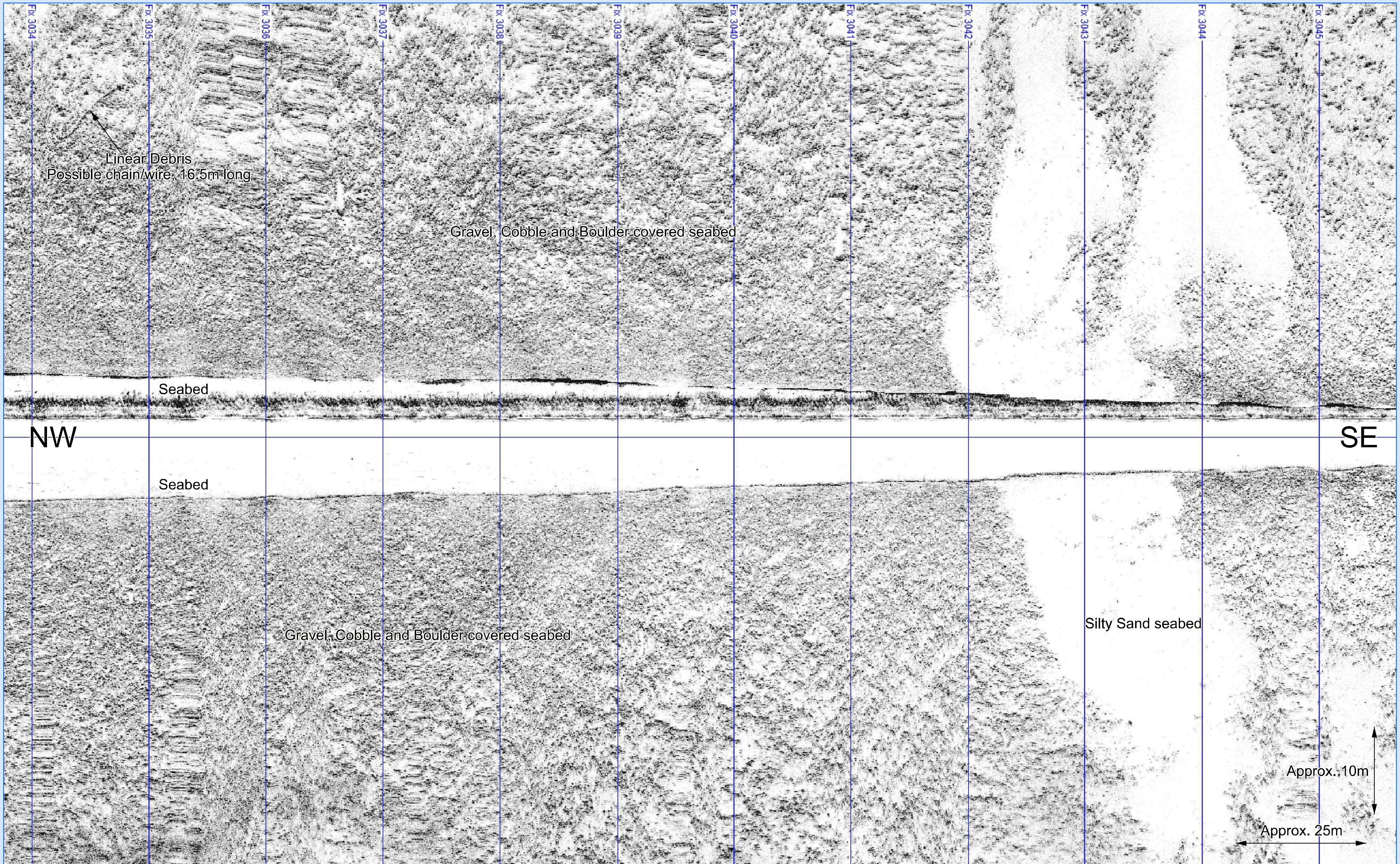
Scale 1 : 4000
Ordnance Survey OSTN15/British National Grid

DATA MONTAGE
Illustrating interpreted outfall pipelines

Figure 1.5

Job No. 11557

C.6 SSS LINE. ILLUSTRATING LINEAR DEBRIS



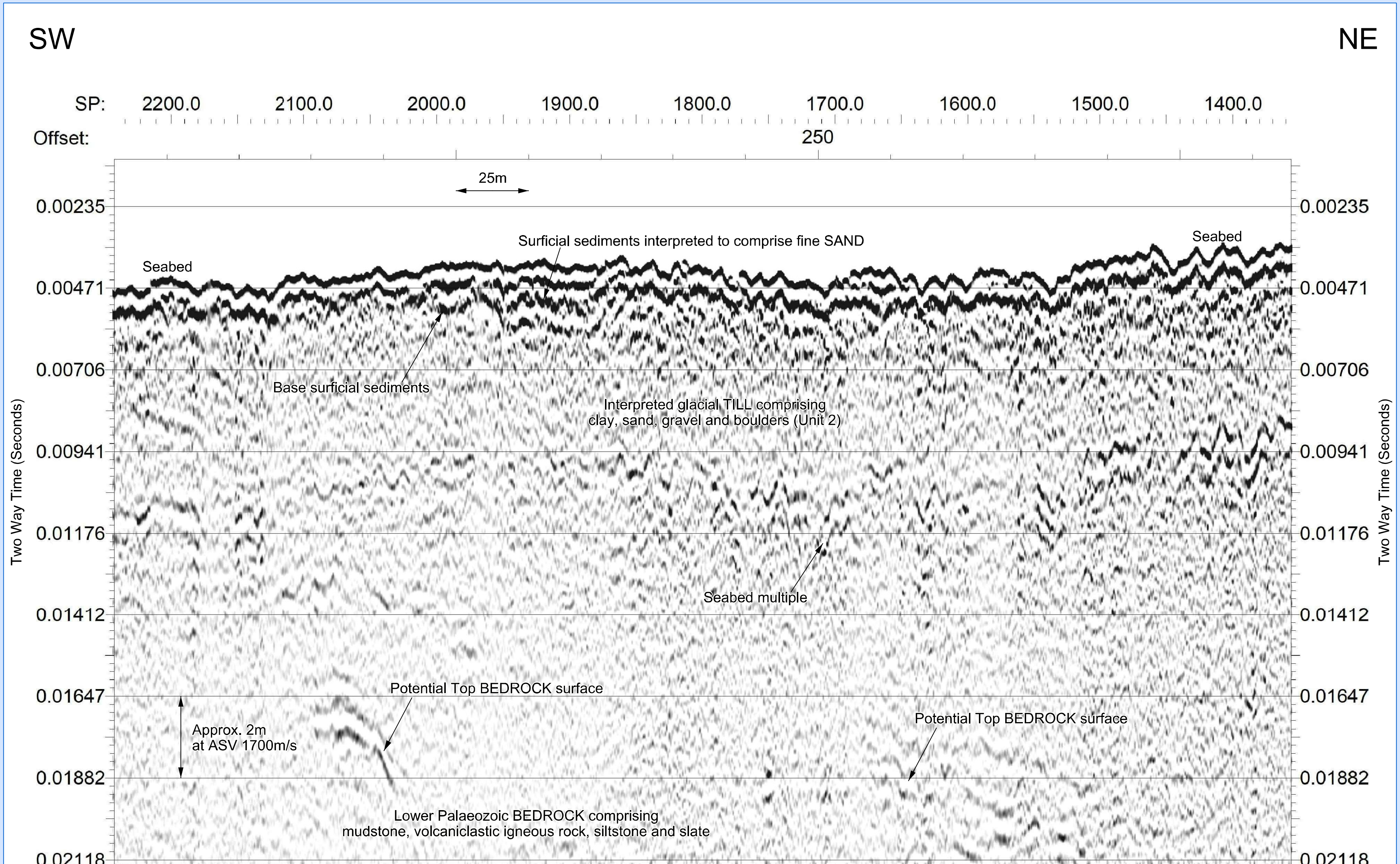
Line 20201119_MX-3H

SIDE SCAN SONAR
Illustrating linear debris

Figure 1.6

Job No. 11557

C.7 BOOMER LINE ILLUSTRATING TYPICAL NEARSHORE PROFILE



Line SB_20201126165521

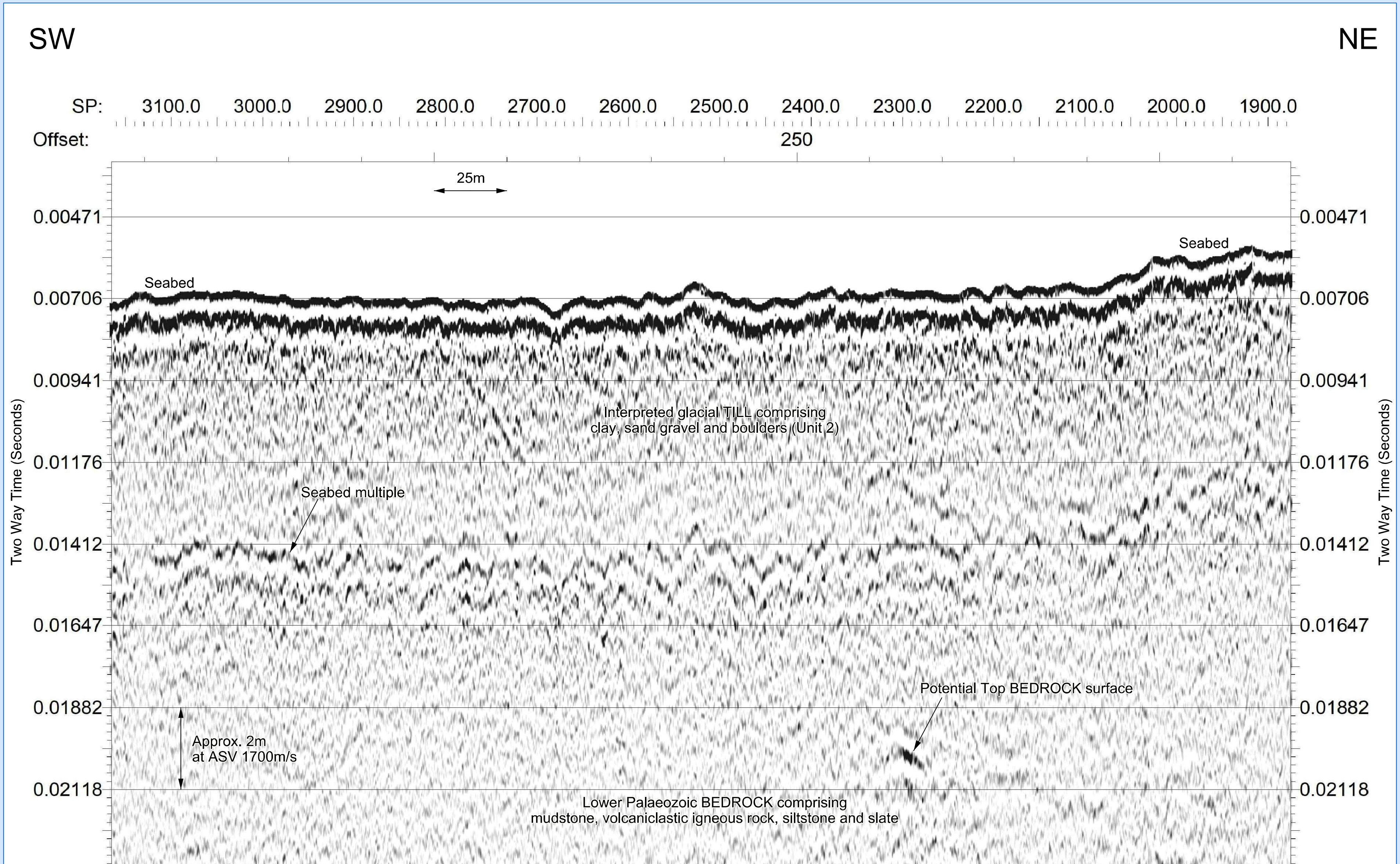
BOOMER

Illustrating typical nearshore profile

Figure 1.7

Job No. 11557

C.8 BOOMER LINE ILLUSTRATING TYPICAL OFFSHORE PROFILE



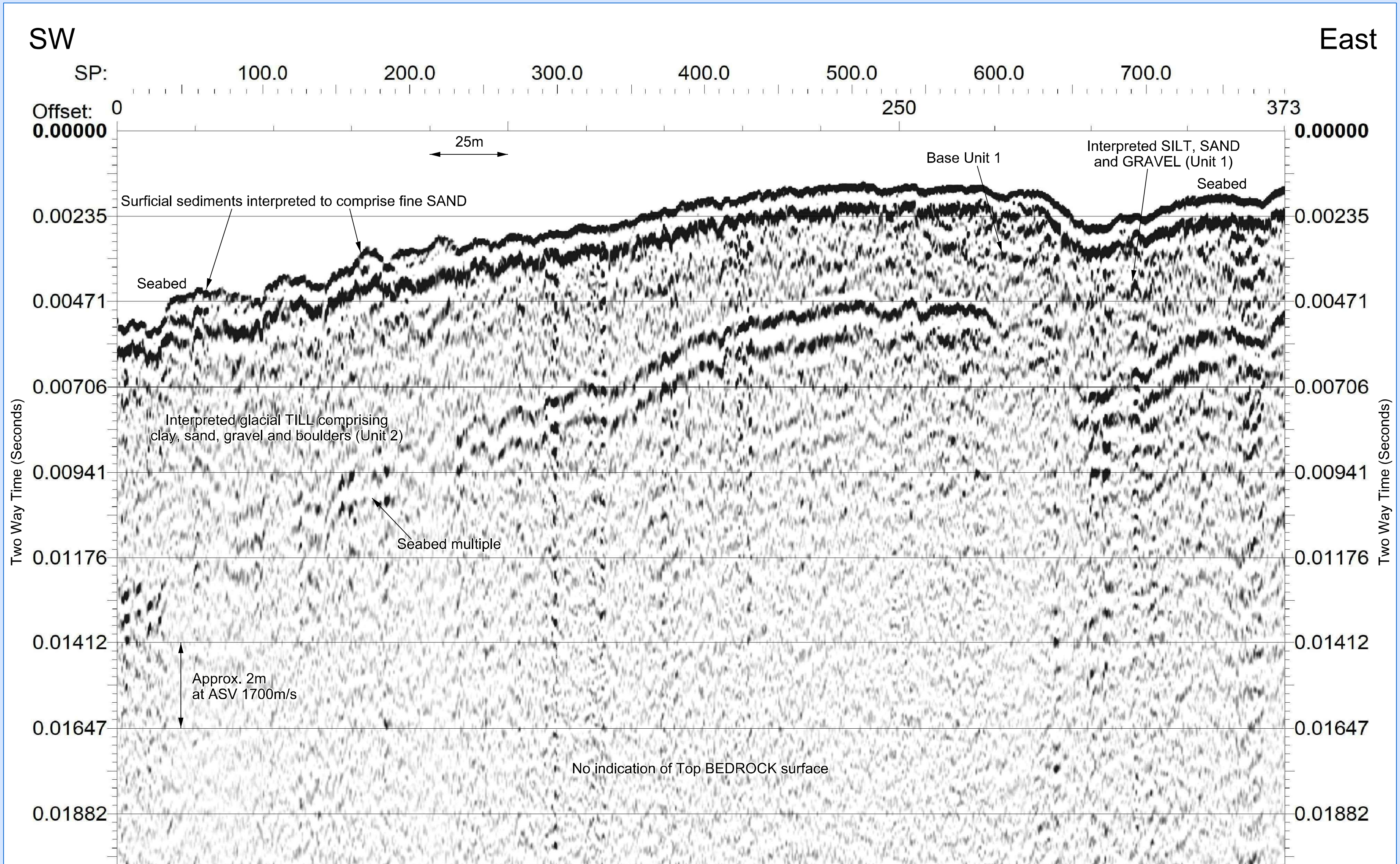
Line SB_20201126140005

BOOMER
Illustrating typical offshore profile

Figure 1.8

Job No. 11557

C.9 BOOMER LINE ILLUSTRATING PROPOSED BREAKWATER CENTRE LINE PROFILE



Line SB_20201129073830

BOOMER
Illustrating proposed breakwater centre line profile

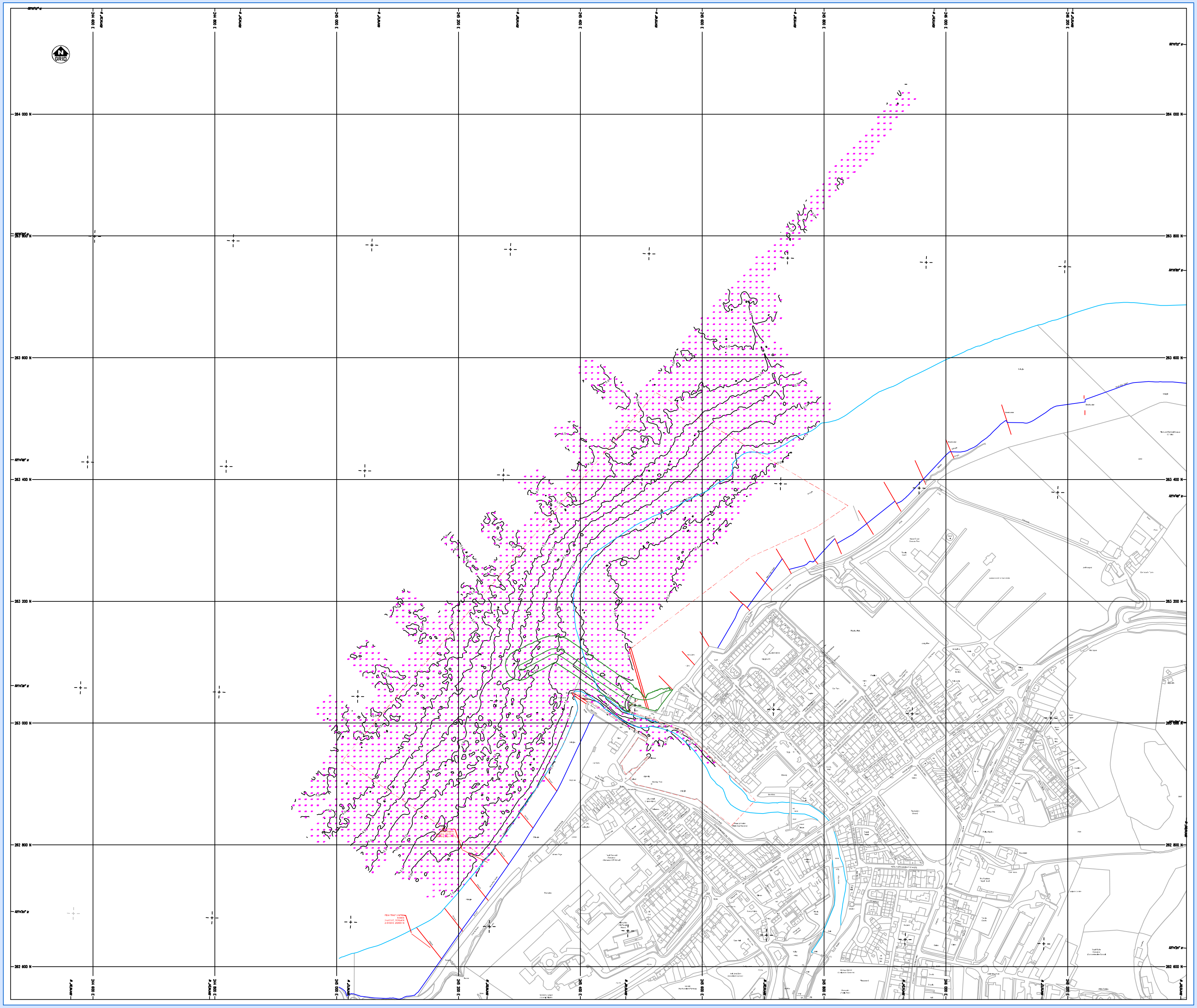
Figure 1.9

Job No. 11557

APPENDIX D

CHARTS

D.1 BATHYMETRY



LEGEND

PROPOSED BREAKWATER

2.5 BATHYMETRIC CONTOURS SHOWN AT 2.5 METRE INTERVALS ODN (ORDNANCE DATUM NEWLYN)

2.0 BATHYMETRIC CONTOURS SHOWN AT 0.5 METRE INTERVALS ODN (ORDNANCE DATUM NEWLYN)

REPRESENTATIVE MBES SPOT DEPTHS IN METRES

SURVEY AREA

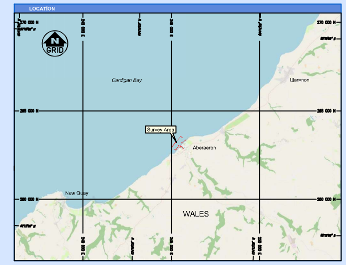
NOTES

DATA WAS REDUCED TO ODN VIA THE OSGM15 GEOID

BATHY WAS GRIDDED AT 1 x 1m

TIME REFERENCED TO UTC

LOCATION



GEODETIC REFERENCE SYSTEM

GEODETIC DATUM:	ORDNANCE SURVEY OSTN15
ELLIPSOID:	AIRY 1830
PROJECTION:	BRITISH NATIONAL GRID
COORDINATE TRANSFORMATION:	FROM ETRS89 TO OSGB 1936/BRITISH NATIONAL GRID EPSG TRANSFORMATION CODE 7953

SURVEY INFORMATION

SURVEY VESSEL:	M.V. TITAN SURVEYOR
SURVEY DATE:	26-NOV-2020 TO 29-NOV-2020
POSITIONING SYSTEM:	TRIMBLE SPS GNSS RECEIVER WITH RTK SOLUTION (C/W TRIMBLE VRS NOW)
NAVIGATION SYSTEM:	QPS QINSy
ECHO SOUNDER (MULTI-BEAM SYSTEM):	KONGSBERG GEOACOUSTICS GEOSWATH GS4
SIDE SCAN SONAR:	EDGETECH 4200FS
SUB-BOTTOM PROFILER:	APPLIED ACOUSTICS SURFACE TOW BOOMER
MAGNETOMETER:	GEOMETRICS G882

SCALE (A0 ORIGINAL)

1 : 2 000 (Horizontal)

20 0 100 200

METRES

TITLE

SURVEY CONTRACTOR

Titan Environmental Surveys Limited
A GARDLINE COMPANY
TITAN ENVIRONMENTAL SURVEYS LIMITED
ORION HOUSE, PARC CRESCENT, WATERTON INDUSTRIAL ESTATE, BRIDGEND, SOUTH WALES, CF31 3BQ
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CLIENT

Quantum Geotechnic

PROJECT TITLE

ABERAERON GEOPHYSICAL SITE INVESTIGATION

DRAWING TITLE

BATHYMETRY

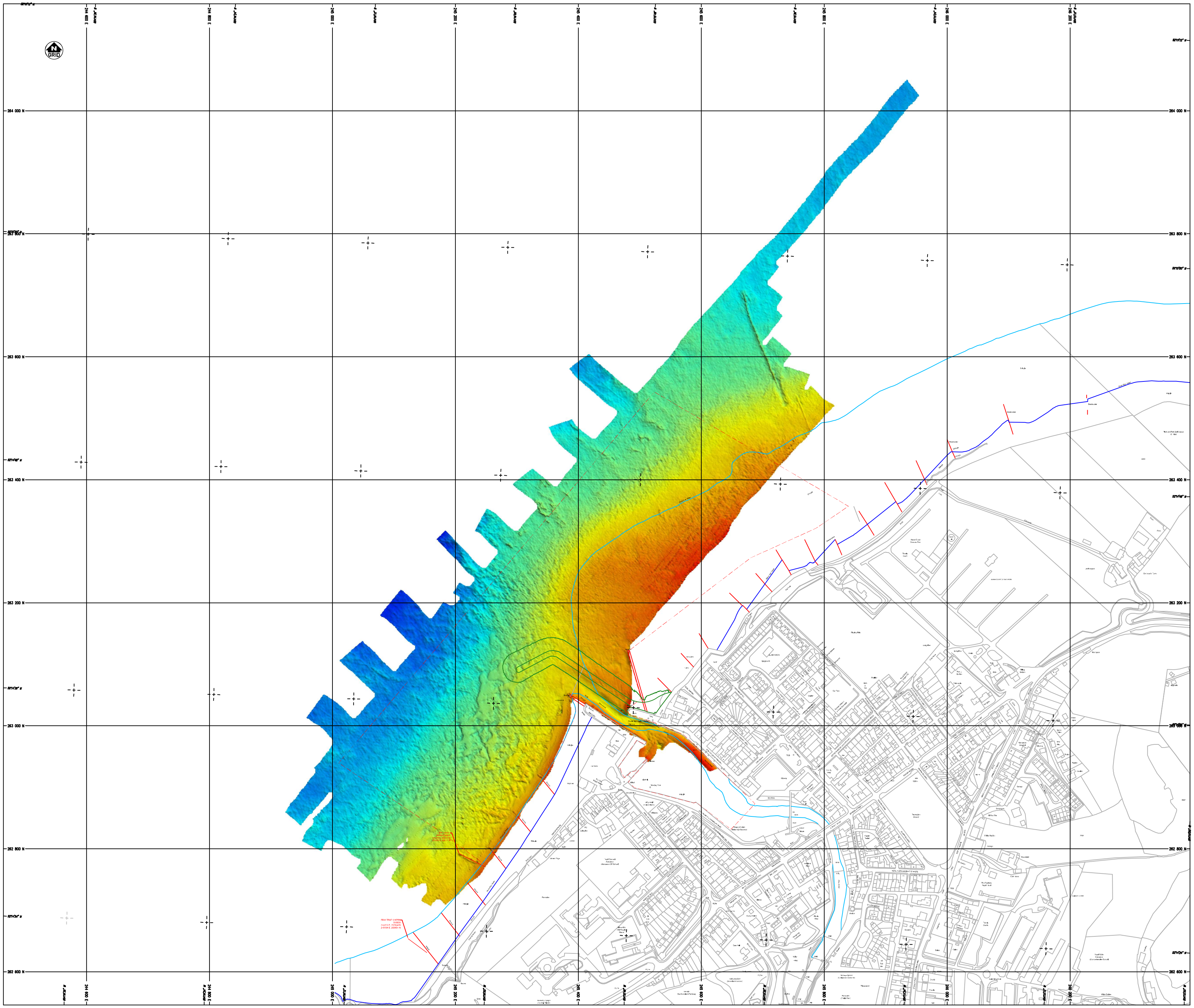
CHART 1 OF 5

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	04-JAN-2021	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	KSM	MC	MK	DIG

TITAN REFERENCE CSBID3173 | REPORT REFERENCE 11557 | DRAWING NUMBER 11557.01

D.2 SHADED RELIEF



LEGEND

PROPOSED BREAKWATER

SURVEY AREA

DEPTH IN METRES BELOW ODN (ORDNANCE DATUM NEWLYN)

0.0 / 1.0 / 2.0 / 3.0 / 4.0 / 5.0 / 6.0 / 6.8

NOTES

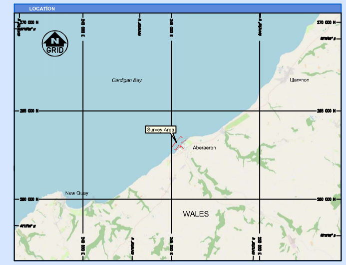
DATA WAS REDUCED TO ODN VIA THE OSGM15 GEOID

BATHY WAS GRIDDED AT 1 x 1m

TIME REFERENCED TO UTC

SHADED RELIEF IMAGE - AZIMUTH=45°, ELEVATION=55°

LOCATION



GEODETIC REFERENCE SYSTEM

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PROJECTION:	BRITISH NATIONAL GRID
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SURVEY INFORMATION

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SURVEY DATE:	26-NOV-2020 TO 29-NOV-2020
POSITIONING SYSTEM:	TRIMBLE SPS GNSS RECEIVER WITH RTK SOLUTION (C/W TRIMBLE VRS NOW)
NAVIGATION SYSTEM:	QPS QINSy
ECHO SOUNDER (MULTI-BEAM SYSTEM):	KONGSBERG GEOACOUSTICS GEOSWATH GS4
SIDE SCAN SONAR:	EDGETECH 4200FS
SUB-BOTTOM PROFILER:	APPLIED ACOUSTICS SURFACE TOW BOOMER
MAGNETOMETER:	GEOMETRICS G882

SCALE (A0 ORIGINAL)

1 : 2 000 (Horizontal)

20 0 100 200

METRES

TITLE

SURVEY CONTRACTOR

Titan Environmental Surveys Limited

A GARDLINE COMPANY

TITAN ENVIRONMENTAL SURVEYS LIMITED
ORION HOUSE, PARC CRESCENT, WATERTON INDUSTRIAL ESTATE, BRIDGEND, SOUTH WALES, CF31 3BQ
TELEPHONE +44 (0) 1656 673673 FAX +44 (0) 1656 673674 WEBSITE WWW.TITANSURVEYS.COM

CLIENT

Quantum Geotechnic

PROJECT TITLE

ABERAERON GEOPHYSICAL SITE INVESTIGATION

DRAWING TITLE

SHADED RELIEF

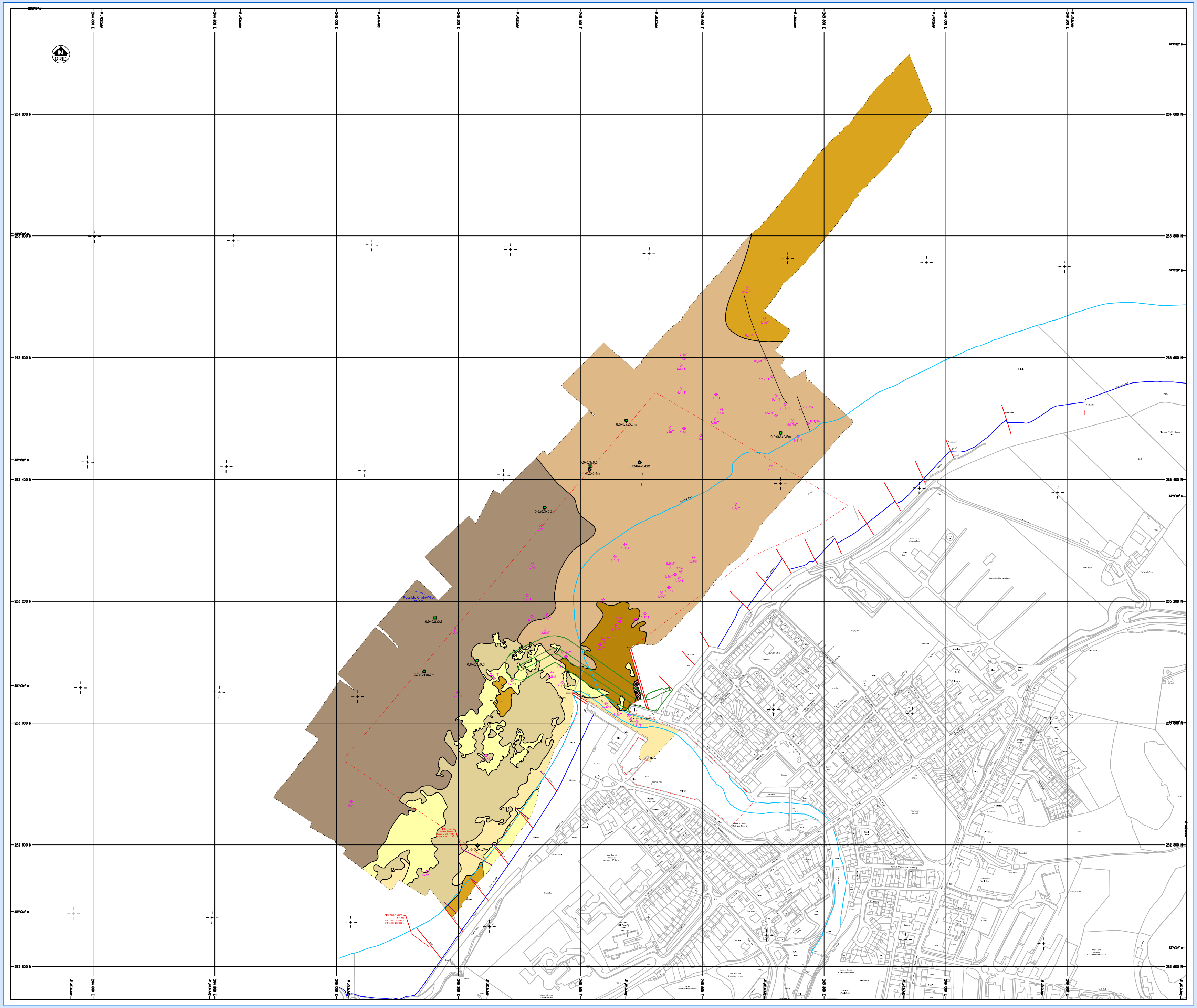
CHART 2 OF 5

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	04-JAN-2021	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	KSM	MC	MK	DIG

TITAN REFERENCE CSBID3173 | REPORT REFERENCE 11557 | DRAWING NUMBER 11557.01

D.3 SEABED FEATURES



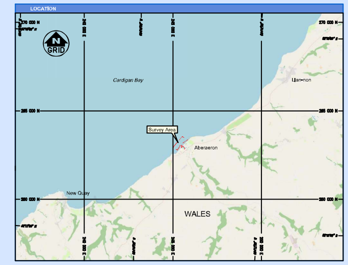
LEGEND

- PROPOSED BREAKWATER
- FINE SAND
- SILTY SAND
- GRAVELLY SAND
- GRAVELLY SAND WITH OCCASIONAL BOULDERS
- GRAVEL
- GRAVEL WITH COBBLES
- GRAVEL WITH COBBLES AND OCCASIONAL BOULDERS
- ROCKDUMP
- EXISTING INFRASTRUCTURE
- INTERPRETED OUTFALL PIPELINE
- LINEAR DEBRIS WITH LENGTH IN METRES
- BOULDER WITH HEIGHT IN METRES
- MAGNETOMETER ANOMALY WITH FIELD STRENGTH IN nT/m
- LIMIT OF SONAR COVERAGE
- SURVEY AREA

NOTES

POOR WEATHER THROUGHOUT THE DURATION OF THE SURVEY HAS LED TO THE POTENTIAL FOR MISSED BOULDERS ACROSS THE SITE, AS SNATCHING EFFECTS MAY HIDE OR RESULT IN LOW CONFIDENCE MEASUREMENTS OF SEABED CONTACTS.

LOCATION



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ELLIPSOID:	AIRY 1830
PROJECTION:	BRITISH NATIONAL GRID
COORDINATE TRANSFORMATION:	FROM ETRS89 TO OSGB 1936/BRITISH NATIONAL GRID EPSG TRANSFORMATION CODE 7953

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SIDE SCAN SONAR:	EDGETECH 4200FS
SUB-BOTTOM PROFILER:	APPLIED ACOUSTICS SURFACE TOW BOOMER
MAGNETOMETER:	GEOMETRICS G882

SCALE (A0 ORIGINAL)

1 : 2 000 (Horizontal)

20 0 100 200 METRES

TITLE

SURVEY CONTRACTOR

Titan Environmental Surveys Limited
A GARDLINE COMPANY
TITAN ENVIRONMENTAL SURVEYS LIMITED
ORION HOUSE, PARC CRESCENT, WATERTON INDUSTRIAL ESTATE, BRIDGEND, SOUTH WALES, CF31 3BQ
TELEPHONE +44 (0) 1656 673673 FAX +44 (0) 1656 673674 WEBSITE WWW.TITANSURVEYS.COM

CLIENT

Quantum Geotechnic

PROJECT TITLE

ABERAERON GEOPHYSICAL SITE INVESTIGATION

DRAWING TITLE

SEABED FEATURES

CHART 3 OF 5

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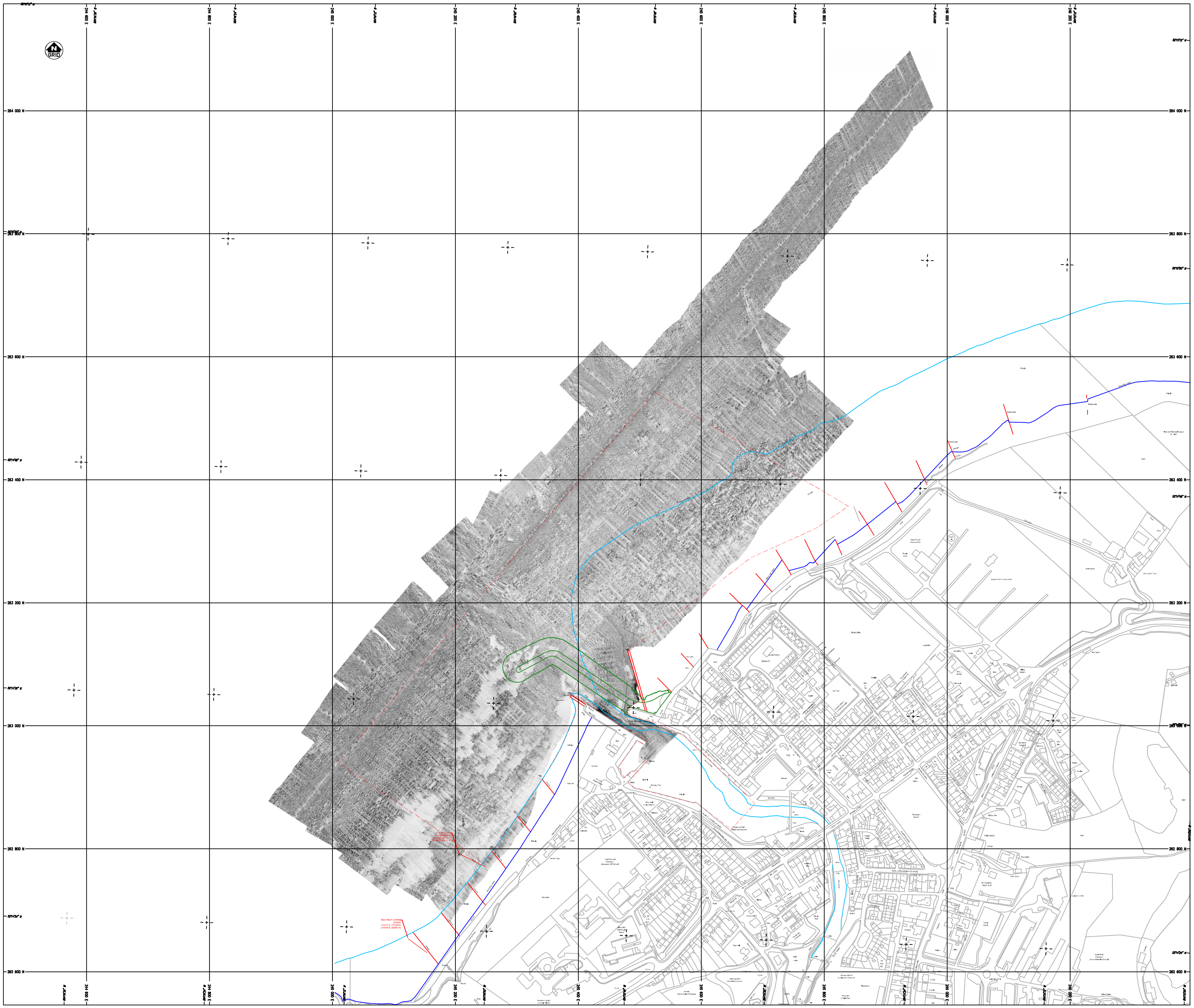
0	04-JAN-2021	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	KSM	EB	MK	DIG

TITAN REFERENCE	CSBID3173	REPORT REFERENCE	11557	DRAWING NUMBER	11557.03

D.4 SSS MOSAIC



LEGEND

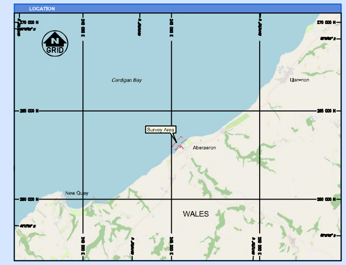
PROPOSED BREAKWATER

SURVEY AREA

NOTES

THE SIDE SCAN SONAR MOSAIC HAS BEEN GENERATED FROM THE HIGH FREQUENCY (APPROXIMATELY 400kHz) DATA AND IS PRESENTED AT A RESOLUTION OF 0.1m.

LOCATION



GEODETIC REFERENCE SYSTEM

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SUB-BOTTOM PROFILER:	APPLIED ACOUSTICS SURFACE TOW BOOMER
MAGNETOMETER:	GEOMETRICS G882

SCALE (A0 ORIGINAL)

1 : 2 000 (Horizontal)

20 0 100 200

METRES

TITLE

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CLIENT

Quantum Geotechnic

PROJECT TITLE

ABERAERON GEOPHYSICAL SITE INVESTIGATION

DRAWING TITLE

SIDE SCAN SONAR MOSAIC

CHART 4 OF 5

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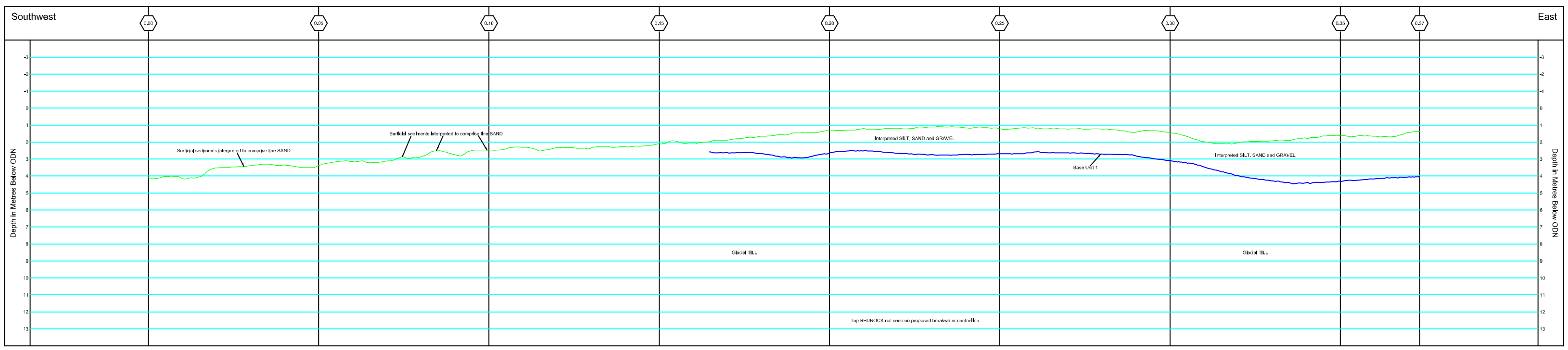
TITAN REFERENCE CSBID3173 | REPORT REFERENCE 11557 | DRAWING NUMBER 11557.04

D.5 INTERPRETED GEOLOGICAL PROFILE



LEGEND

SEABED

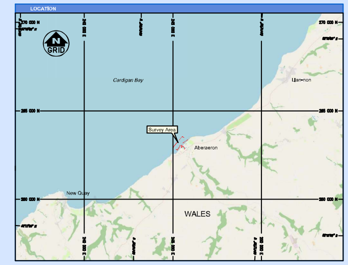
BASE UNIT 1

NOTES

ASSUMED SEISMIC VELOCITY = 1700m/s

VERTICAL SCALE = 1 : 100

LOCATION



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SIDE SCAN SONAR:	EDGETECH 4200FS
SUB-BOTTOM PROFILER:	APPLIED ACOUSTICS SURFACE TOW BOOMER
MAGNETOMETER:	GEOMETRICS G882

SCALE (A0 ORIGINAL)

1 : 500 (Horizontal)

5 0 25 50

METRES

TITLE

SURVEY CONTRACTOR

TITAN ENVIRONMENTAL SURVEYS LIMITED
ORION HOUSE, PARC CRESCENT, WATERTON INDUSTRIAL ESTATE, BRIDGEND, SOUTH WALES, CF31 3BQ
TELEPHONE +44 (0) 1656 673673 FAX +44 (0) 1656 673674 WEBSITE WWW.TITANSURVEYS.COM

CLIENT

PROJECT TITLE

ABERAERON GEOPHYSICAL SITE INVESTIGATION

DRAWING TITLE

INTERPRETED GEOLOGICAL PROFILE (CENTRE LINE THROUGH PROPOSED BREAKWATER)

CHART 5 OF 5

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	04-JAN-2021	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	KSM	EB	MK	DJG

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