REPORT

Geophysical Survey of Flow-slide Barrier

Amity Point, North Stradbroke Island

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1.0 INTRODUCTION

Golder Associates Pty Ltd, a member of WSP (Golder) was engaged by Redland City Council (RCC) to undertake a non-intrusive geophysical investigation along the existing Flow-Slide Barrier (FSB) and offshore area at Amity Point, North Stradbroke Island. In general accordance with proposal document CX21453895-001-P-Rev1 dated 13 August 2021, Golder carried out geophysical testing with the objective being to provide information to assist in monitoring changes in the condition of the FSB since previous geophysical surveys were carried out by Golder in 2016 and 2017 (documented in report ref: 1650770-003 Rev2 and 1650770-006 Rev1).

This report presents the result of both the land and marine components of the completed geophysical investigation, which involved using the land based Multi-Channel Analysis of Surface Waves (MASW), Electromagnetic (EM), and Ground Penetrating Radar (GPR) survey methods, in combination with the overwater Sub-Bottom Profiling (SBP), Side Scan Sonar (SSS), and marine Electrical Resistivity Imaging (ERI) methods. Acquisition of the geophysical data was carried out between November and December 2021 by a crew of two (2) experienced Golder geophysicists.

2.0 SITE DESCRIPTION AND PROJECT UNDERSTANDING

The rock armoured FSB stretches for approximately 900 m, from the Amity Point boat ramp in the south, to the northern-most property located on Millers Lane. The FSB fronts onto mainly private residential allotments. We understand that RCC commissioned Golder to undertake this repeat geophysical survey to provide an updated assessment of the profile and condition of the FSB as part of an update to the RCC’s ongoing Amity Point Shoreline Erosion Management Plan (SEMP), and to inform maintenance activities.

We understand that the FSB consists predominately of boulders, which at the landward side are overlain by topsoil and fill and largely covered by backyard lawns. The toe of the wall is below Lowest Astronomical Tide (LAT) level and is partially buried beneath marine sands. The FSB rock material is subject to erosion through coastal seabed processes and channel dynamics and has on occasions been required to be replenished in several places.

As the result of ongoing erosion, FSB movement, and replenishment, the rock profile is considered variable in its form and founding level. Work completed previously by Golder (documented in report ref:1650770-006-R-Rev1, dated 5 September 2017) found that the rock armour is estimated to extend between 7 m to 9 m from the FSB crest on its landward side and between 3 m to 13 m towards seaward. Previous geophysical results indicated potential boulder displacement from the FSB. Some of these boulders were found up to 60 m seaward of the FSB. The FSB was interpreted to range in thickness from <1 m to 7.5 m on the landward side and up to 6 m thickness offshore.

3.0 SCOPE OF WORKS

Golder was commissioned by RCC to make an updated estimate of the landward and seaward extents of the FSB rock armour using combined land and overwater geophysical survey methods.

The scope of works included:

- A land-based geophysical component, comprising MASW, EM, and GPR survey methods along the (approximately) 900 m of shorefront along the FSB; and
- A marine geophysical component, comprising SSS, SBP, and marine ERI survey methods along the (approximately) 900 m nearshore area along the FSB.

The results from the combined geophysical investigation would be used to produce a site wide assessment of the rock armour thickness and width.

4.0 METHODOLOGY

Details of each of the completed geophysical methods are provided below.

4.1 Multi-Channel Analysis of Surface Waves (MASW)

4.1.1 Overview

Multi-channel Analysis of Surface Waves (MASW) is a seismic method that utilises the dispersive properties of surface waves to determine the shear wave (S-wave) velocity profile of the subsurface. The S-wave velocity is influenced by material type and density and therefore can be used to image the subsurface soil profile and assist in making an assessment regarding the depth to the base of the rock wall.

4.1.2 Field Procedures and Equipment

A total of 39 MASW lines were completed along the site. MASW lines were set up where practicable, with care taken to leave private property as it was found.

The MASW survey involves moving a geophone streamer at pre-determined intervals. The seismic energy source for the MASW survey was produced by hitting a metal plate with a 5 kg sledgehammer (see Inset 1). Upon impact, a transducer “trigger switch” attached to the hammer initiates the MASW record.

Vibrations of the S-waves were recorded using 4.5 Hz Geophones arranged along the streamer in a linear array of 24 channels, spaced 0.5 m apart. The data was logged using a Geometrics Geode seismograph. MASW soundings were spaced at 1 m intervals in straight lines both parallel and perpendicular to the wall frontage. The hammer impact location, or “shot offset”, was positioned 1 m from the final geophone of the array.

The start and end locations of the MASW lines were marked on site, and the coordinates taken using a handheld Garmin GPS, with quoted accuracy of ±5 m.

Inset 1: MASW streamer set-up on FSB, using sledge hammer seismic source

The Acquisition parameters used during the MASW survey were as follows:

- Sampling interval: 0.125 ms

- Record length: 1 s
- Files saved in Seg2 format

The completed MASW line details are summarised below in Table 1 and are presented in the site locality maps in Figure 01 and Figure 02.

Table 1: Seismic Survey Line Location Summary

Line ID	Orientation	Line distance (m)	Easting*	Northing*	Line distance (m)	Easting*	Northing*	Seismic Line Length (m)
LINE 0	S-N	0	543260	6969104	71.5	543260	6969174	71.5
LINE 1	S-N	0	543264	6969177	37.5	543262	6969214	37.5
LINE 2	S-N	0	543263	6969211	57.5	543274	6969269	57.5
LINE 3	S-N	0	543271	6969270	31.5	543273	6969301	31.5
LINE A	W-E	0	543268	6969259	21.5	543287	6969255	21.5
LINE 4	S-N	0	543272	6969303	33.5	543277	6969336	33.5
LINE B	W-E	0	543274	6969286	21.5	543294	6969277	21.5
LINE 5	S-N	0	543283	6969352	28.5	543278	6969381	28.5
LINE C	W-E	0	543275	6969307	21.5	543297	6969304	21.5
LINE 6	SW-NE	0	543279	6969381	39.5	543300	6969415	39.5
LINE 7	SW-NE	0	543302	6969415	28.5	543313	6969439	28.5
LINE D	W-E	0	543309	6969426	21.5	543329	6969417	21.5
LINE 8	S-N	0	543311	6969432	49.5	543311	6969481	49.5
LINE 9	S-N	0	543311	6969480	15.5	543316	6969493	15.5
LINE 10	SW-NE	0	543318	6969500	35.5	543341	6969525	35.5
LINE E	NW-SE	0	543325	6969505	21.5	543343	6969493	21.5
LINE 11	SE-NW	0	543329	6969542	34.5	543308	6969570	34.5
LINE F	W-E	0	543305	6969567	16.5	543321	6969569	16.5
LINE 12	SW-NE	0	543303	6969566	49.5	543315	6969614	49.5
LINE G	NW-SE	0	543315	6969615	21.5	543332	6969601	21.5
LINE H	NW-SE	0	543326	6969641	21.5	543345	6969631	21.5
LINE 13	SW-NE	0	543329	6969650	35.5	543351	6969678	35.5
LINE I	NW-SE	0	543329	6969650	21.5	543347	6969640	21.5
LINE 14	SW-NE	0	543353	6969687	14.5	543359	6969699	14.5
LINE 15	SW-NE	0	543360	6969698	17.5	543368	6969712	17.5
LINE 16	SW-NE	0	543370	6969714	18.5	543379	6969730	18.5
LINE J	NW-SE	0	543372	6969722	21.5	543389	6969709	21.5
LINE 17	SW-NE	0	543378	6969732	27.5	543387	6969759	27.5
LINE 18	S-N	0	543393	6969765	31.5	543398	6969795	31.5
LINE K	NW-SE	0	543394	6969772	21.5	543412	6969758	21.5
LINE 19	SW-NE	0	543398	6969798	19.5	543407	6969816	19.5
LINE L	NW-SE	0	543412	6969821	21.5	543431	6969810	21.5
LINE M	NW-SE	0	543417	6969833	21.5	543434	6969821	21.5
LINE 20	SW-NE	0	543417	6969843	23.5	543431	6969862	23.5
LINE N	NW-SE	0	543435	6969867	21.5	543455	6969858	21.5
LINE 21	SW-NE	0	543435	6969865	51.5	543464	6969906	51.5
LINE O	NW-SE	0	543462	6969908	21.5	543476	6969893	21.5

Notes: * Coordinates recorded in WGS84, Z56.

4.1.3 Data Processing and Analysis

The MASW data was processed using Surfseis (ver. 5.0) software developed by Kansas Geological Survey. Data processing consists of three parts: creating .kgs group files and applying line geometry, generating dispersion-curves and picking of dispersion curves, and the inversion. After removing any "noisy" traces from the seismic record, the acquired data is transformed into the frequency-phase velocity domain and the spectrum of the fundamental-mode surface wave (Rayleigh wave; M0) is separated from other seismic waves (e.g., body waves). A dispersion curve is then picked following the trend of energy of the fundamental mode surface wave. The inversion process in Surfseis converts the picked dispersion curve to a one-dimensional (1D) solution of shear velocity (V_s) versus depth at the mid-point of the dataset being analysed. The 1D solutions from each location are then contoured as 2D cross-sections of V_s to facilitate interpretation.

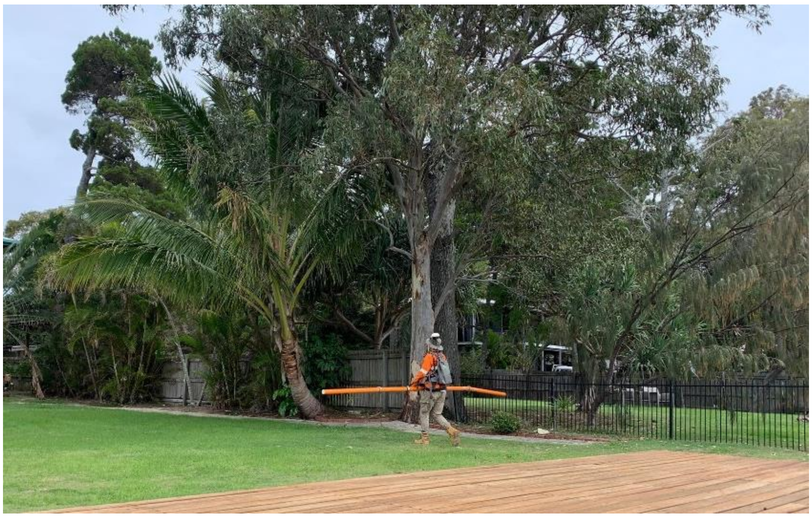
4.2 Electromagnetic (EM) Survey

4.2.1 Overview

The electromagnetic (EM) method utilises the electromagnetic induction concept, whereby an alternating current is passed through a wire coil (the transmitter) producing a time-varying magnetic field. This field induces an electrical current in nearby conductive materials. The induced currents produce a secondary magnetic field, which is sensed with the primary field at the receiver coil. The apparent conductivity of the subsurface is influenced by void ratio, degree of saturation, salinity of groundwater, metallic content, and material type. Therefore, variations in apparent conductivity can be imaged in two-dimensional horizontal slices of the subsurface to infer the distribution of rock within the ground materials.

4.2.2 Field Procedures and Equipment

The EM survey was completed using the GF Instruments CMD-Explorer frequency domain electromagnetic conductivity meter. The CMD-Explorer measures apparent conductivity (in milli-siemens per metre, mS/m) of the subsurface at 2.2 m, 4.2 m, and 6.7 m below the instrument level, simultaneously. The rock wall was screened with EM by completing lines spaced approximately 5 m apart and extending approximately 5-20 m from the edge of the wall, dependant on site access. Lines were completed on foot, with the conductivity meter harnessed on to the operator (see Inset 2).



Inset 2: EM conductivity meter harnessed to operator, showing typical site conditions

The CMD-Explorer was used in the horizontal coplanar (HCP) configuration, where the dipole orientation is vertical. This maximises the penetration depth of the instrument. The instrument was set up approximately 1 m above surface level and carried at walking pace (~5 km/hr), logging continuously at a measurement frequency of 2.5 Hz. The system was integrated with a backpack mounted DGPS for positioning information, accurate to 1 m.

A track plot of the completed EM survey test locations is shown in Figures 3 and 4.

The measuring ranges for the CMD instrument are as follows:

- Apparent conductivity: 1000 mS/m, resolution 0.1 mS/m
- Measurement accuracy: ±4% at 50 mS/m.

4.2.3 Data Processing

The separately acquired EM data sets from each property along the rock wall frontage were first collated into one large spreadsheet. The software package Surfer 18 was then used to plot the colour contours of the three different apparent conductivities at each effective depth sample (1.2 m, 3.2 m, and 5.7 m below ground level [bgl]).

4.3 Ground Penetrating Radar (GPR)

4.3.1 Overview

GPR is a geophysical method that is used to create high resolution images (sections) of the shallow subsurface. The GPR system consists of one transmit antenna that emits an electromagnetic pulse into the ground. Emitted electromagnetic radiation (in the megahertz range) is reflected by subsurface structures, voids and/or any other boundaries with a different dielectric constant and/or conductivity. These reflections are then received at a second antenna. The reflecting horizons, or objects, can occur where there is an abrupt change in the subsurface material dielectric permittivity, such as at the interface between saturated and unsaturated materials (water table), stratigraphic horizons, and interfaces between natural and man-made materials.

The antennas are moved stepwise along a traverse and readings are taken at discrete intervals. At each step, the amplitudes of received radar energy are recorded as a function of time, processed in real-time for display purposes, and the raw data recorded digitally for later processing and presentation.

The GPR method has a limitation in the presence of electrically conductive soil (such as most clays) in which electromagnetic waves are attenuated and therefore severely restrict the radar signal range and the maximum depth of investigation. Typically, increased soil moisture, especially in the highly conductive marine environment, further increases the radar attenuation rates, since an increase in moisture content usually causes an increase in ground electrical conductivity.

4.3.2 Field Procedures and Equipment

The GPR survey was conducted using equipment listed below:

- MALA Ground Explorer Control Console on IPAD
- 450 MHz frequency MALA Ground Explorer antenna
- GPR cart with calibrated odometer wheel

In ideal conditions, the 450 MHz antenna can provide reasonable resolution of anomalies down to a depth of approximately 2 m to 4 m. The odometer attached to the rough terrain cart accurately measures surveyed distances, and the collected data was positioned using a cart-mounted DGPS system.

The survey was completed on foot, pushing a cart mounted GPR antenna along continuous lines, both parallel and orthogonal to the rock wall alignment (see Inset 3).

A site plan showing the completed GPR line locations is shown in Figures 5 and 6.

Inset 3: GPR survey underway in typical site conditions

4.4 Sub-Bottom Profiling (SBP)

4.4.1 Overview

SBP is a geophysical method that is used to create high resolution images (sections) of the shallow subsurface in marine settings. The SBP system consisted of a boomer source and hydrophone receiver array, that were each towed 20 m behind the vessel and parallel to each other. The boomer source emits a seismic pulse which transmits energy through water and penetrates the seabed. The energy reflected from the layers beneath the seabed is received by the hydrophone array and recorded and processed by an on-board acquisition computer.

The objective of the SBP survey is to enable mapping of the extent and thickness of the toe of the rock wall beneath the sea floor.

4.4.2 Equipment and Field Procedures

The Sub-Bottom Profiling (SBP) was completed using an Applied Acoustics Boomer system, with a 200-600 Joules model towfish, towed 20 m behind the vessel. The Applied Acoustics system is a wideband frequency modulated (FM) sub-bottom profiler utilising full spectrum CHIRP technology resulting in high resolution imagery of the sub-bottom stratigraphy and structure.

The acquisition settings consisted of 20 kHz sampling frequency, a trigger interval of 200 ms and record length of 50 ms. The vessel speed for the SBP survey was generally maintained at 3 to 5 knots.

The SBP equipment was interfaced to a computer system through SonarWiz 6 software, which enabled navigation data to be appended to the seismic digital record and depth window control. The seismic data were recorded in the industry standard SEGY format in accordance with typically accepted practice.

A track plot of the completed SBP survey lines is shown in Figures 7 and 8.

4.4.3 Data Processing

The SEGY data files were imported into ReflexW v 8.1 software for processing and interpretation. During data processing filtering, trace interpolation and normalisation, and gain enhancements were considered to optimise the output of the seismic records. Interpretation of the SBP data involved bottom tracking and, where observed, identifying the top and base of the buried FSB rock material along the seabed.

4.5 Side Scan Sonar (SSS)

4.5.1 Overview

Side Scan Sonar (SSS) is a geophysical technique which provides high resolution images of the seabed, allowing identification of features on the seafloor. The objective of this technique was to assess the extent of the toe of the rock wall beneath the water and enable mapping of any other seabed features present including extent of displaced rock armour boulders.

4.5.2 Equipment and Field Procedures

The side scan sonar survey was undertaken using a digital Tritech Starfish Side Scan Sonar. This is a high resolution SSS system that is used to collect sea floor sonar data defining the likely nature of the materials and objects on the seabed. The SSS towfish operated at 450 kHz and with a beam range of 25 m. The towfish was mounted to the vessel and was interfaced with SonarWiz 6 software. This also provides real time mosaics and digitally records the data with time stamps and navigation data in accordance with typically accepted practice. The survey was carried out at a vessel speed of 4 to 5 knots.

4.5.3 Data Processing

The raw SSS files were imported into SonarWiz 6.0 software for processing and interpretation. Analysis of the SSS data involved offset corrections, beam width corrections, bottom tracking, gain enhancement, and productions of mosaics. Picking of features was undertaken in both the waterfall mode, where high resolution images allow improved delineation of features, and also in the generated mosaic where geographical correlation of features allows patterns to be better identified.

4.6 Marine Electrical Resistivity Imaging

4.6.1 Overview

Marine Electrical Resistivity Imaging (ERI) is used for imaging subsurface structures using electrical measurements collected at the surface. The method maps differences in the electrical properties of subsurface materials which can result from variations in sediment or rock type. Volcanic rock, which is what the rock armour is composed of is expected to have a higher resistivity than the surrounding saturated sand.

4.6.2 Equipment and Field Procedures

The marine ERI was carried out using a ZZ Resistivity resistivity meter and a 32-electrode cable with 2 m electrode spacing. Acquisition was carried out using ZZ Universal software and a laptop computer. A map of the completed marine ERI line locations is provided in Figures 9 and 10.

4.6.3 Data Processing

The raw marine ERI data were edited and processed in ZZ Resistivity inversion software. In order to generate a resistivity image from the marine ERI data it is necessary to carry out an inversion that produces a model (that is, a spatially varying distribution of resistivity) which gives an acceptable fit to the data and satisfies any other prescribed constraints. Prior to running each inversion, test locations were assigned based on DGPS data collected during the survey, and sea floor data, provided to Golder by RCC, was integrated into the model to assist in constraining the inversion results.

4.7 Navigation

The horizontal datum used in this report is the World Geodetic System 1984 (WGS84) Map Grid of Australia (MGA) Zone 56.

The vessel (and all ancillary locations) positioning was determined with DGPS positions. This typically has sub-metre accuracy, depending upon horizontal dilution of precision (HDOP) values. This level of accuracy is usually adequate for this type of survey. Lever arm offsets between layback tie points and the GPS antenna centre were rigorously determined and checked throughout the survey. Sonarwiz survey software was used for pre navigation set up and on-board vessel navigation along pre-defined survey lines.

5.0 RESULTS

5.1 Multi-Channel Analysis of Surface Waves (MASW)

The results of the MASW survey are presented as contoured sections of modelled S-wave velocities (V_s) versus elevation (Figures 11 to 28). The sections are presented at a natural scale of 1:150, and the MASW sections are all shown using the same colour scale. The distance shown on the x axis is a plan distance, and represents the distance along the completed MASW line. Note that the MASW sections are from survey lines parallel to the rock wall and lines orthogonal to the rock wall. The nature of MASW processing is such that no data is generated on the two ends of each completed MASW line, over approximately 5.5 m sections at each end. The resulting effect is that the orthogonal MASW lines will only image the FSB in locations where the FSB materials extend greater than 5.5 m landward from the seaward extent of the accessible land platform created by the FSB.

The MASW survey was completed as a series of discrete lines terminating at the boundaries on individual properties, which resulted in non-continuous data.

The modelled V_s values range from 60 m/s to 650 m/s. Reliable estimates of V_s were obtained to a depth of between approximately 3 to >10 m below ground level (BGL).

For the MASW lines completed parallel to the rock wall, the velocity contours generally show horizontal layering. Most of the velocity sections show a velocity inversion, with a zone of higher velocities overlying lower velocities, and velocities increasing below this. Where present, this profile has been interpreted as representing a mixed zone of boulders, fill materials, and possible voids or air pockets between the boulders, with the distinct low velocity zone representing the interface between the rock armour and underlying dense sands. This profile is not present on all sections of the MASW lines completed parallel to the rock wall, and in these cases the base of rock armour has not been interpreted. In some locations where the base of rock armour has been interpreted, the higher velocity material in the shallow layer connects through to the lower velocity underlying materials. In these locations it is considered likely that the rock armour is placed in a denser sand material and the low-velocity inversion zone is not observable, and an interpreted base of rock armour has been interpolated through these locations. However, it would be recommended that further intrusive testing be completed to provide calibration of the MASW results and interpretation.

The MASW lines completed orthogonal to the rock wall show a more variable profile, and most of the sections do not show a strong velocity inversion indicating that they did not encounter the rock wall profile. This is likely due to the rock wall extending less than 6 m landward from the furthest accessible point on the seaward side. Typically, the orthogonal lines show a continuous increase in velocity with depth, with velocities ranging from those typical of very loose to loose sands (<100 to 200 m/s) to those typical of dense to very dense sands (350-500 m/s). This is considered to be indicative of a profile of loose sands overlying dense sands, with some densification of the very loose sands at the surface as a result of compaction due to surface traffic.

In some locations, the seaward end of the MASW section shows a velocity inversion similar to that observed in the parallel lines; at these locations, and where it is in agreement with the available EM results, it has been interpreted as the edge of the rock wall, tapering away to the landward side. Where a velocity inversion similar to that observed in the parallel lines is present but the EM results show no indication of rock wall materials, no interpretation of the MASW results has been made.

On the S-wave velocity sections shown in Figures 11 to 28, an interpreted base of the FSB rock materials has been indicated using a thickened, dashed red line. MASW lines which the EM results indicate are off the FSB footprint have not been interpreted with respect to the FSB materials. The thickness of the interpreted base of the FSB rock materials has been geo-referenced and provided as an interpreted rock depth contour map, presented in Figures 29 and 30.

5.2 Electromagnetic Survey (EM)

Results of the EM screening over the site are presented in Figures 31 to 34. The figures show the colour contour maps of the apparent conductivity across the site at the sample depth of 1.2 m BGL. The 3.2 m and 5.7 m BGL conductivities were considered to sample too great a depth and as a result were dominated by the effects of saline ground water saturation and were less effective at reflecting changes in the relatively shallow rock armour thickness. As a result, these depth samples have not been presented as part of this report. The 1.2 m BGL conductivity readings generally ranged between 2 mS/m and 400 mS/m with average and median conductivity values of 30 mS/m and 22.5 mS/m respectively. Each of the apparent conductivity contour maps show a relatively continuous, high conductivity feature running approximately north to south along the western side of the survey area. This is likely to represent the effect of saturation of the rock wall with seawater, and occurs predominantly when in close proximity to the sea. High conductivity features are also observed in discrete locations interspersed along the survey area, and these features are typically associated with proximity to buildings and surface structures containing high conductivity or ferrous materials. The locations of possible ferrous materials observed during the EM survey have been marked on Figures 31 to 34 with a magenta-coloured diamond symbol.

The occurrence of the rock armour has been interpreted to coincide with the edge of moderately high conductivity values between 15 to 25 mS/m. This is in general agreeance with the interpreted extents of the rock armour observed in the EM results from the 2017 investigation, and additionally shows general agreeance with the MASW results. Landward of the rock armour, conductivity values are generally less than 20 mS/m, except for isolated pockets of high conductivity associated with high conductivity surface structures and objects such as fences, buildings, vehicles.

The interpreted lateral extent of the rock armour has been shown on Figures 31 to 34 using a thickened, dashed red line.

5.3 Ground Penetrating Radar (GPR)

Some example sections from the GPR survey are provided in Figures 35 to 37, alongside coincident or parallel MASW sections. The presence of high conductivity materials severely attenuates the GPR signal and typically prevents imaging beneath such materials. As such it was considered likely that the presence of saline ground water in the survey area may prevent adequate ground penetration with the GPR for the purposes of this investigation. The results show this to be generally the case, and this is consistent with the results of the GPR survey completed during the 2017 investigation.

In Figures 35 to 37, all the lines show some sections with high amplitude ringing signatures from the very near surface to depth. This indicates a strong, high conductivity material close to the surface, with no penetration beneath this material.

In the sections where this GPR response is not at the very near surface, the GPR sections still show penetration to be limited, but they also show regions where there is a variable GPR response in the upper 1 m to 2.5 m, typical of fill and boulders, overlying a more stratified continuous linear reflector which may be representative of the base of the FSB rock materials. Although the example GPR sections show some data useful for further interpretation, the large majority of GPR data was considered to be highly attenuated due to the saline ground conditions, and was not used in this report.

The GPR results, where data quality and penetration were considered sufficient, were not used to assess seawall thickness on their own; they were however used to complement and provide confidence in the MASW results and interpretation shown on Figures 11 and 28.

5.4 Sub-Bottom Profiling

The SBP data was acquired along the offshore extent of the rock armour wall, comprising seven longitudinal lines oriented parallel to the wall. The seaward most line extended approximately 50 m out from the rock armour wall. The main features of the sub-bottom profiling results are summarised below.

The SBP data is generally of good quality. Adequate depth penetration was achieved along the majority of the survey area to interpret the base of the rock boulders used to create the FSB and displaced rock boulders. Depth penetration typically ranged from between 2 m to 10 m below the seabed. The SBP reflection sections are provided in Figures 38 to 43. The reflection sections without any interpretation are shown at the top of each figure, and the same sections with the interpreted seafloor and sub-bottom reflectors overlain are shown on the bottom of the figure.

There were a few isolated areas where the vessel engine noise impacted resolution of the data. The effect of moderate swells are observed on some sections of the lines, but they are not enough to negatively impact the interpretation of the results. Following post-processing, several acoustic artifacts were recognisable in the data, especially seabed ‘multiples’ in shallow water. These require to be identified and isolated during interpretation for sub-bottom features.

The SBP sections for the lines completed in closer proximity to the FSB typically show a highly variable seafloor, generally underlain by a laterally continuous, high amplitude reflector (R1) of between 1 m to 2 m thickness. This layer is quite continuous across the survey area and is interpreted as a sand horizon with boulders outcropping through this reflector. Beneath this the SBP signal becomes more muted and laterally variable. Some locations show a scattered reflection profile (R2), with small, localised, hyperbolic, high amplitude reflections. The areas of scattered reflections show good correlation with the locations of exposed FSB material observed in the SSS results, and these areas are interpreted as the rock armour layer below the seabed. It is unclear if there is signal attenuation below this or whether the reduction in amplitude is coinciding with the base of the rock armour. Where present, the base of the high amplitude, hyperbolic reflections (R2) has been delineated and is interpreted to represent the minimum thickness of the FSB rock materials. Where R2 is not observed the base of R1 is interpreted as the limit of the FSB rock materials.

SBP lines completed further seaward from the shore show a similar response however the presence of the R2 reflector is more intermittent.

Where water depths were shallow, in the lines closest to the FSB, the SBP results typically do not image the seabed reflector as it is hidden by the presence of a high amplitude, linear response generated by the direct arrival between the transducer and the receiver array, which interferes with the reflected signal both at the seabed and the near surface. This effect makes interpretation of the data at these lines very difficult, and is most evident on lines SBP-007 and SBP-010. The results of SBP-007 are so swamped by this effect that the results were considered unreliable for interpretation and are not presented in this report.

An interval velocity of 1500 m/s and 1600 m/s was used to convert ‘two-way times’ seismic data into an interpreted depth for the seabed and the sub-bottom reflectors respectively. These were then corrected for tide levels at the time of survey, and used to estimate the thickness of the FSB rock material.

The interpreted thickness of the FSB rock material layer has been gridded using the Surfer 18 software package (Golden Software) and the results presented as plan view contour map in Figures 44 and 45. This layer has been generated on the combined R1 and R2 reflectors. These figures indicate that the FSB rock material is thickest over the sections closest to the land. The interpreted thickness varies between 0.5 m and 8 m. Most areas indicate thinner rock materials (<2 m thick, blue colours), but some areas show deeper zones of rock material which appear to be close to 8 m thick. The extents of the deeper, scattered reflection profile (R2) have been marked on these figures with a thickened, red line. The extents of this interpreted R2 layer are suggestive of “runouts” of rock boulders from the edge of the revetment wall, indicative of narrowing strips of thicker boulder masses extending out into the channel, and these zones show good correlation with the locations of exposed FSB materials observed in the SSS data. Outside the extents of the R2 layer, the interpreted thickness is based solely on the interpreted R1 layer and the interpreted thickness is generally low (<2 m) and it is possible that these areas incorporate both areas of sand horizon with boulders embedded in it, and also areas where it is only the sand horizon and no rock materials are present.

5.5 Side Scan Sonar

The processed SSS mosaics are presented in Figures 46 to 48. The SSS data was generally of good quality, and interpreted seabed features have been identified in the SSS data over the survey area.

The toe of the exposed rock armour revetment wall is defined in the SSS data and is shown by the continuous blue line in Figures 46 to 48. In addition, the outer extent of exposed rock armour boulder is shown by the red line. Beyond this line, there is no evidence on the SSS images of any rock armour boulders exposed on the seabed. Ripples and sand waves are generally evident of the seabed surface beyond the red line. The surface extent of the observable FSB rock material extends up to 50 m seaward of the toe of the revetment wall in the central foreshore area.

The SBP data is indicative that the rock armour boulders are likely to be blanketed by a layer of sand, possibly being deposited from bottom currents flowing from the channel inlet.

5.6 Marine ERI

The marine ERI sections are presented in Figures 49 & 50. The resistivity results for line MERI-11, the line completed the furthest offshore from the FSB, were found to be very noisy and were not considered reliable for further interpretation, and the results for this line have not been presented in this report.

The modelled resistivity range in the ERI sections is very small, with resistivity values ranging from 0.1 to 1.1 ohm.m. This indicates relatively homogenous resistivity conditions, likely as a result of saltwater saturation of the seafloor materials. The resistivity profiles generally show a vertical resistivity profile, with resistivity values greatest at the seafloor and decreasing with increasing depth below seafloor, however the zones of higher resistivity appear to be quite broad and poorly defined. The highest resistivity values occur in the line completed nearest to the shore (MERI-10), where the SBP data indicates that the rock armour boulders are the thickest and the SSS data shows the rock armour boulders has the most extensive distribution on the seafloor. The resistivity values are observed to generally decrease with increasing distance from the shore. Zones of higher resistivity (>0.7 ohm.m) have been marked on Figures 49 & 50 with a thickened black line.

Resistivity high features show some consistency across adjacent lines, and the interpreted resistive zones correlate moderately well with the locations of thicker FSB rock material interpreted in the SBP data, but some zones of higher resistivity (>0.7 ohm.m) are observed on outside of the locations of thicker FSB rock material interpreted in the SBP data.

5.7 Uncertainty in the Interpretation of FSB Rock Material Thickness

The quality of recorded data was generally good, but we note that there is a margin of error in all remote sensing methodologies. This margin of error can be difficult to quantify, but based on our experience with these methods, when considering the error margins for the interpreted thickness of rock assessments, the following should be considered:

- **MASW** – previous experience with this method indicates that typically MASW models have an error margin of ~10% of the imaged depth. In addition to this, and with no intrusive results to verify the model interpretation, there is potential for error within the interpreted target interface. Allowing a further 10% error to account for this results in a cumulative error of 20%. The maximum depth of the interpreted base of rock armour on the land side in this report is found to be approximately 4.5 m, this results in an error margin of approximately 0.9 m.
- **SBP** – the interpreted depth of rock from the SBP results is dependent on an assumed seismic (P-wave) velocity interval for the mixed rock boulder and fill materials. As the material is saturated, the velocity will be in excess of the velocity of water (~1500 m/s), and less than the velocity of rock (typically 2000 to 2200 m/s). For the interpretation used in this report we have assumed a velocity of 1600 m/s. Our experience indicates that this is typical of a mixed, saturated fill material such as this. To support this assumed velocity, an analysis of the P-wave velocities observed in the seismic records from the MASW testing, in unsaturated conditions, was undertaken. This showed velocities of 1000 to 1300 m/s in unsaturated conditions, which is comparable to the assumed velocity used in the SBP when the saturation effect is taken into account. However, without intrusive testing to verify the results it would be recommended to apply a 10% error margin to this value. In addition to this error margin for depth conversion, the geophysical signature considered to be representative of rock / boulders, and that considered to be representative of natural sands, is not always a sharp interface, with resulting ambiguity in the interpretation. We estimate this ambiguity may result in an error of up to 30% in the interpreted depth of the sub bottom reflectors in these conditions. The resulting cumulative error of 40%, when applied to the maximum interpreted depth of rock being 8.0 m in the SBP results, results in an error margin of approximately 3.2 m.

It is recommended that the results of the MASW and SBP work be verified by intrusive investigations.

6.0 COMPARISON OF RESULTS AGAINST RESULTS OF PREVIOUS INVESTIGATION

Golder previously completed a geophysical investigation, using the same methods as those presented in this report and over approximately the same survey footprints, between the years of 2016 and 2017 (referred to in this report as the 2017 investigation). Overall, the results from this investigation and the 2017 investigation show strong agreeance, with distinct similarities in the extents and thickness of interpreted FSB rock material.

When considering comparisons between different data sets, it is important to consider factors inherent in the data sets that may cause differences, which may not all be due to changes in ground conditions. Differences may be a result of factors including but not limited to differing as-done test locations, differences in accuracy and sensitivity of equipment used to undertake the testing, environmental variations such as weather at the time of testing, positioning error, and subjective ambiguities in the data processing and interpretation stages. Ground conditions may change due to temporal effects of natural or man-made process. However, it is possible that minute changes may be outside the detection limits of the survey methods.

The following sections provide further detail on the correlations between the results of this investigation and the 2017 investigation.

6.1 Multi-Channel Analysis of Surface Waves (MASW)

Generally, the MASW S-wave velocity profiles between the 2017 and current investigations showed very similar results. The S-wave profiles from each investigation indicated a horizontally layered profile, with most velocity sections completed over the FSB showing a surface layer of higher velocities overlying lower velocities, with velocities increasing below it. This is consistent with interpreted conditions of mixed boulders, fill materials and possible voids or air pockets between the boulders within a loose sand material, overlying denser sands.

The interpreted thickness of the FSB rock materials based on the MASW S-wave velocity profiles was contoured for both the 2017 investigation and this investigation. While some localised discrepancies are observed between the two thickness contour maps, the overall trends generally show a good correlation. The 2017 investigation indicated interpreted rock material thickness of between < 1 m up to 3.7 m, whilst the interpreted thickness in this investigation ranged between 0.5 m to 5 m.

6.2 Electromagnetic Survey (EM)

Results of the EM screening over the site from both the 2017 and current investigations were used to generate colour contour maps of the apparent conductivity. Each of the apparent conductivity contour maps show a relatively continuous, high conductivity feature running approximately north to south along the western (seaward) side of the survey area, interpreted as saturation of the rock wall with seawater. High conductivity features are observed in both datasets showing discrete locations interspersed along the survey area, which are typically associated with proximity to buildings and surface structures containing highly conductive or ferrous materials.

The shallow conductivity readings from the 2017 investigation ranged between approximately 2 mS/m and 600 mS/m, and for the current investigation these values ranged between 2 mS/m and 400 mS/m.

The lateral extent of the FSB rock materials has been interpreted from each investigation, based on the change from moderately high conductivity values to lower conductivity vales further inland. The interpreted extents of the rock materials observed in the EM results from the 2017 investigation generally show a strong correlation with those obtained in the current investigation.

Figures 51 to 54 show the interpreted extents of the FSB rock materials from EM and SSS data for both the 2017 investigation and this current investigation.

6.3 Ground Penetrating Radar (GPR)

The GPR results from the 2017 investigation and this report showed strong similarities, in both cases identifying the presence of high conductivity materials which severely attenuated the GPR signal, preventing adequate ground penetration with the GPR for the purposes of the investigations.

Although isolated GPR sections provided some data useful for further interpretation, the large majority of GPR data from both investigations was considered ineffective and was not used in assessing the FSB conditions. Where data quality and penetration was considered sufficient, the results were used to complement and provide confidence in the MASW results and interpretation.

6.4 Sub-Bottom Profiling

The SBP results from the 2017 and current investigations showed broad similarities, however some differences in the detail of results are observed. The SBP data collected in the current investigation provided higher resolution reflection sections, with the following observed features and the contact between these areas better defined in this recent investigation:

- linear high amplitude reflectors;

- areas with more muted reflection response;
- and areas of scattered reflection responses.

In both investigations, where water depths were shallow (in the lines closest to the FSB) the SBP results were observed to not image the seabed reflector due to seismic interference from the direct arrival between the transducer and the receiver array, making interpretation of the data at these lines difficult.

Interpreted thickness contour maps of the FSB rock material were generated for each investigation, based on assumed interval velocities, tidal data at the time of each survey, and bathymetry data provided to Golder by RCC. The broad trends observed in the figures from both investigations show strong correlations. Zones of thicker interpreted FSB material thickness are observed in coincident locations along the length of the survey. Generally, the interpreted thickness values presented in this report are lower than the values observed in the 2017 investigation, and this can largely be attributed to the higher resolution of SBP data from the current investigation allowing for a more accurate and refined assessment of the extent of interpreted FSB rock material conditions.

6.5 Side Scan Sonar

The processed SSS mosaics from both the 2017 and current investigations identified similar interpreted seabed features, including the toe of the exposed rock armour revetment and the outer extent of exposed rock armour boulder. The extents observable of both these features from both the 2017 and current investigations are shown in figures 51 to 54.

The broad trends of these two features identified in the two investigations show a strong correlation. The interpreted toe of the FSB observed in the SSS results is generally consistent between the 2017 and 2021 investigations, with small discrepancies likely related to both positioning inaccuracies and movements in seafloor sand levels. Similarly, the broad characteristics of the observed exposed FSB materials on the seafloor show good agreement. At the southern end of the survey area, offshore from the Amity boat ramp, the 2017 SSS survey identified an 80 m long exposure of FSB materials extending approximately 50 m out from the FSB wall. In the 2021 survey results this now shows as two separate “runouts” extending out from the FSB, which is likely a result of increased sand cover in this area. Other major zones of exposed FSB materials observed in the SSS results show good correlation, with inconsistencies likely attributable to both positioning inaccuracies and movement of sand materials on the seafloor.

6.6 Marine ERI

The extents of the interpreted resistive zones from the 2017 and 2021 investigations are shown in figures 55 and 56 using grey and black lines respectively. In the north of the survey area, the interpreted resistive zones from the two investigations generally show good correlation, however in the southern half of the survey area the recent 2021 investigation shows the interpreted resistive zones to be more continuous and extend further seaward in comparison with the 2017 marine ERI results, indicating possible changed subsurface conditions in this area.

7.0 INTERPRETED CROSS SECTIONS OF FSB PROFILE

Based on the results of this investigation, cross-sections of the interpreted FSB profile have been generated. The cross sections have been extracted at profiles approximately perpendicular to the shoreline, and are presented at approximately 50 m intervals along the survey extents. Figure 57 shows the interpreted FSB rock material extents plan and has the cross section locations overlain. The cross sections are provided in Figures 58 to 61. These present cross sections showing the following features:

- surface profile (based on supplied bathymetry and elevation data, green and dashed red lines respectively);

- the thickness of the interpreted FSB rock boulder/sand profile thickness based on the MASW and SBP interpretations (shown by brown hatched areas on the seaward side and the land side);
- the lateral extents of the zones where the scattered R2 SBP reflector was observed and interpreted to be mainly FSB rock boulder material (shown by light purple hatched area on the seaward side of the sections).

8.0 SUMMARY

A geophysics investigation was successfully completed along the existing Flow-Slide Barrier (FSB) and offshore area along an approximately 900 m long section between the Amity Point boat ramp in the south to the northern-most property located on Millers Lane in Amity Point, North Stradbroke Island. Land based geophysical methods of MASW, EM and GPR were completed on the land side of the FSB, and overwater methods of SBP, SSS and marine ERI were completed in the offshore area. The investigation generally provided good quality data and allowed for an assessment of the vertical and landward lateral extents of the FSB rock armour.

The MASW survey showed a consistent higher-strength layer overlying low-strength materials in the MASW lines completed parallel to the rock armour, which varied in thickness from 0.5 m to 5 m. This was interpreted to represent the rock armour overlying softer sands.

The EM survey showed a trend of high conductivities over the rock armour, with the conductivity values dropping with increasing distance from the wall crest. An approximate conductivity value of 15 mS/m to 25 mS/m was interpreted as being representative of the lateral extent of the rock armour. This interpretation shows the rock armour to extend up to 15 m landward from the crest of the rock armour, and appears to correspond well with the results of the orthogonal MASW lines. The EM results are susceptible to the influence of surface objects with metallic content and so are liable to be affected by surface structures related to property fences, structures, and metallic objects.

The GPR survey was completed across the landward site on lines both parallel and orthogonal to the rock armour. The GPR signal was observed to image the base of the rock armour in locations where high conductivity groundwater was not present and correlated well with the interpreted MASW results. However, for a large portion of the area covered by the GPR survey the presence of shallow saline ground water appears to significantly attenuate the GPR signal, with insufficient depth penetration to allow an interpretation of the base of the FSB rock material. Where possible, the GPR survey was used to complement and provide confidence in the MASW results.

The SSS survey provided imagery of the seabed surface, and has been used to identify the exposed toe of the FSB revetment slope to extend from between approximately 3 m and 30 m from the FSB crest. The survey also allowed an assessment of the extent of exposed rock boulders on the seabed. A number of regions were interpreted as rock armour material extending up to 65 m out from the shore. These features correlate well with the deeper zones of FSB rock material signatures identified in the SBP survey.

The SBP survey was completed along seven longitudinal lines parallel to the shoreline, approximately 5 m to 10 m apart and extending 50 m from the exposed rock armour wall. The SBP sections for the lines completed in closer proximity to the FSB typically show a highly variable seafloor, underlain by a continuous reflector which is interpreted as a sand horizon with boulders outcropping through it. Beneath this the SBP signal becomes more muted. Some locations show a scattered reflection profile interpreted as zones of predominantly buried rock boulder materials. SBP lines completed further seaward indicate a similar profile however the zones of deeper buried materials become more intermittent. In the SBP lines closest to the FSB the results were considered unreliable for interpretation due to interference with the seabed reflector from the direct arrival.

Based on the SBP data interpretation it appears that there is a near continuous, thin reflector layer over the majority of the survey area, however this reflector consists of a continuous shallow reflector interpreted to be a sand horizon with rock boulders outcropping through it. The distribution of thicker zones of interpreted FSB rock materials, where a deeper scattered reflection profile was identified, are less continuous across the survey area and show evidence of features extending outward from the land in possible “runouts” of rock boulders from the edge of the revetment wall. The thickness of this interpreted layer is in the northern central part of the foreshore, where it can be up to 8 m thick. Along the survey extents there are a total of five of these thicker zones extending from the foreshore, and these areas all coincide with boulder outcrop on the seabed as seen in the SSS data.

Resistivity high signatures in the marine ERI data are consistent with the lateral distribution of rock armour boulders delineated in the SBP and SSS data, while being broader and less well defined.

A comparison between the results from the 2017 investigation and this investigation show that all the survey methods completed in each of the investigations showed comparable results and generally strong agreement in the interpreted outcomes. Variations observed in the two data sets may reflect changes in ground conditions, including the placement and erosion/displacement of FSB rock materials, but it is possible that this may also be a result of other factors including differing test locations, equipment accuracy and sensitivity, environmental variations, positioning error, and data processing and interpretation ambiguities.

Cross-sections of the interpreted FSB rock armour profile at intervals along the completed survey area have been generated and are provided as part of this report.

The geometry of the rock armour data presented in this report should be treated as approximate only as they have been interpreted using remote sensing methods. Verification of the results by intrusive methods is recommended.

9.0 LIMITATIONS

Golder’s geophysical services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions and subject to the time limits, financial and physical constraints applicable to the services.

The multi-channel analysis of surface waves, electromagnetic, ground penetrating radar, sub-bottom profiling, side scan sonar and marine electrical resistivity imaging techniques used in the work are remote sensing geophysical methods that may not detect all subsurface features. Depth of penetration is dependent on the nature of the subsurface, acquisition parameters and data quality. Furthermore, it is possible that interpreted features such as stratigraphic boundaries, extent of rock armour materials, assessment of fills, faults, voids, other geologic characteristics, and also buried features / utilities may, upon intrusive sampling, prove to have been misinterpreted. Accurate interpretation of remote sensing data benefits from and to some extent can rely on the site-specific correlation of information with that obtained from direct observation, possibly borehole drilling, in situ testing or digging methods.

Your attention is drawn to the document titled – “Important Information Relating to this Report”, which is included in Appendix A. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters.

Golder Associates Pty Ltd

Romney Rayner
Senior Geophysicist

Tariq Rahiman
Principal Geophysicist

RR/TR/hn

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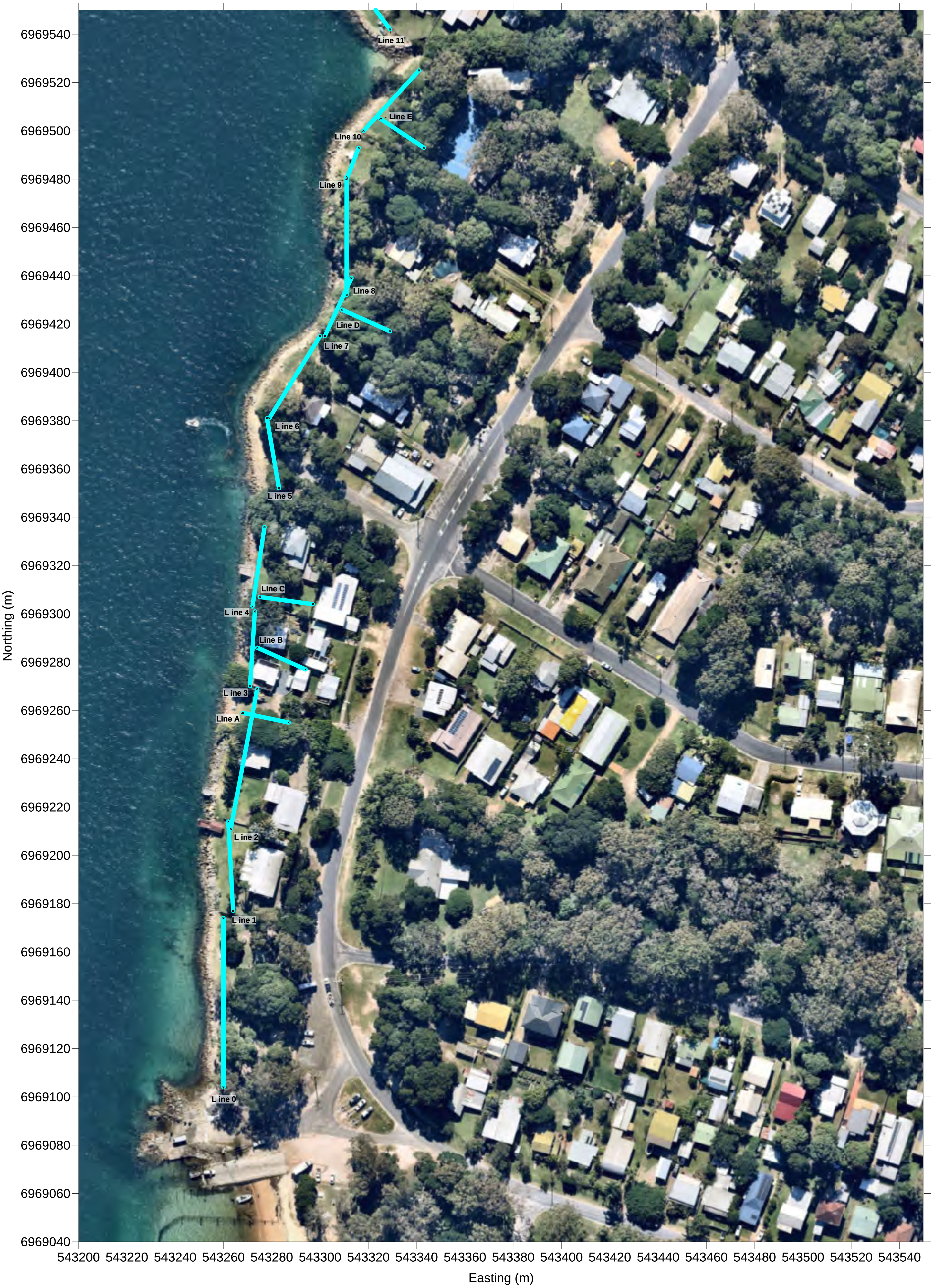


LEGEND

MASW LINE

CLIENT
REDLAND CITY COUNCIL

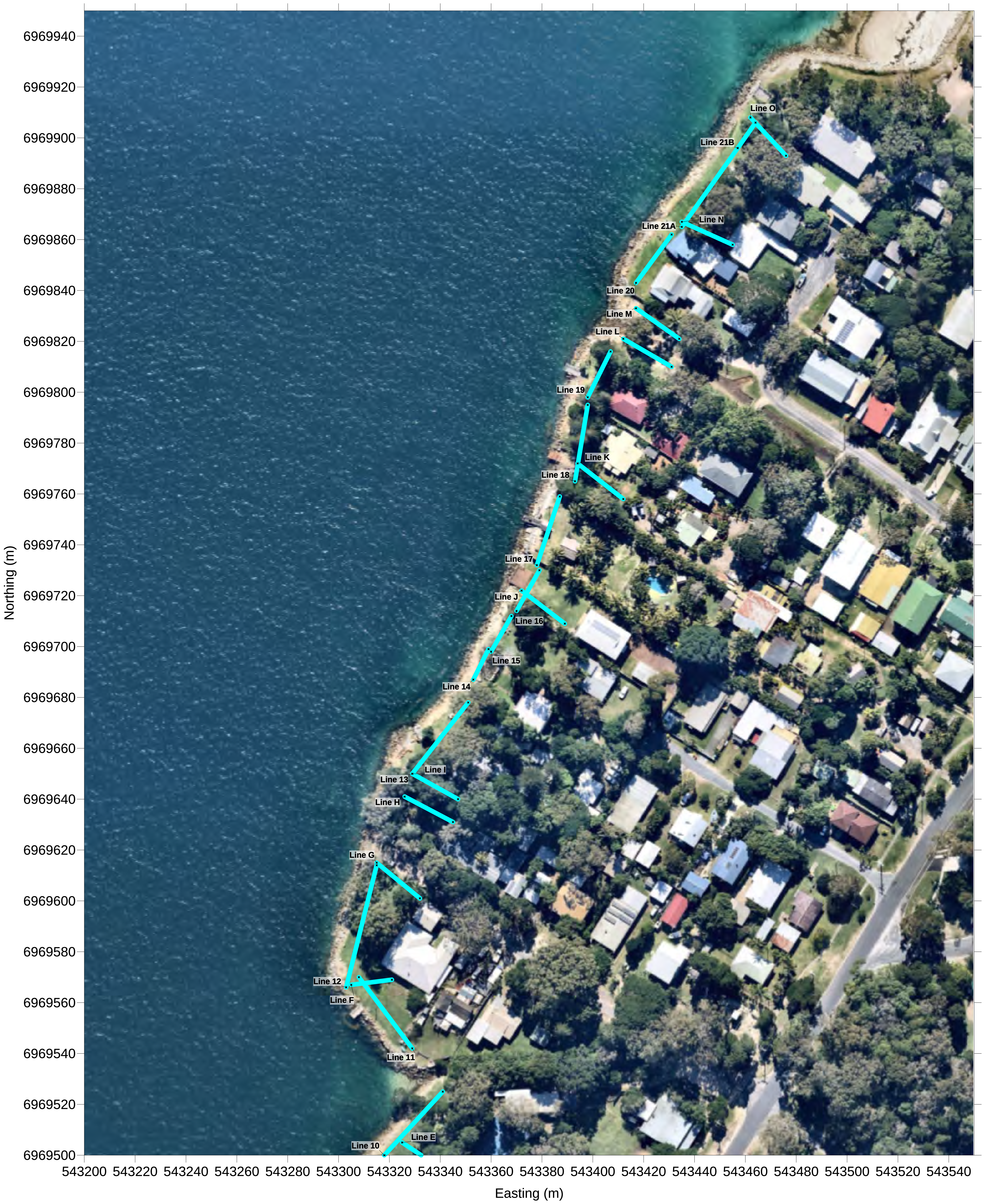
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
MASW LOCALITY PLAN - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	01



LEGEND

MASW LINE

CLIENT REDLAND CITY COUNCIL	PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
MASW LOCALITY PLAN - NORTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	02

LEGEND

EM Trackplot

CLIENT	REDLANDS CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	RR
APPROVED	TR
TITLE	**EM TRACKPLOT - SOUTH**

PROJECT NO.	DELIVERABLE	REV.	FIGURE
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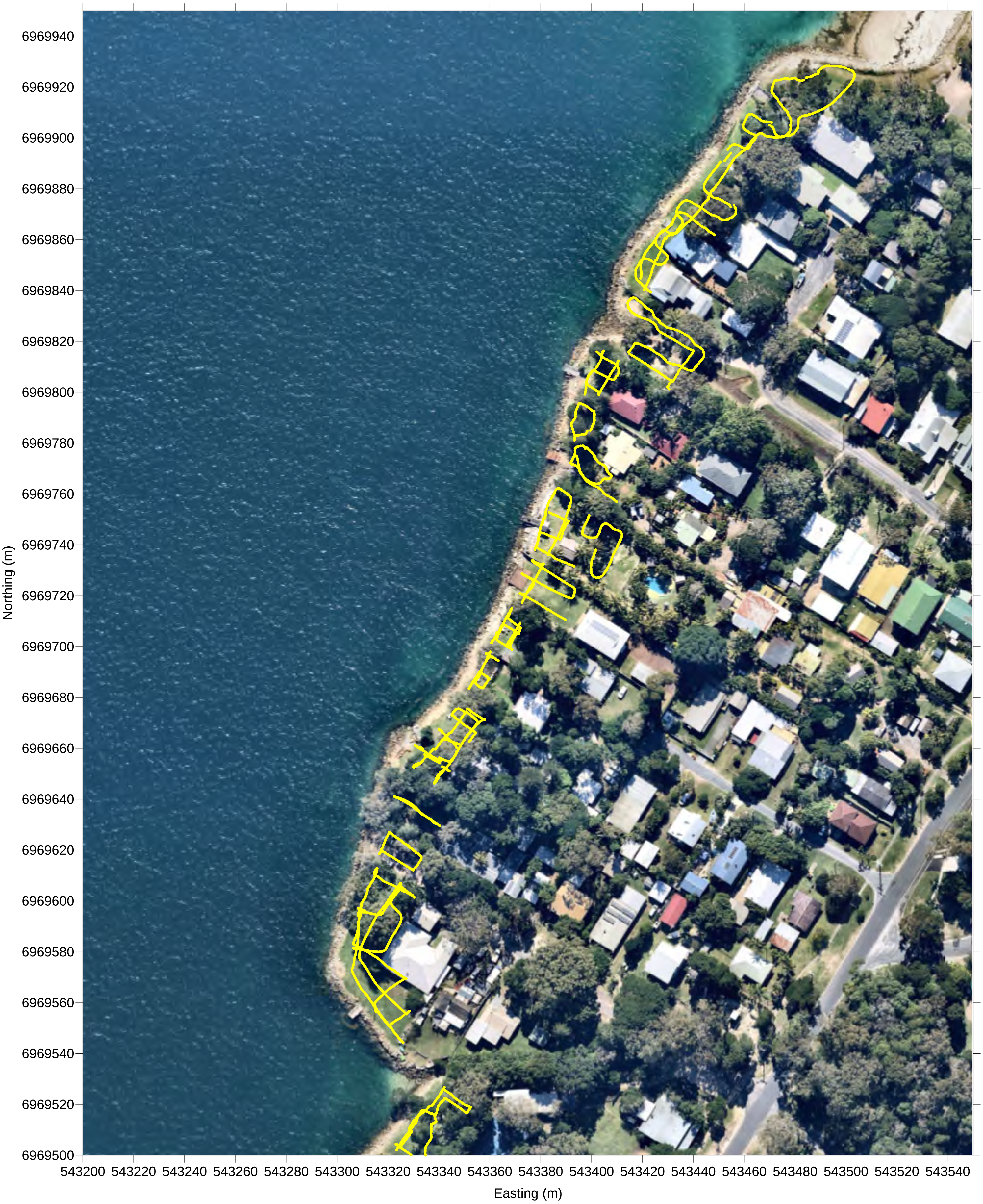

LEGEND

EM Trackplot

CLIENT REDLANDS CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-01-17 DESIGNED: RR PREPARED: LR REVIEWED: RR APPROVED: TR	TITLE **EM TRACKPLOT - NORTH**	
		PROJECT NO. 21453805	DELIVERABLE 001 · REV. Rev0 · FIGURE 04

LEGEND

GPR LINE

CLIENT
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PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
GPR LOCALITY PLAN - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
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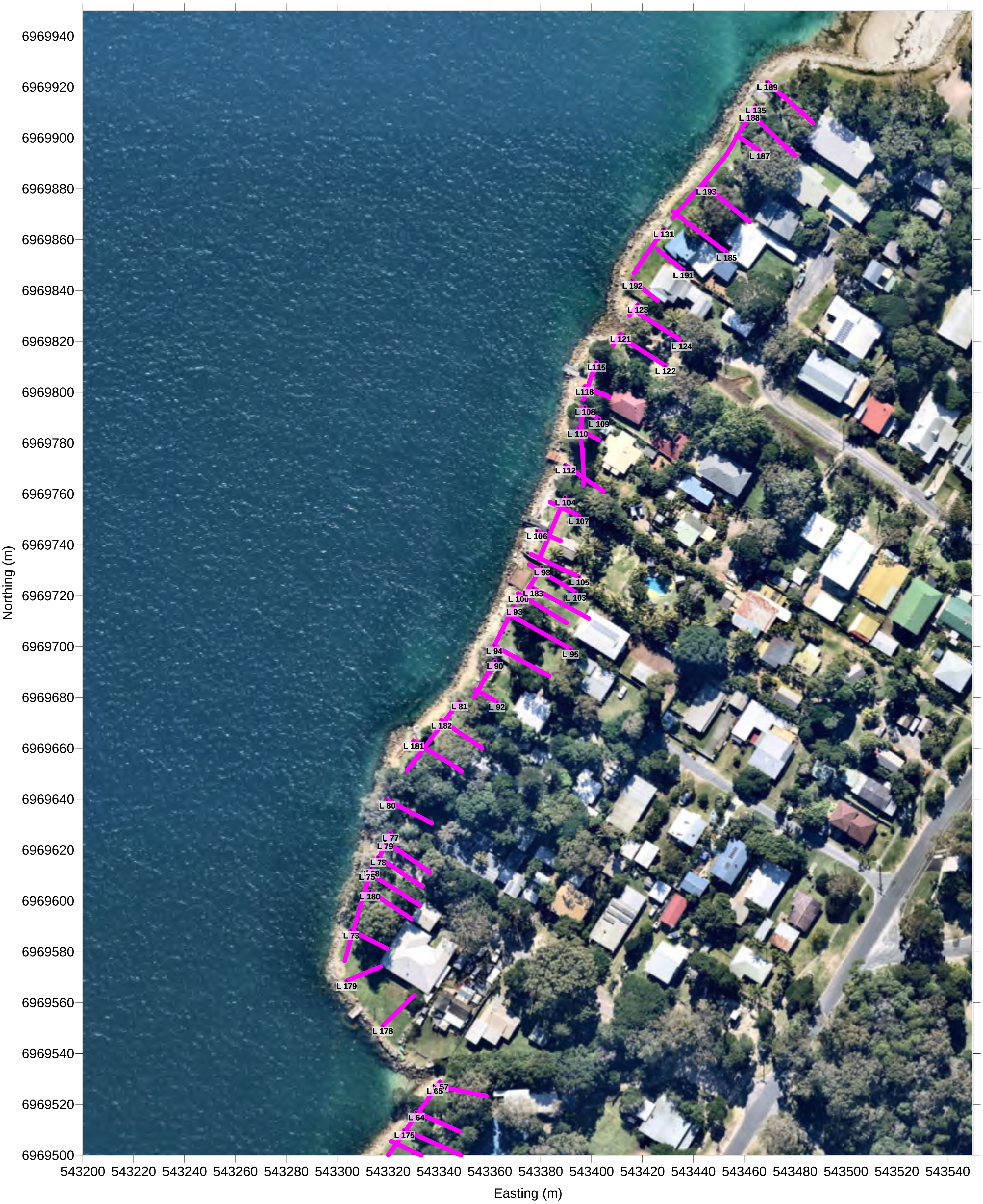
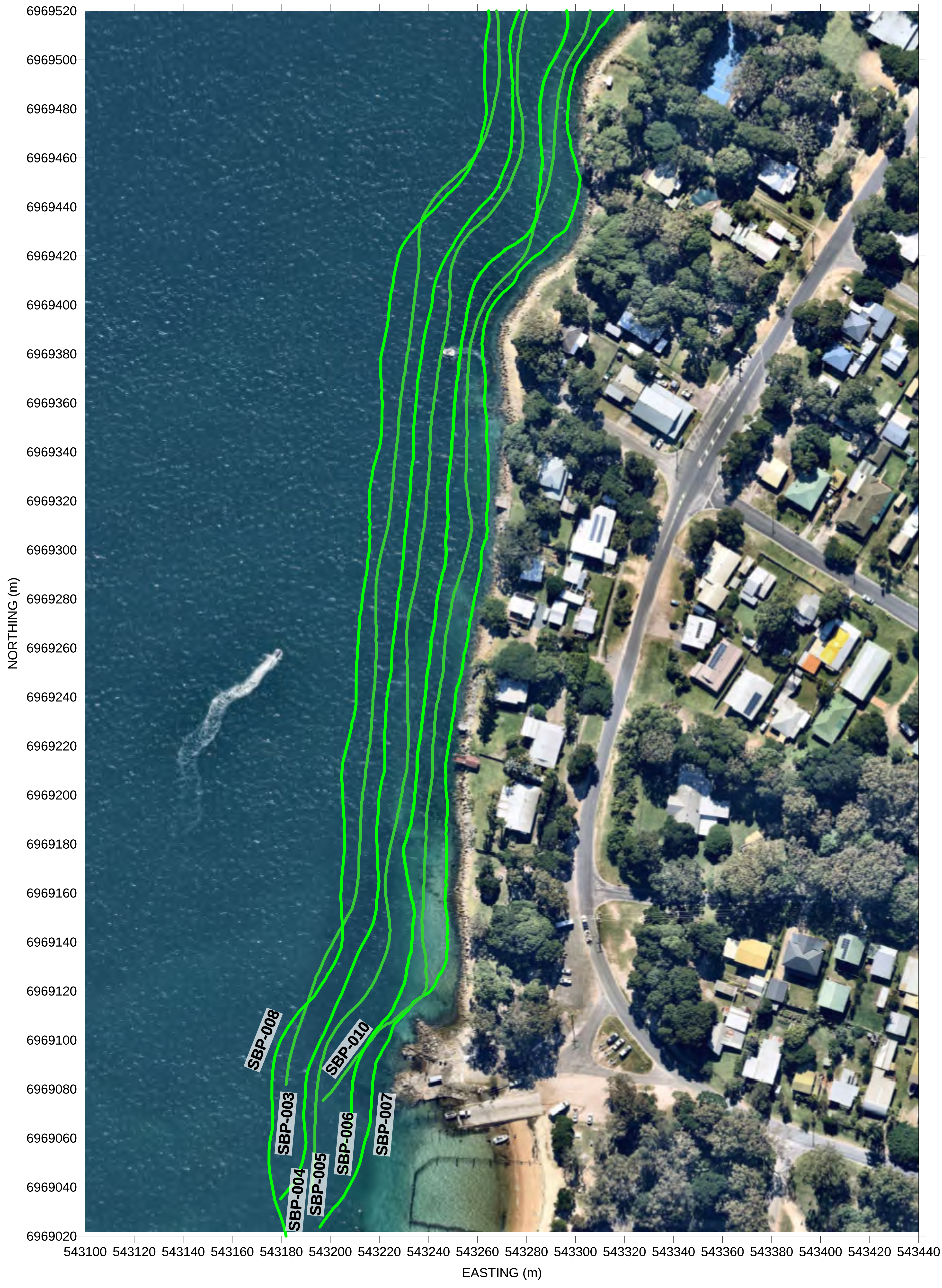


LEGEND

GPR LINE

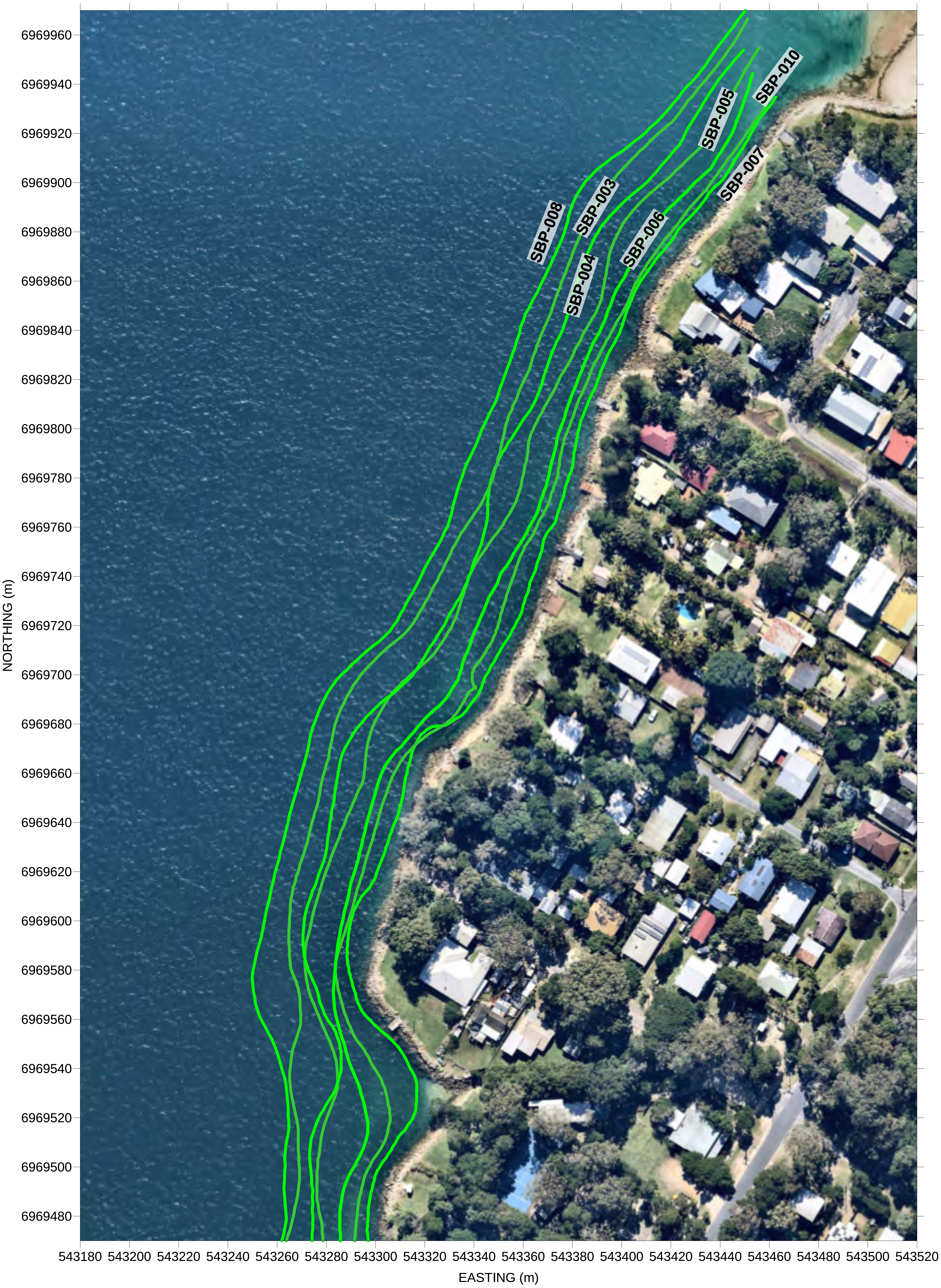
CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR
TITLE	GPR LOCALITY PLAN - NORTH
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	06



LEGEND

SBP LINE

CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR
TITLE	SBP LINE LOCALITY PLAN - SOUTH
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	07



LEGEND

SBP LINE

CLIENT
REDLAND CITY COUNCIL

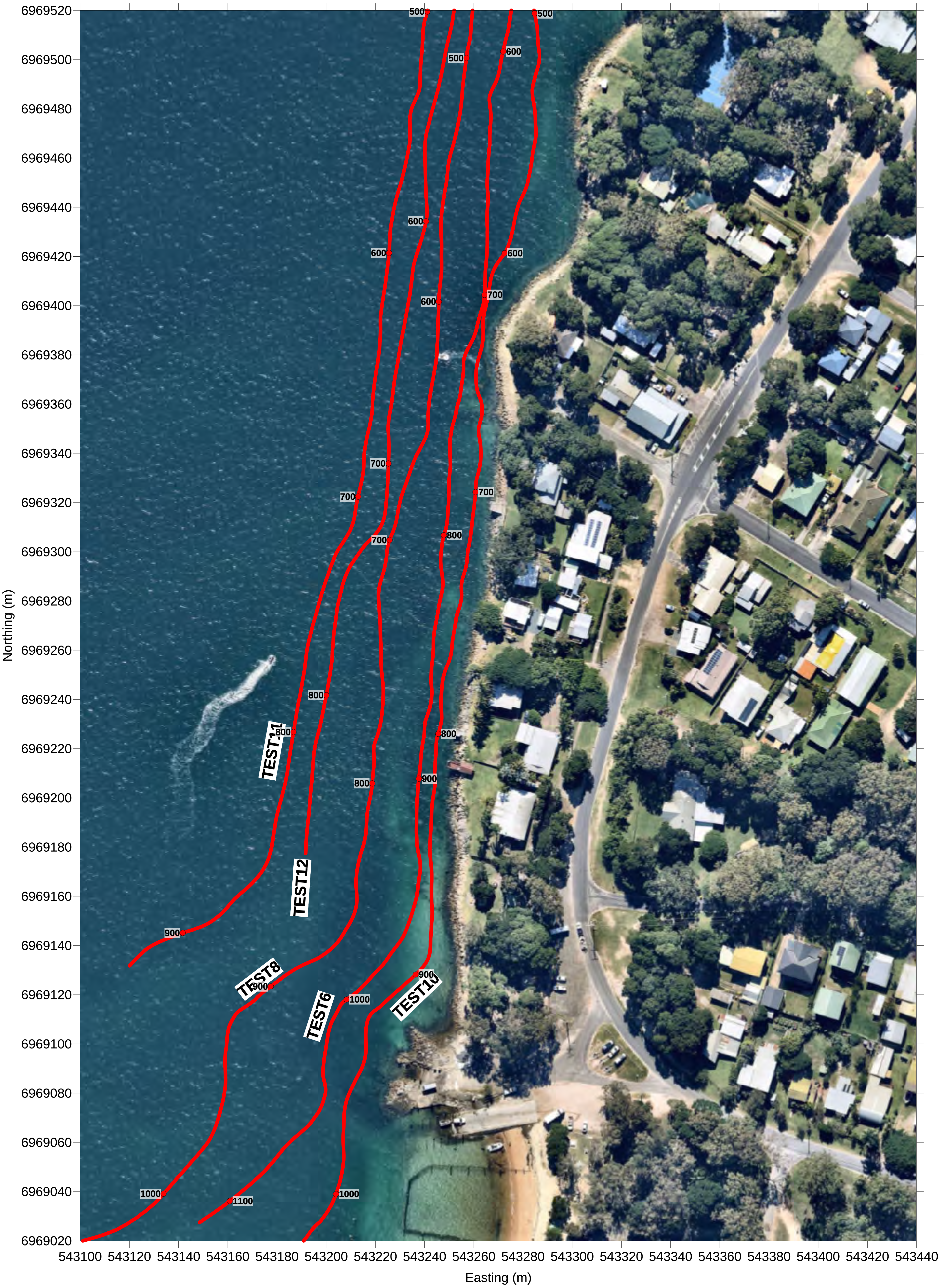
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
SBP LINE LOCALITY PLAN - NORTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	08



LEGEND

MERI LINE

CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
MERI LOCALITY PLAN - SOUTH

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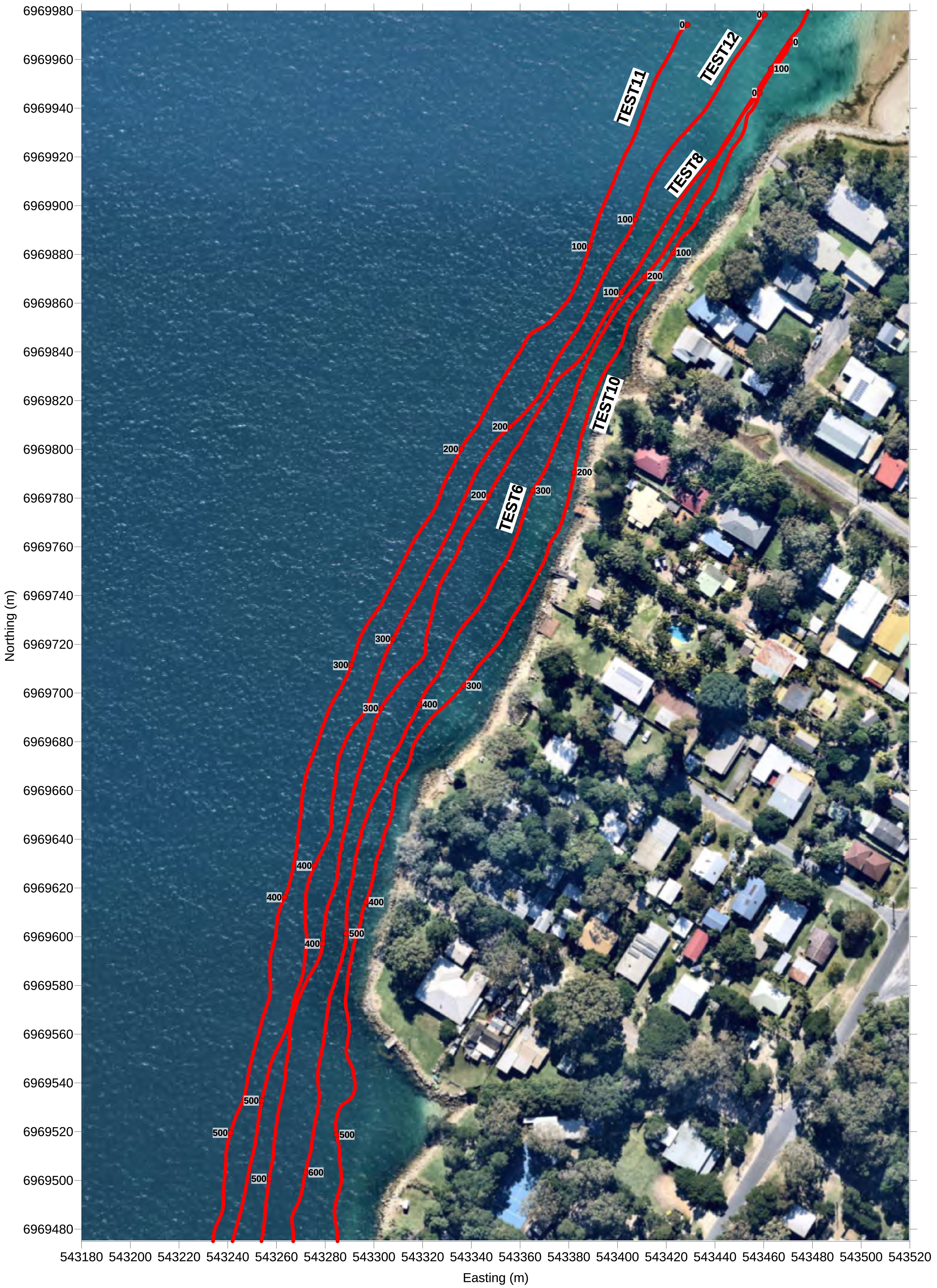

LEGEND

MERI LINE

CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	RR
APPROVED	TR

TITLE
MERI LOCALITY PLAN - SOUTH

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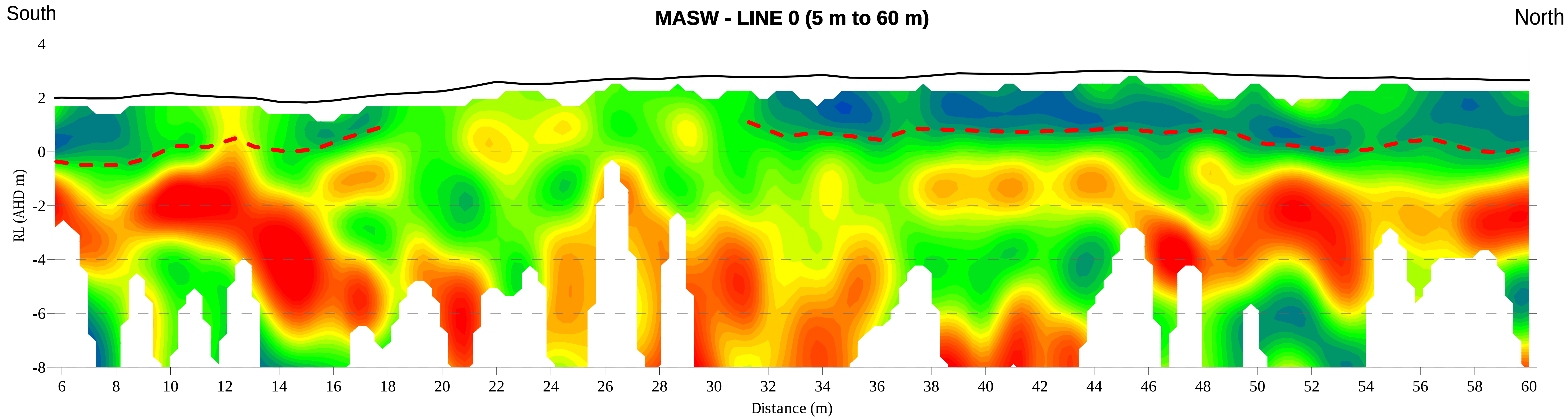
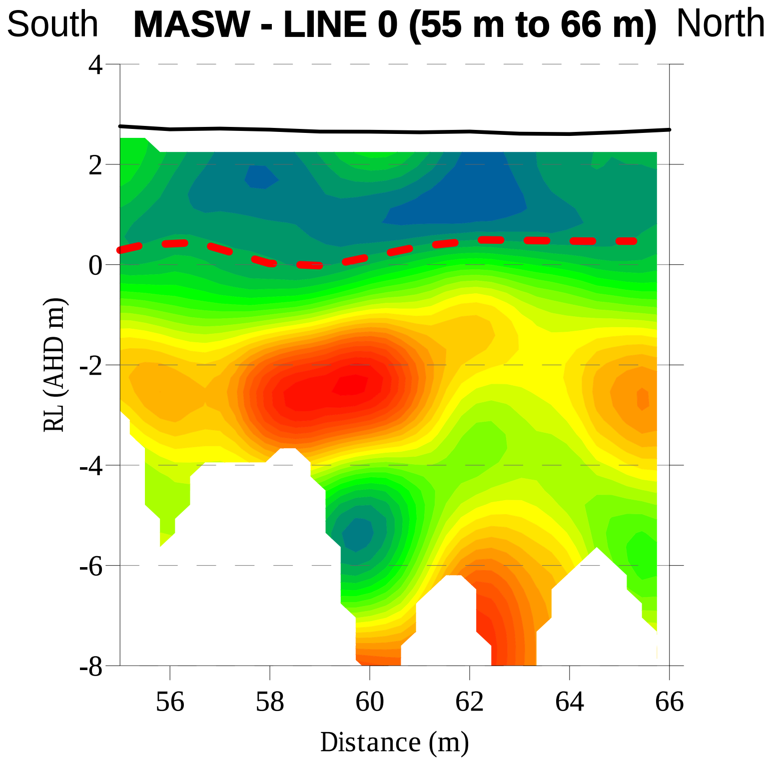
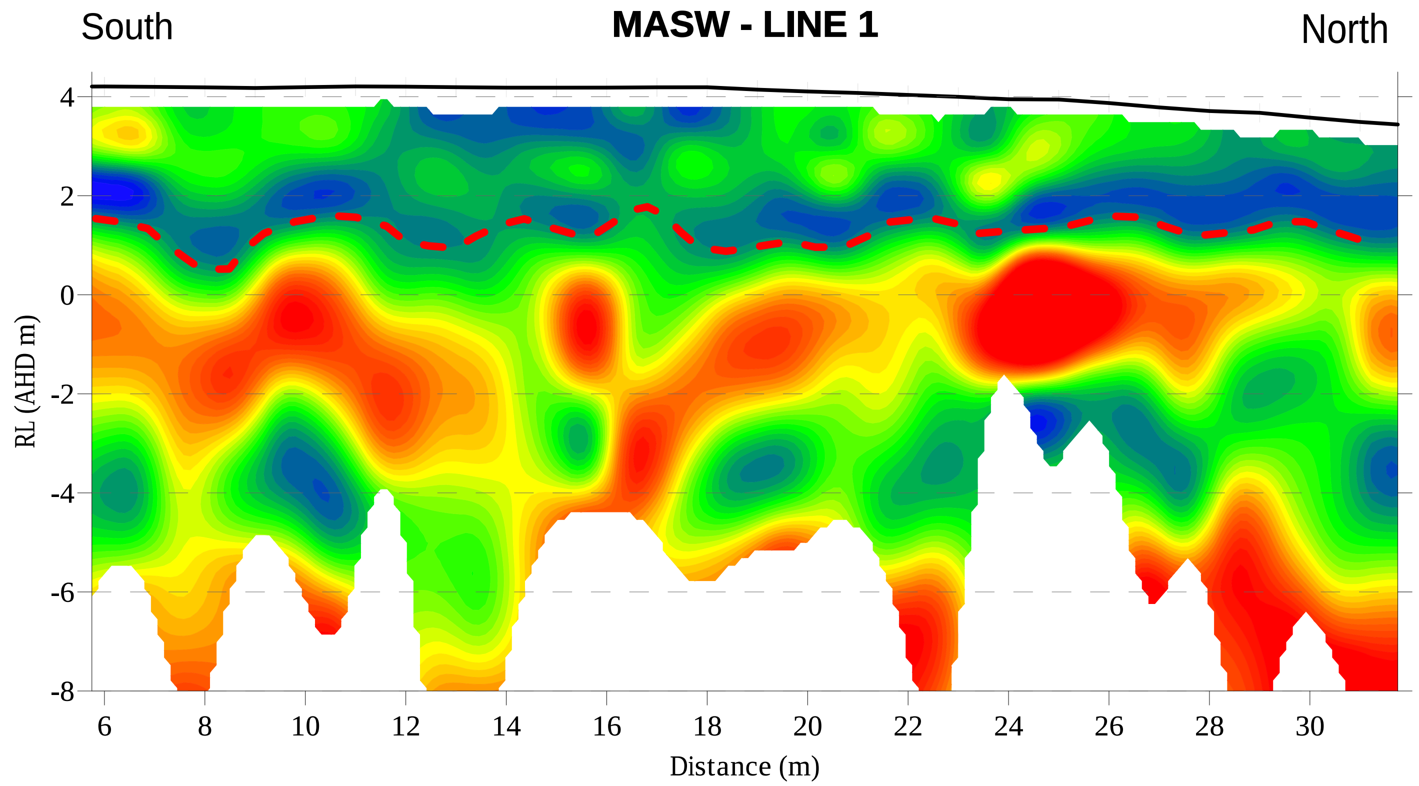






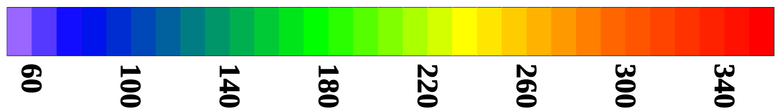
LEGEND

INTERPRETED BASE OF ROCK ARMOUR

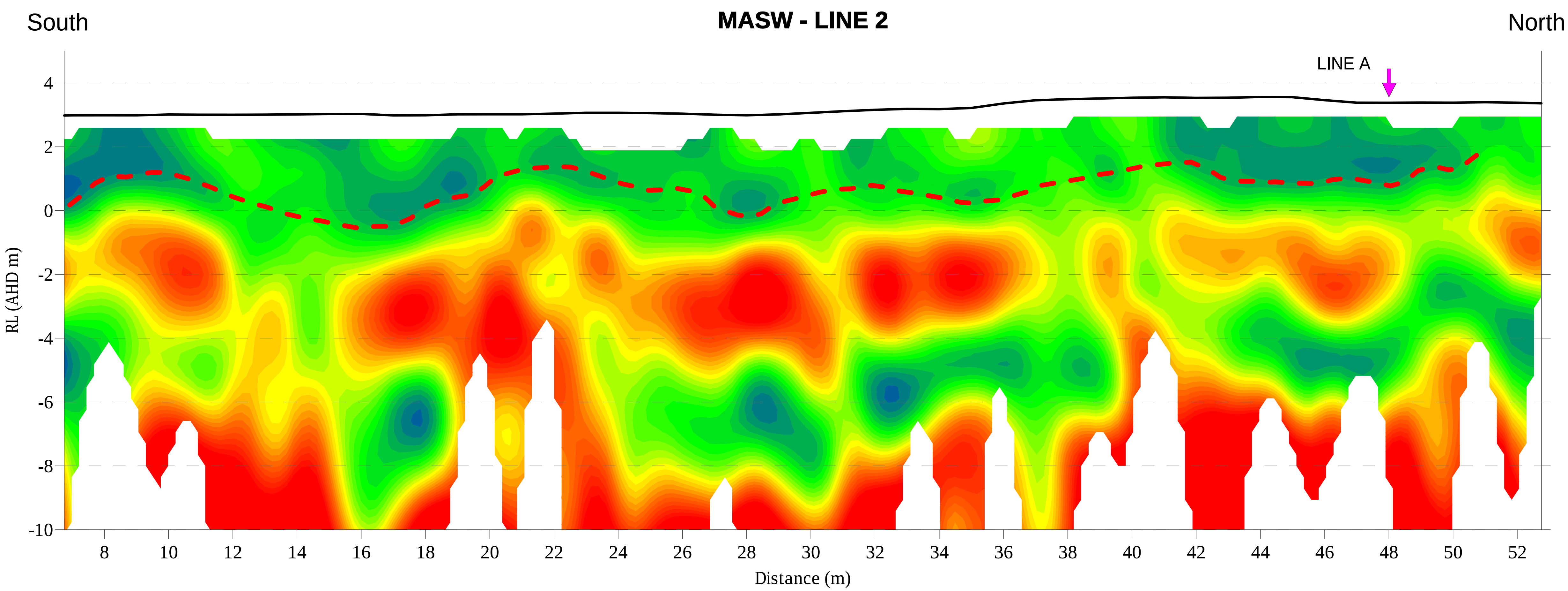
ORTHOGONAL LINE INTERSECTION

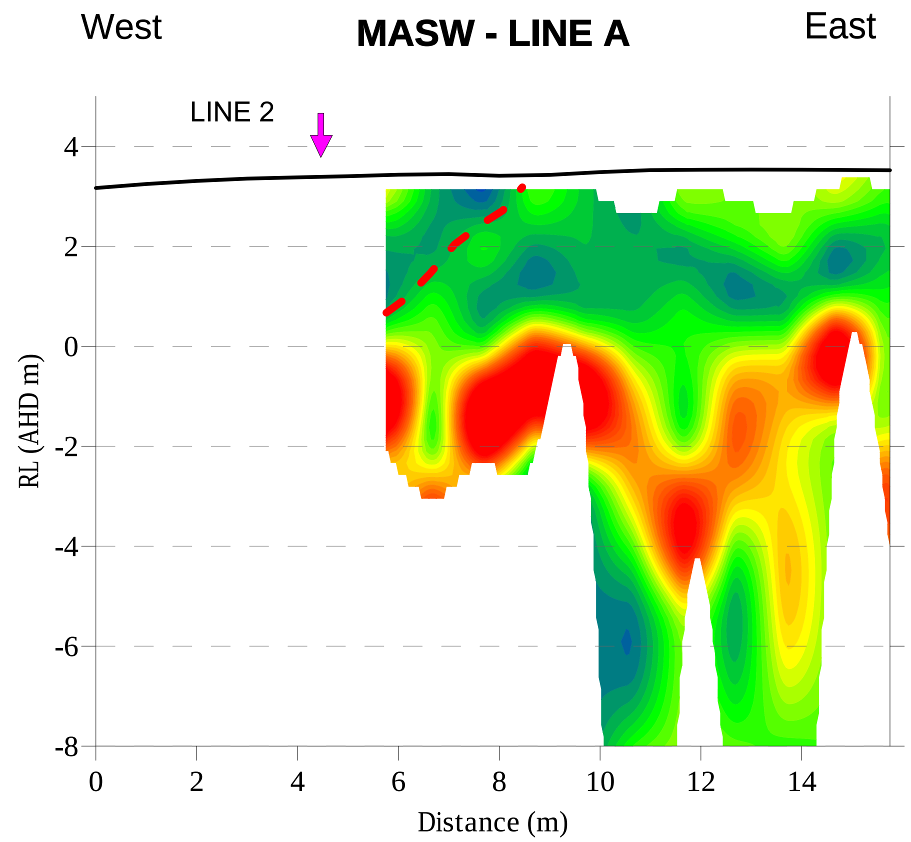
NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD 2022-01-18 DESIGNED RR PREPARED LR REVIEWED TR APPROVED --	TITLE **MASW SECTION LINE 0 & 1**	
		PROJECT NO. 21453805	DELIVERABLE 001
		REV. Rev0	FIGURE 11





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
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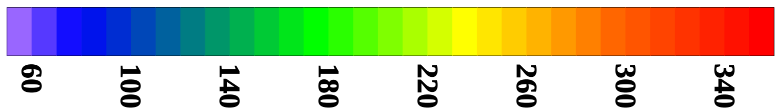
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

LIMITATIONS
Golder Associates geophysical services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions and subject to the time limits, financial and physical constraints applicable to the services.

MASW is a remote sensing geophysical method that may not detect all subsurface features. Depth of penetration is dependent on the nature of the subsurface, acquisition parameters and data quality. Furthermore, it is possible that interpreted features such as stratigraphic boundaries, top of bedrock, faults, voids, other geologic hazards and utilities may, upon intrusive sampling, prove to have been misinterpreted.

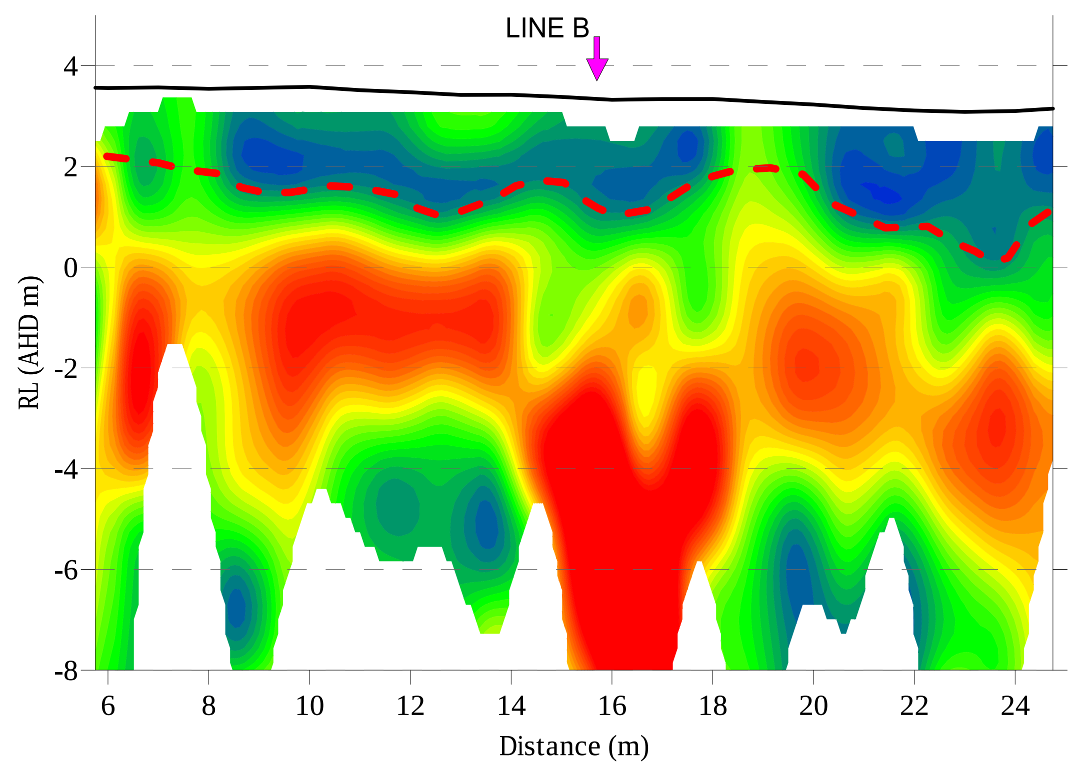
MASW data are analysed using inverse modelling to provide a model of the subsurface conditions and geologic structure. This process does not necessarily produce a unique solution, i.e. a single geophysical dataset can produce multiple outputs that meet the specified constraints. Different modelling methods and software may produce different results. This inherent uncertainty in the results should be considered during the interpretation process. Accurate interpretation of geophysical data relies on the site-specific correlation of information with that obtained from borehole drilling, test pits or other direct observation methods.

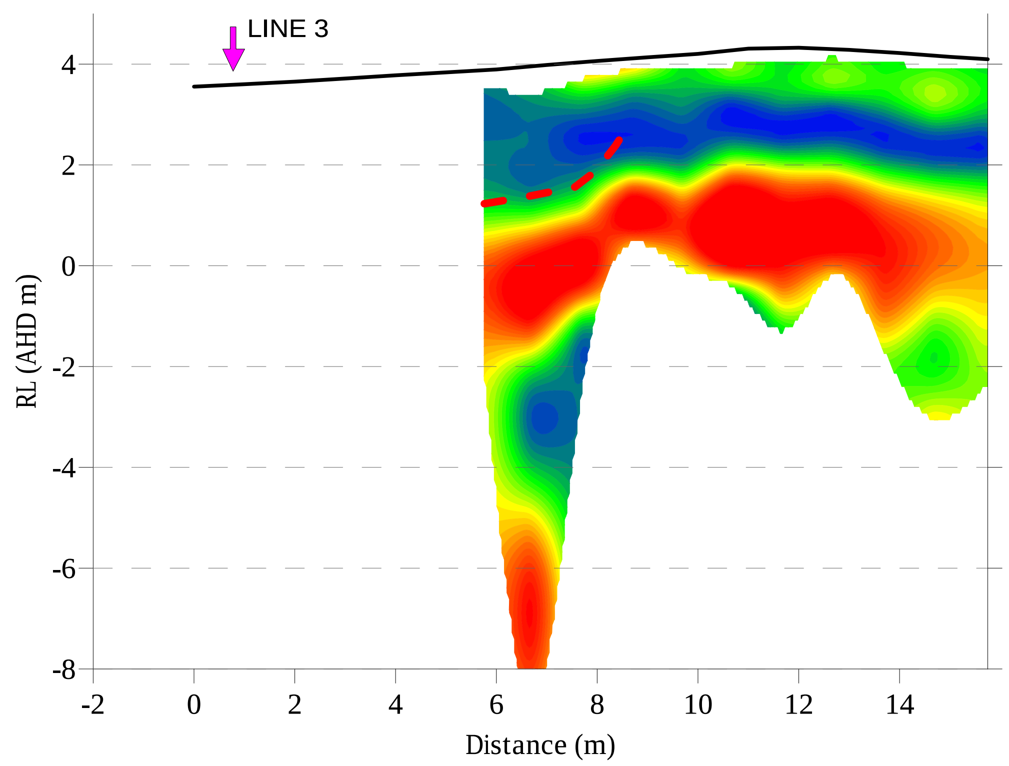
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT	REDLAND CITY COUNCIL	PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP	TITLE	**MASW SECTION LINES 2 & A**
YYYY-MM-DD	2022-01-18	PROJECT NO.	21453805
DESIGNED	RR	DELIVERABLE	001
PREPARED	LR	REV.	Rev0
REVIEWED	TR	FIGURE	12
APPROVED	--		

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

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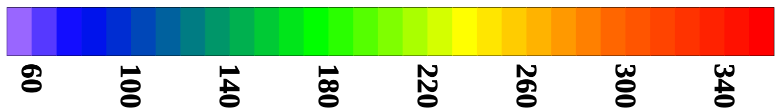
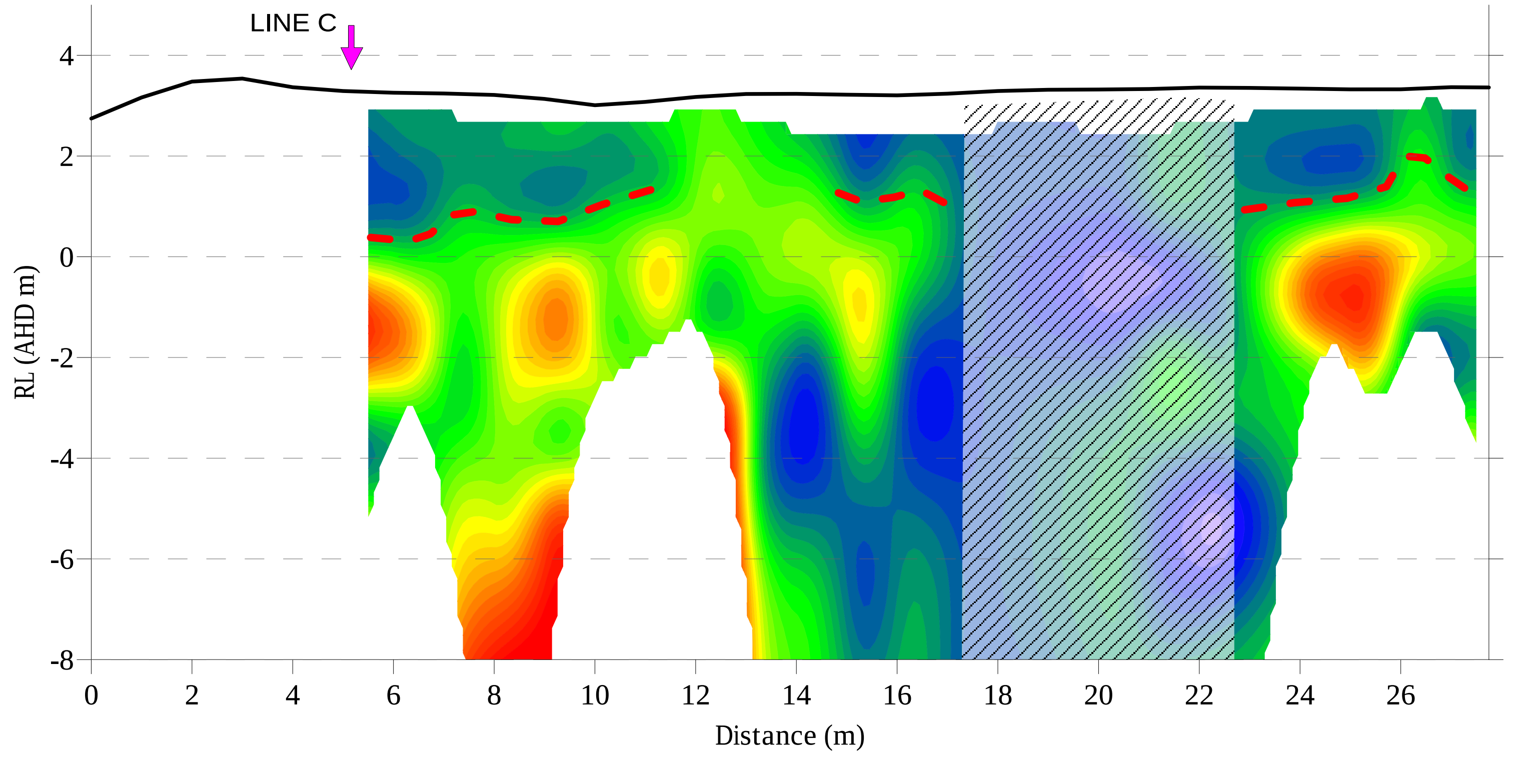
SEISMIC S-WAVE VELOCITY, V_S (m/s)

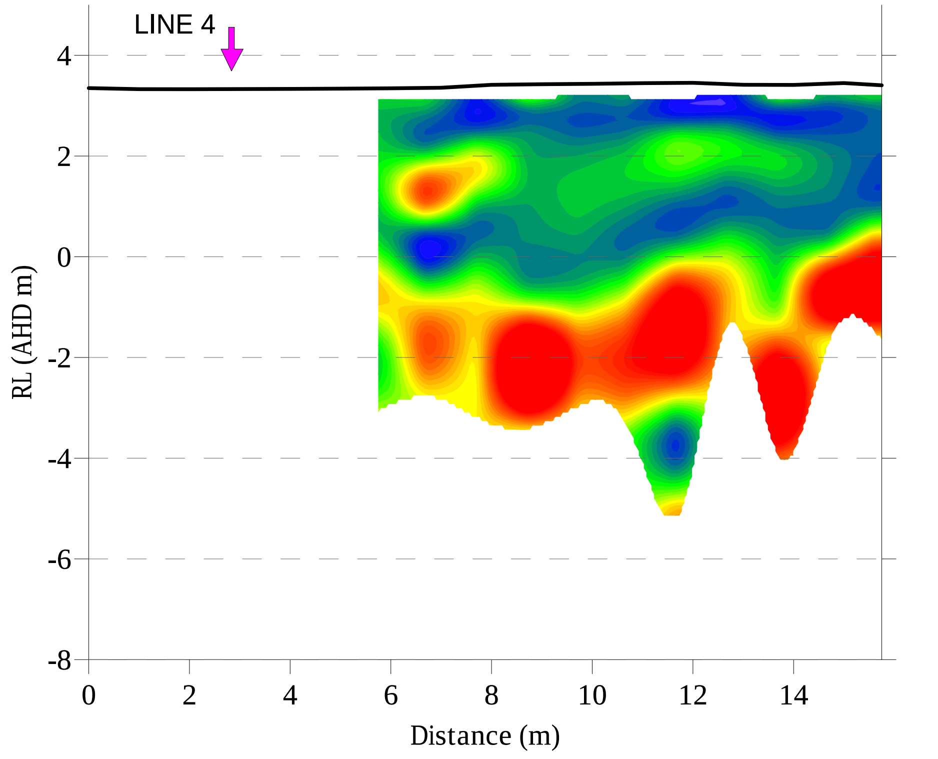


CLIENT REDLANDS CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-01-18 DESIGNED: RR PREPARED: LR REVIEWED: TR APPROVED: --	TITLE **MASW SECTION LINES 3 & B**	
		PROJECT NO. 21453805	DELIVERABLE 001 / REV. Rev0 / FIGURE 13

South **MASW - LINE 4** North



West **MASW - LINE C** East



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

MODEL CONSIDERED UNRELIABLE DUE TO POOR QUALITY SEISMIC SIGNAL

NOTES:
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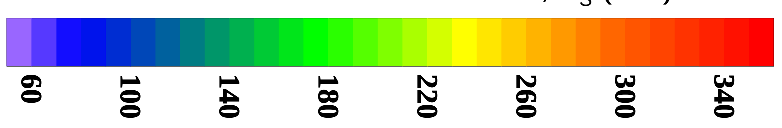
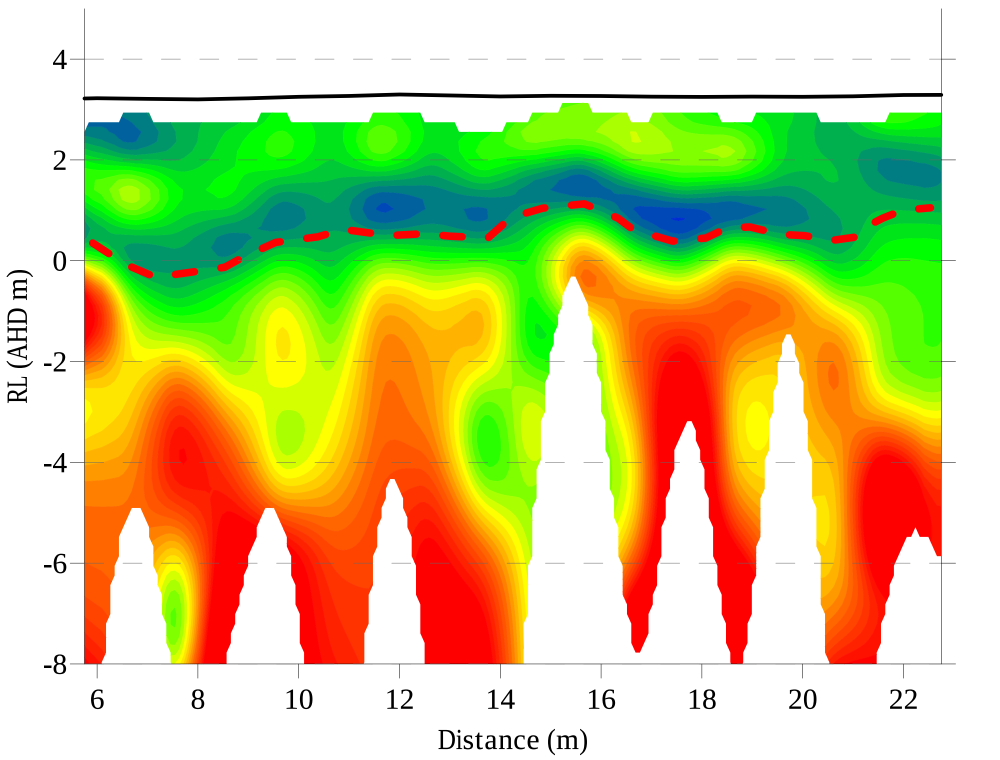
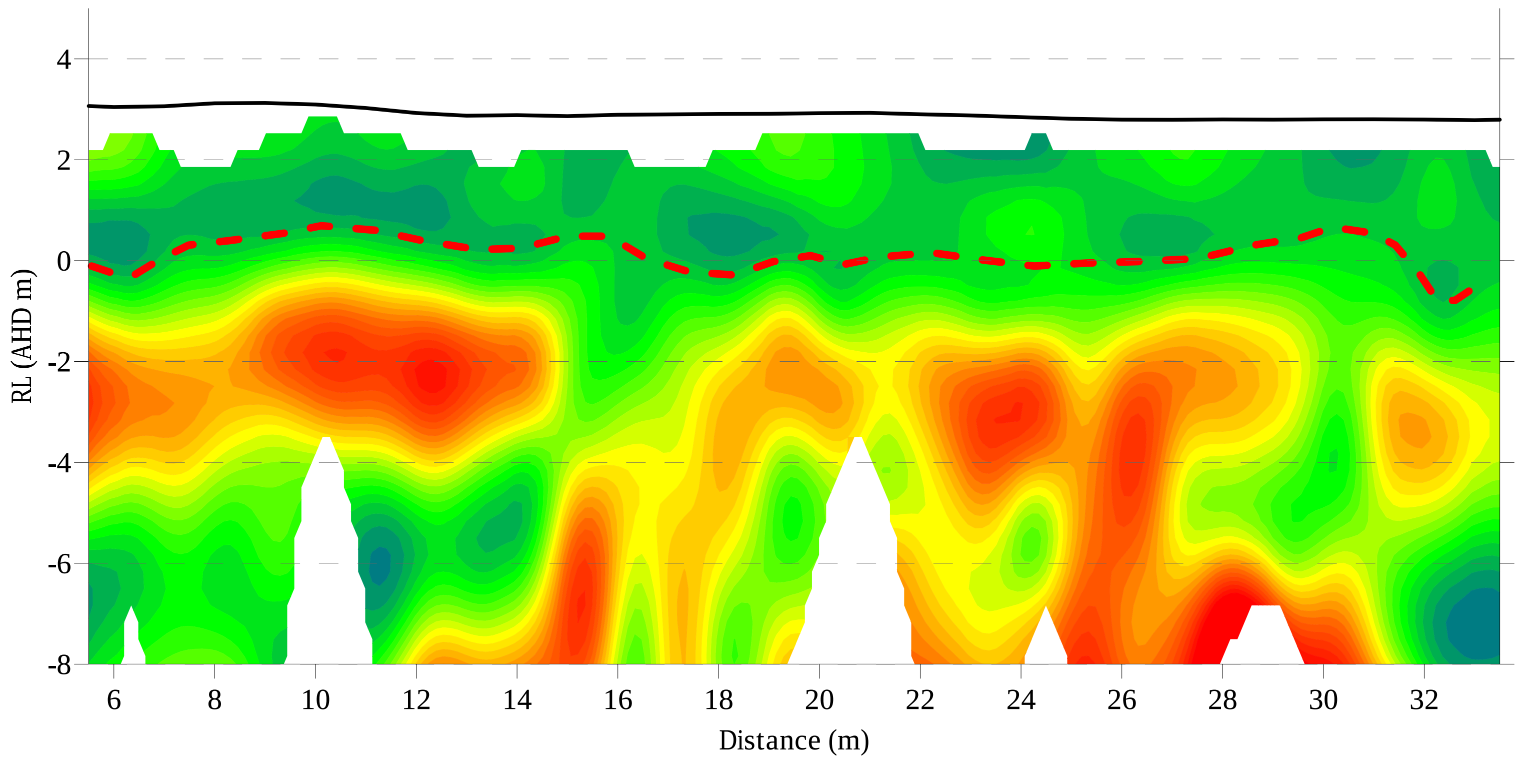
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT	REDLAND CITY COUNCIL	PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP	TITLE	**MASW SECTION LINES 4 & C**
YYYY-MM-DD	2022-01-18	PROJECT NO.	21453805
DESIGNED	RR	DELIVERABLE	001
PREPARED	LR	REV.	Rev0
REVIEWED	TR	FIGURE	14
APPROVED	--		





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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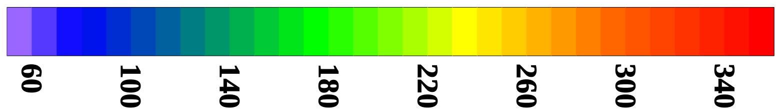
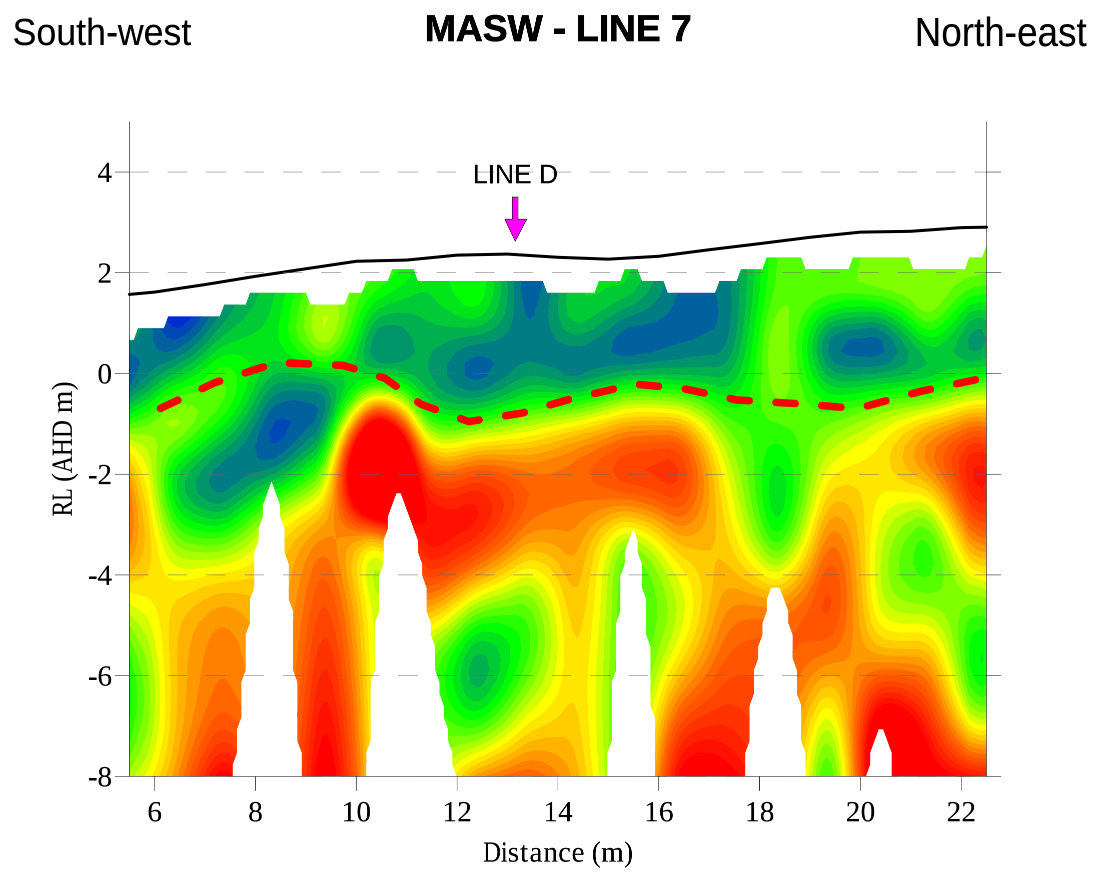
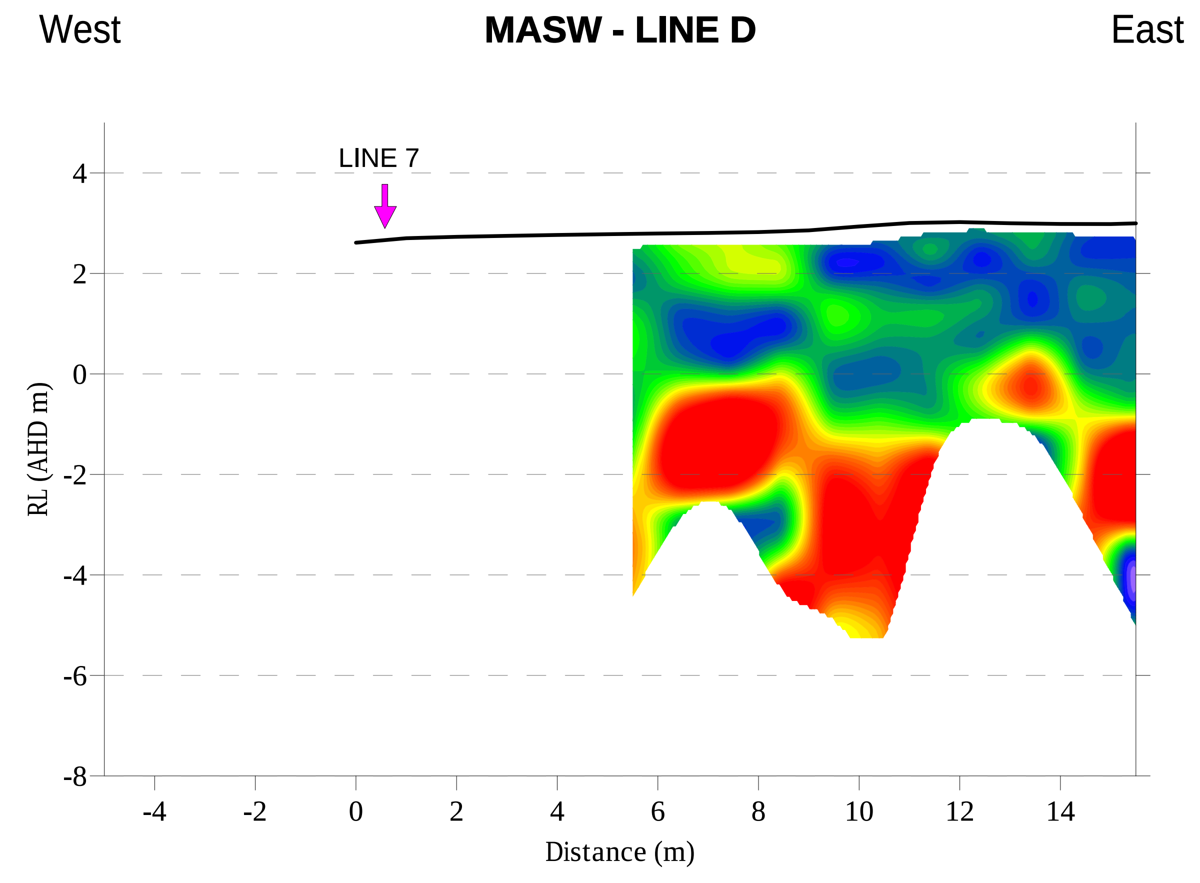
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-02-04 DESIGNED: RR PREPARED: LR REVIEWED: TR APPROVED: --	TITLE **MASW SECTION LINE 5 & 6**	
		PROJECT NO. 21453805	DELIVERABLE 001 / REV. Rev0 / FIGURE 15





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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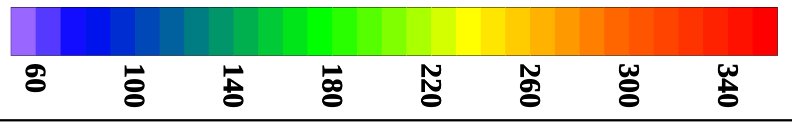
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

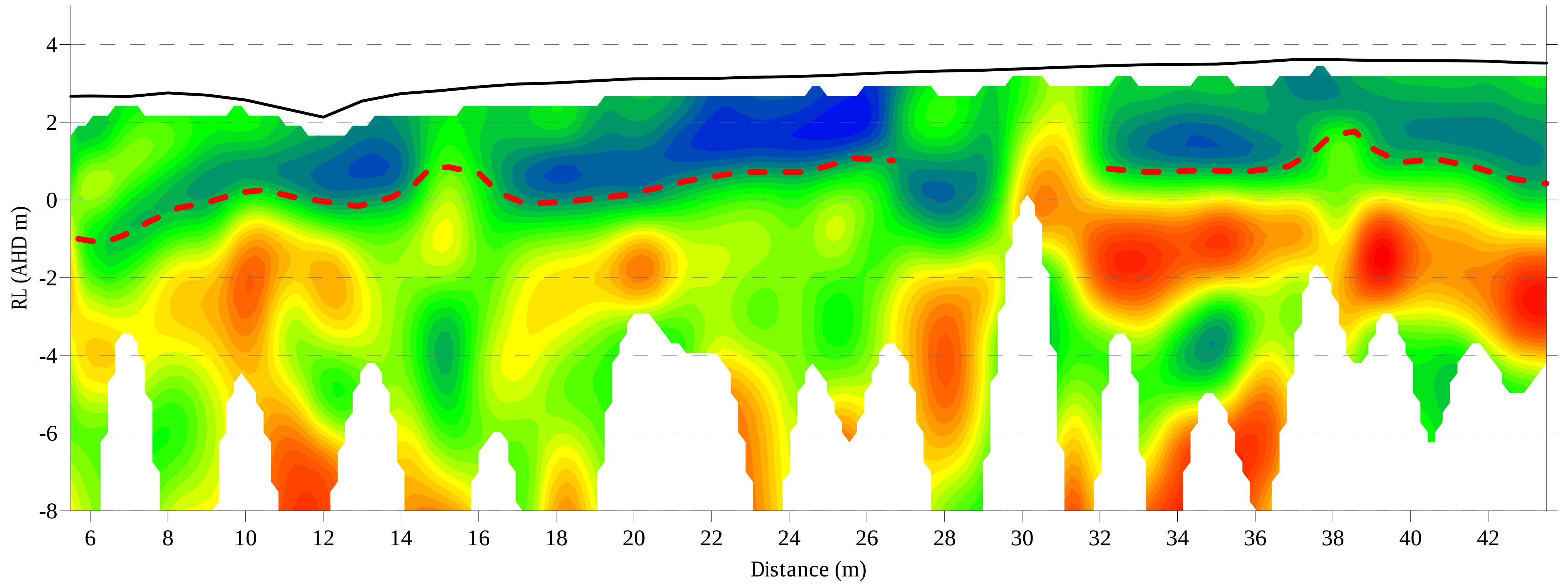
CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

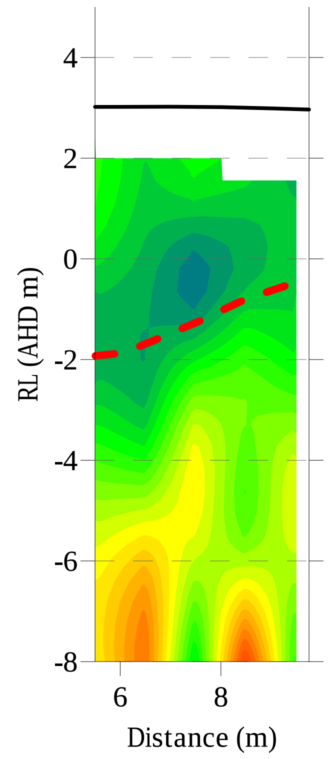
TITLE
MASW SECTION LINE 7 & D

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	16

South **MASW - LINE 8** North



South-west **MASW - LINE 9** North-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
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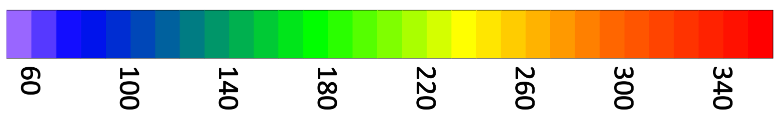
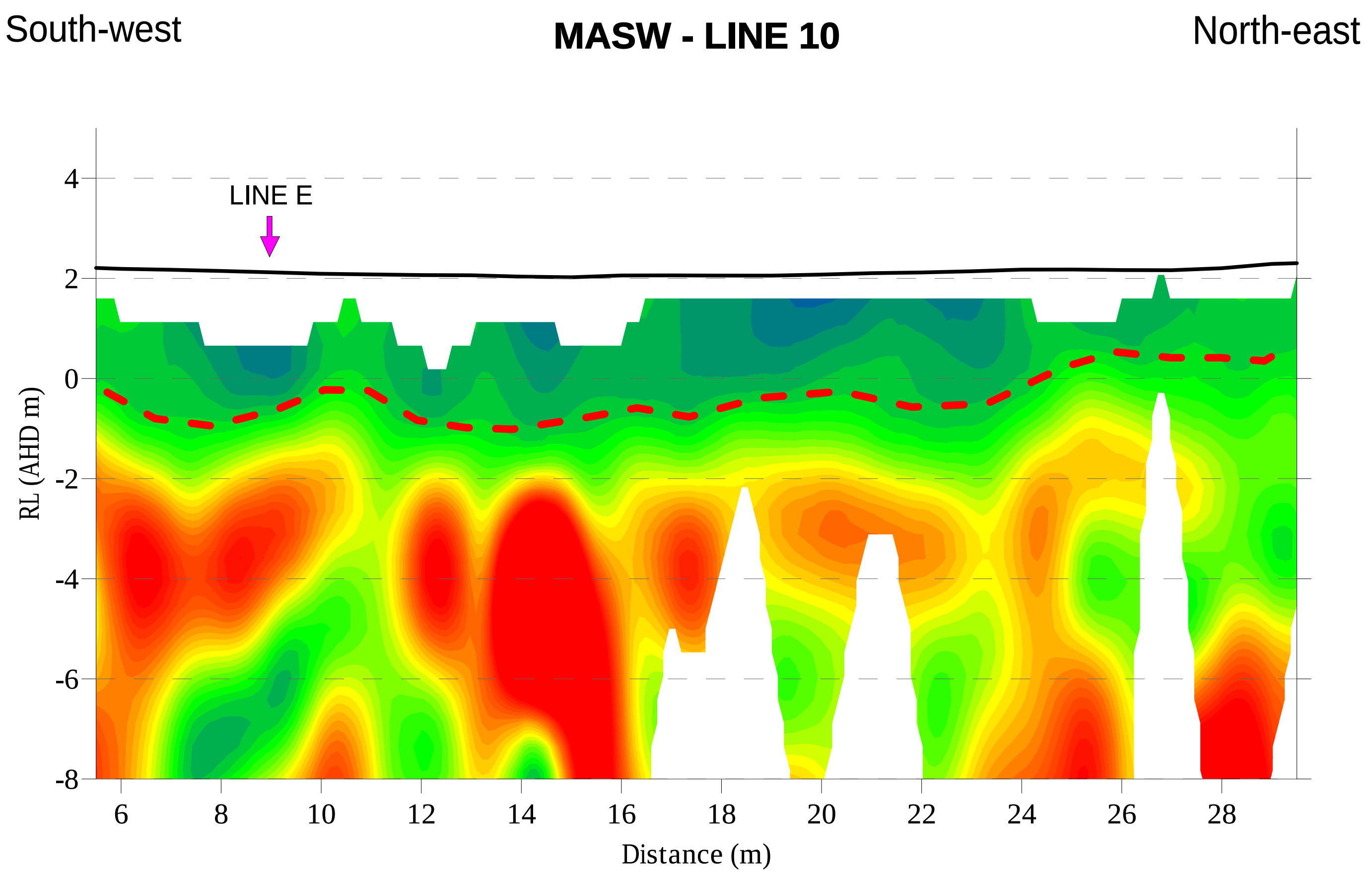
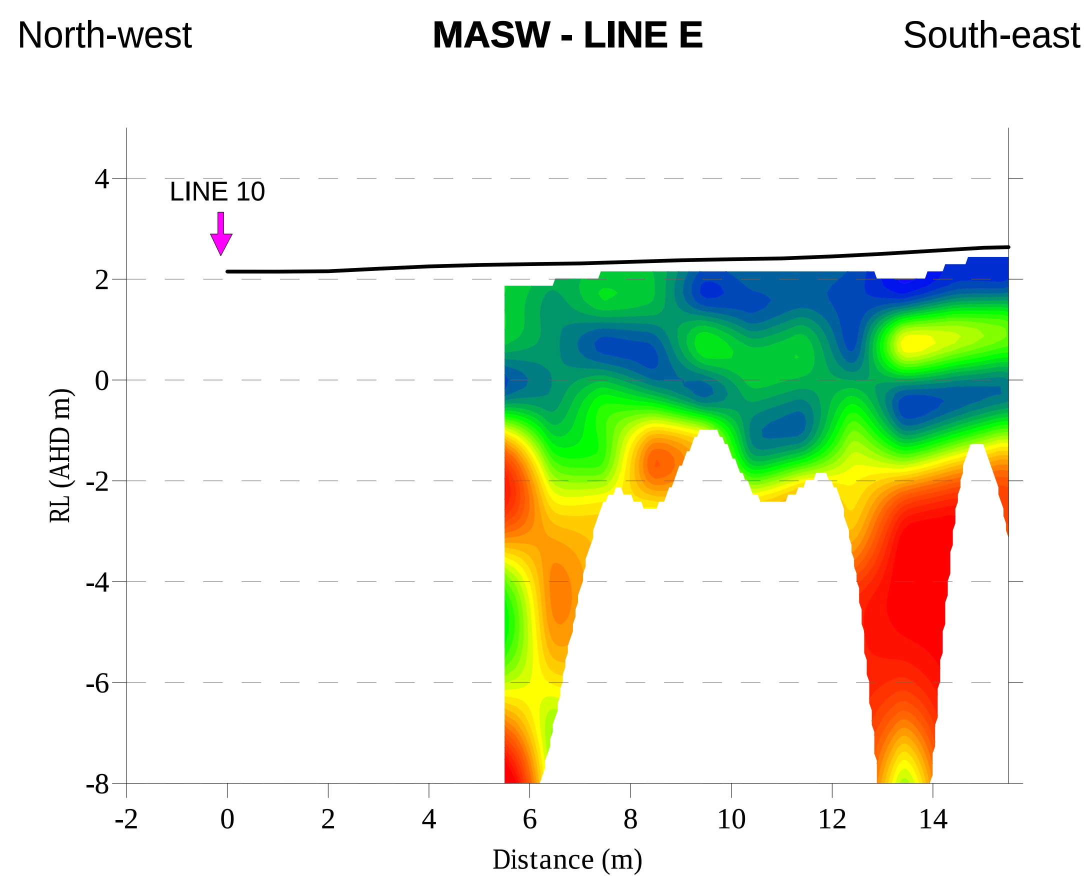
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-02-04 DESIGNED: RR PREPARED: SS REVIEWED: TR APPROVED: --	TITLE **MASW SECTION LINE 8 & 9**	
PROJECT NO. 21453805	DELIVERABLE 001	REV. Rev0	FIGURE 17





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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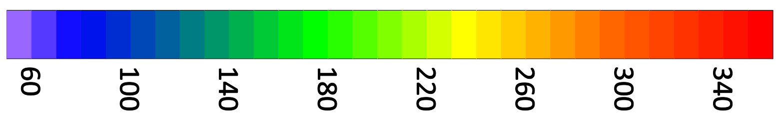
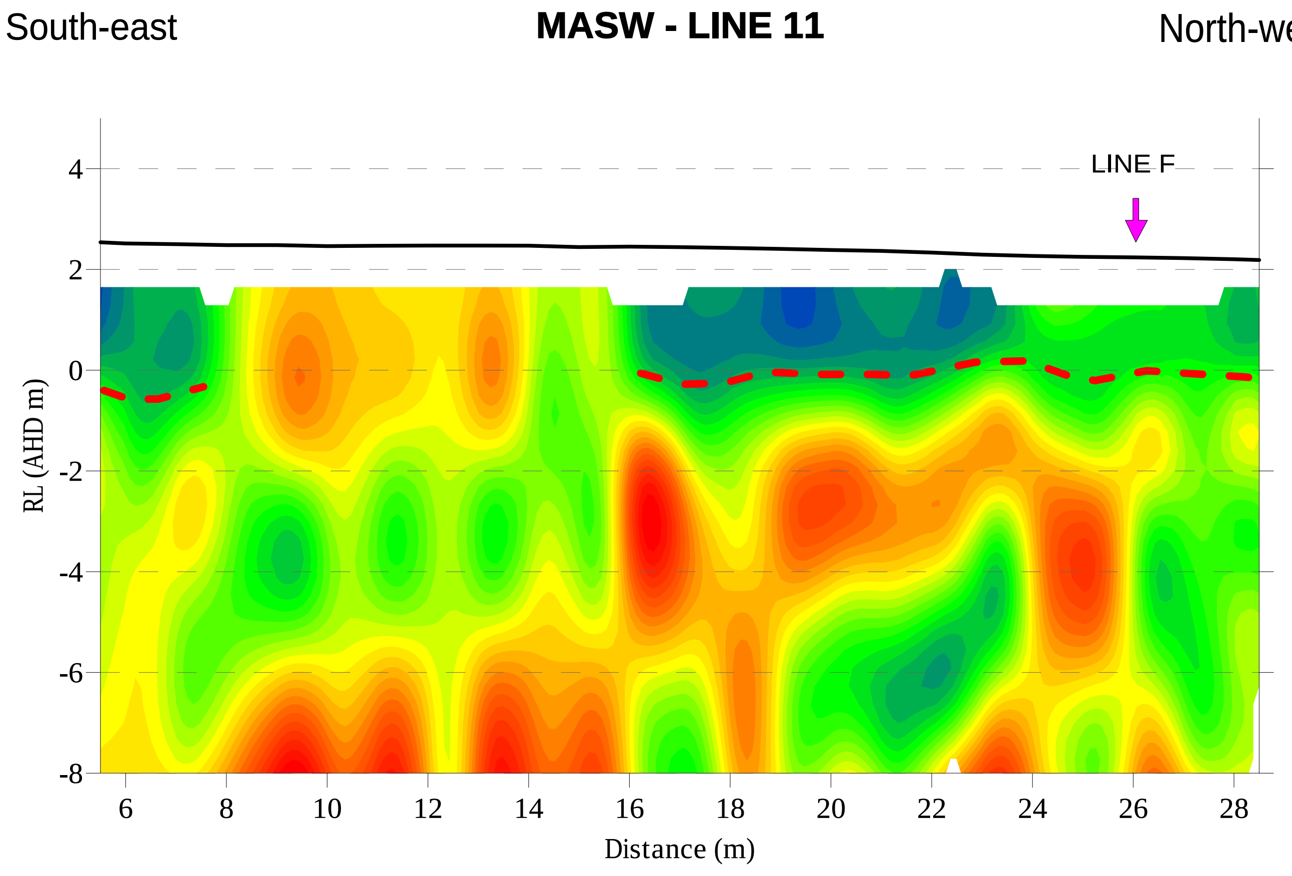
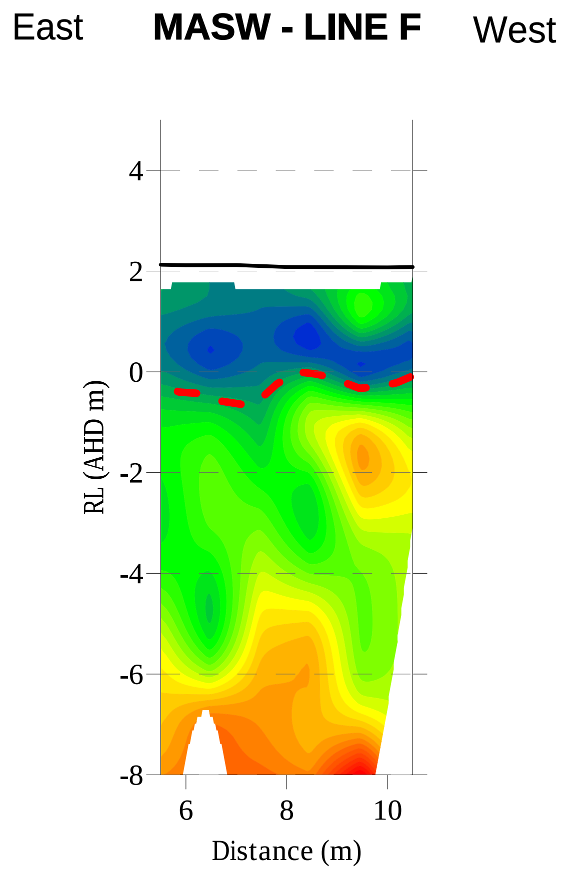
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-02-04 DESIGNED: RR PREPARED: SS REVIEWED: TR APPROVED: --	TITLE MASW SECTION LINE 10 & E	
		PROJECT NO. 21453805	DELIVERABLE 001
		REV. Rev0	FIGURE 18





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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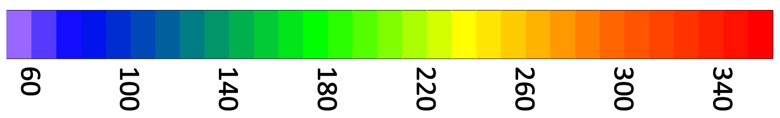
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

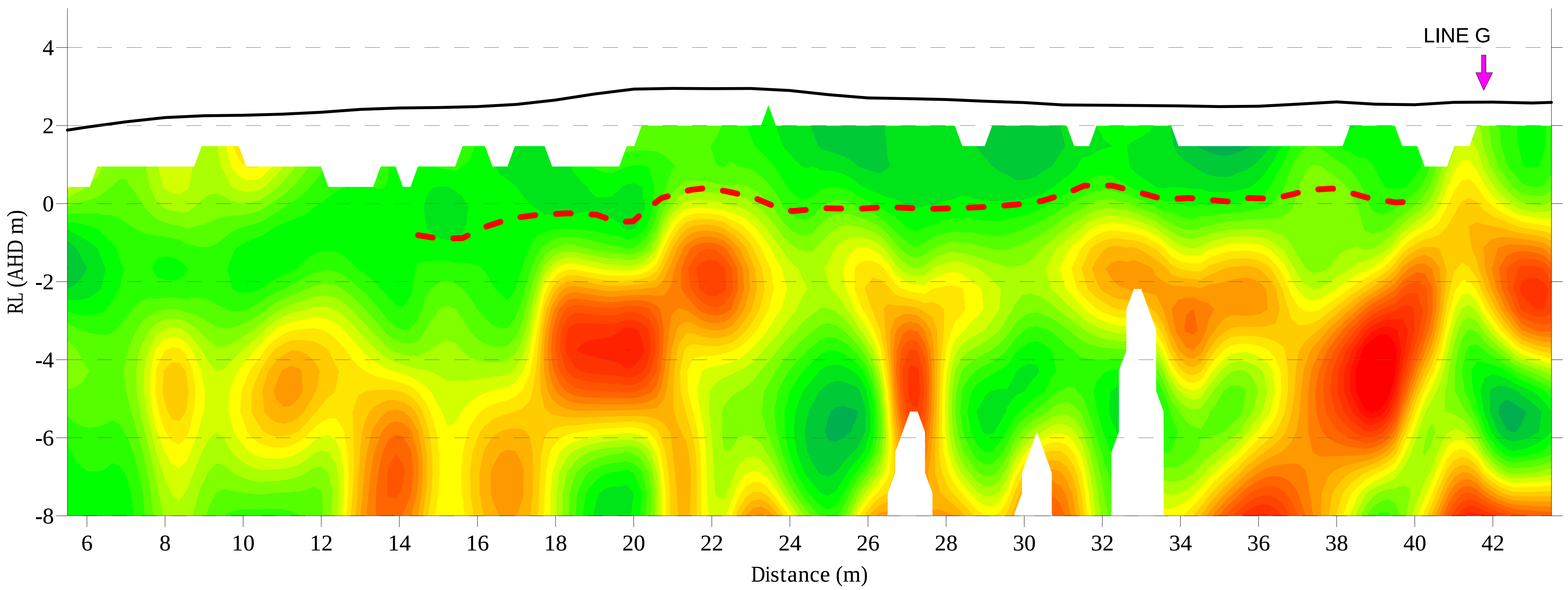
TITLE
MASW SECTION LINE 11 & F

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	19

South

MASW - LINE 12

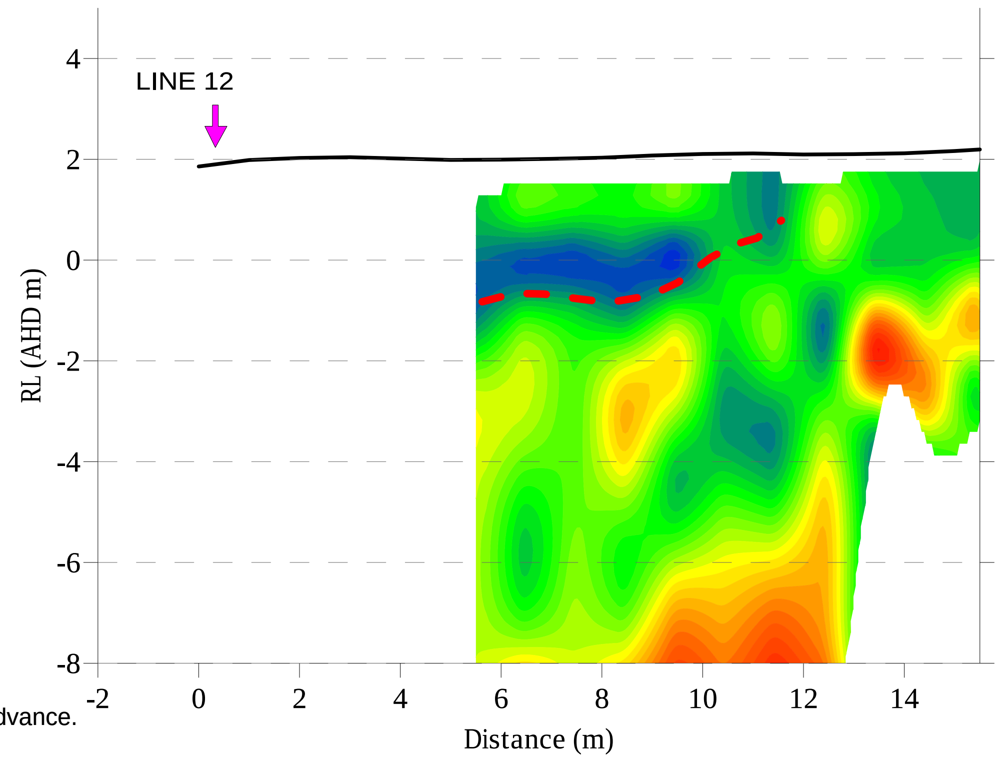
North



North-west

MASW - LINE G

South-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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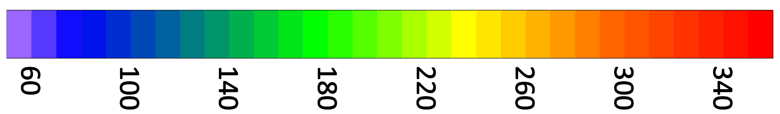
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

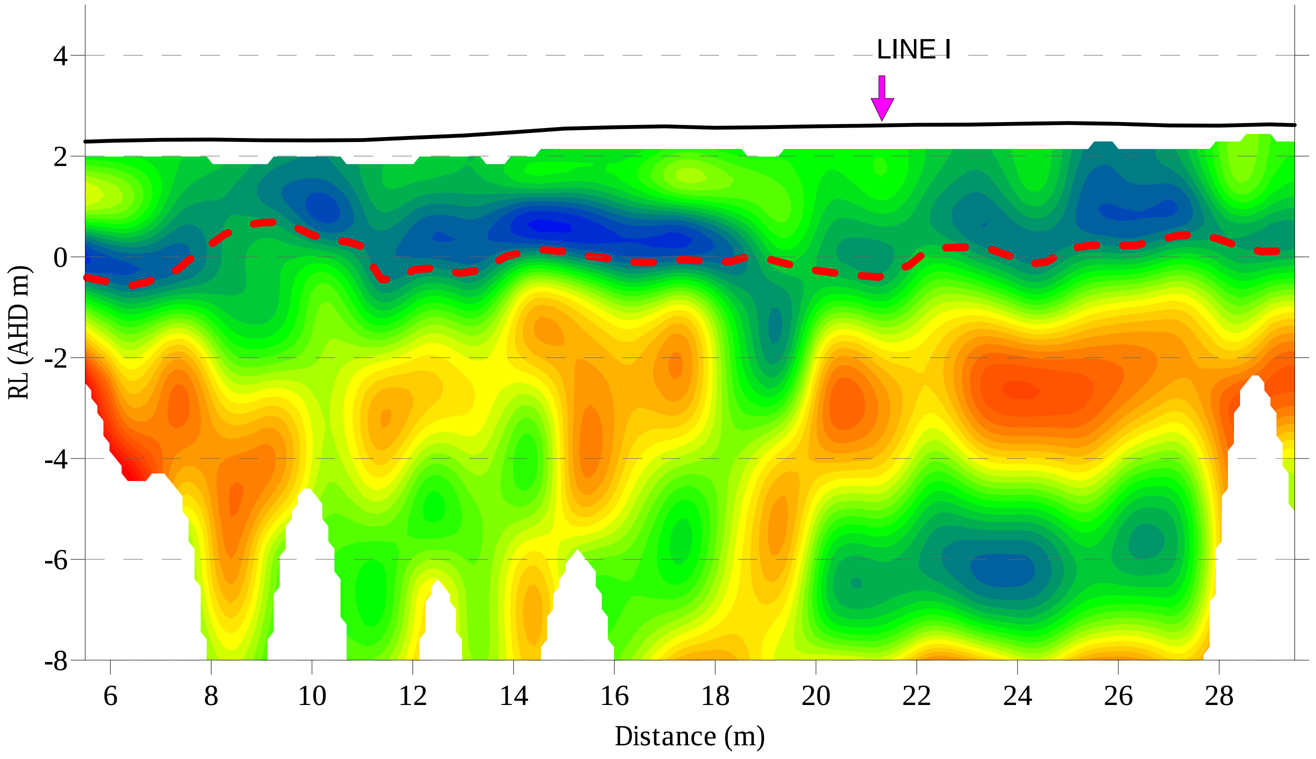
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

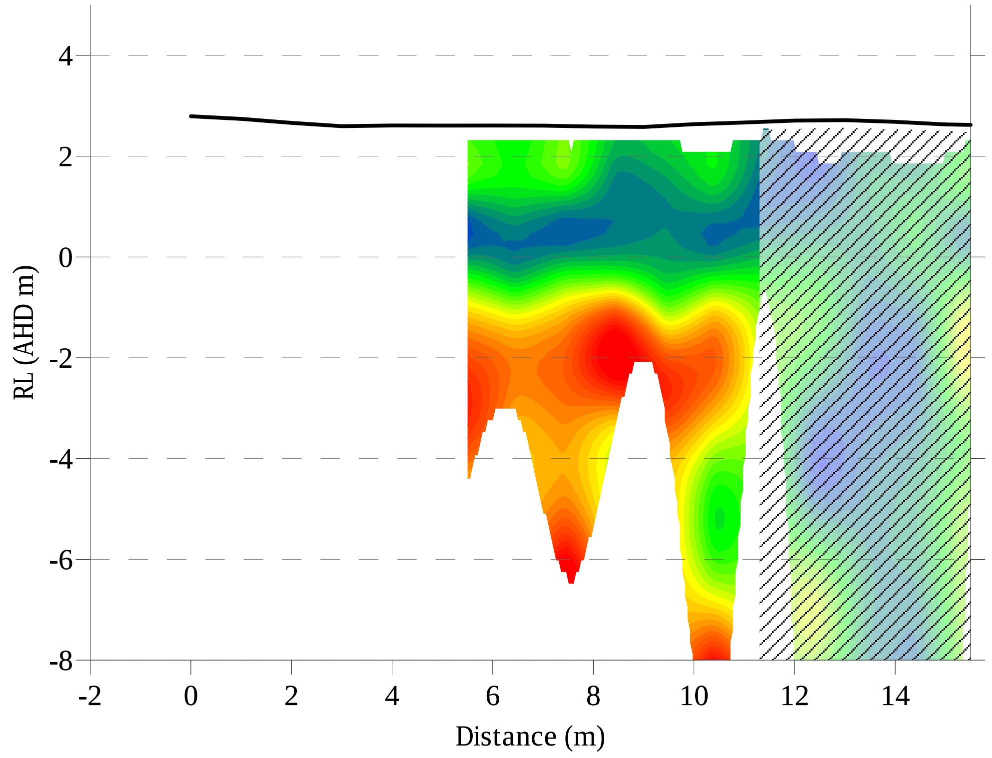
TITLE
MASW SECTION LINE 12 & G

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	20

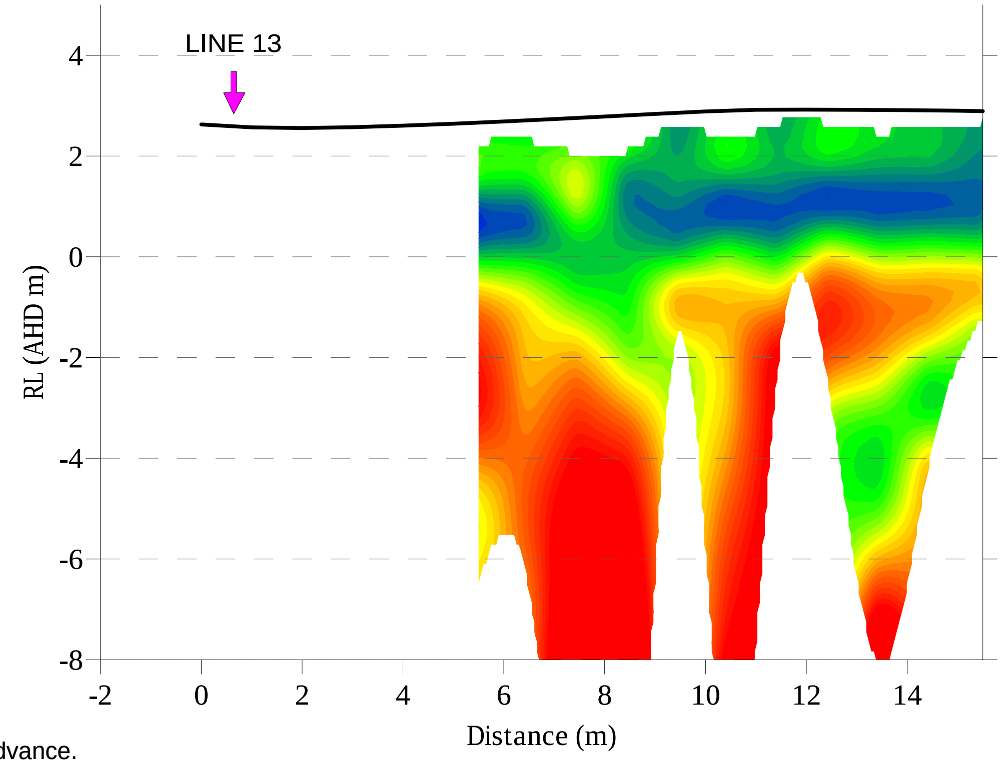
South-west **MASW - LINE 13** North-east



West **MASW - LINE H** East



West **MASW - LINE I** East



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

MODEL CONSIDERED UNRELIABLE DUE TO POOR QUALITY SEISMIC SIGNAL

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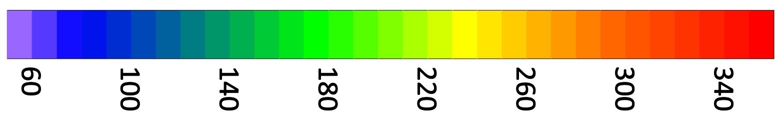


CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

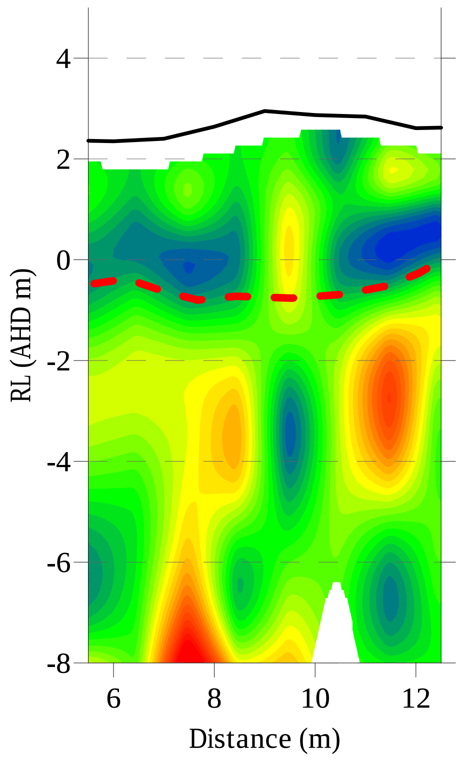
CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

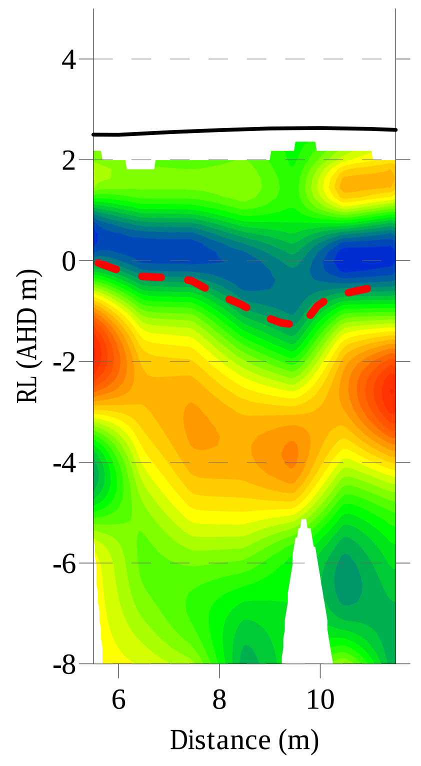
TITLE
MASW SECTION LINE 13 & H & I

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	21

South-west **MASW - LINE 14** North-east



South-west **MASW - LINE 15** North-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

LIMITATIONS

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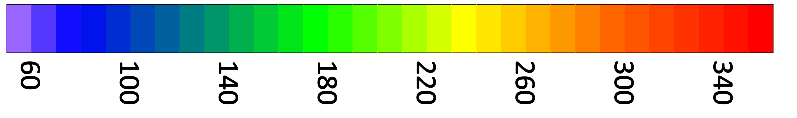
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

CONSULTANT
GOLDER MEMBER OF WSP

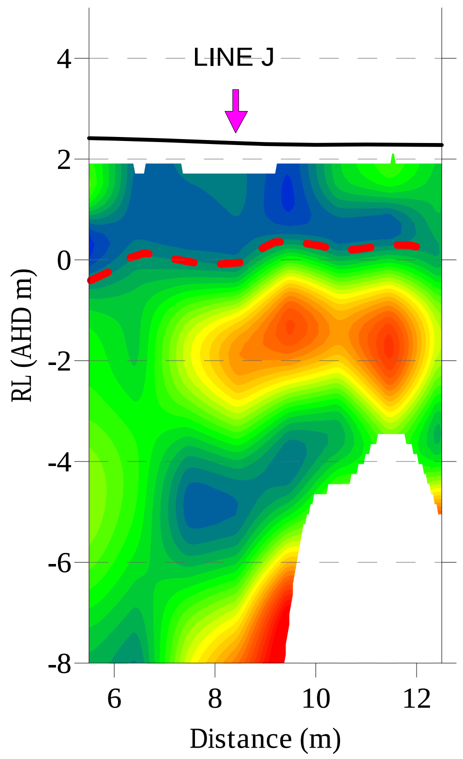
YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

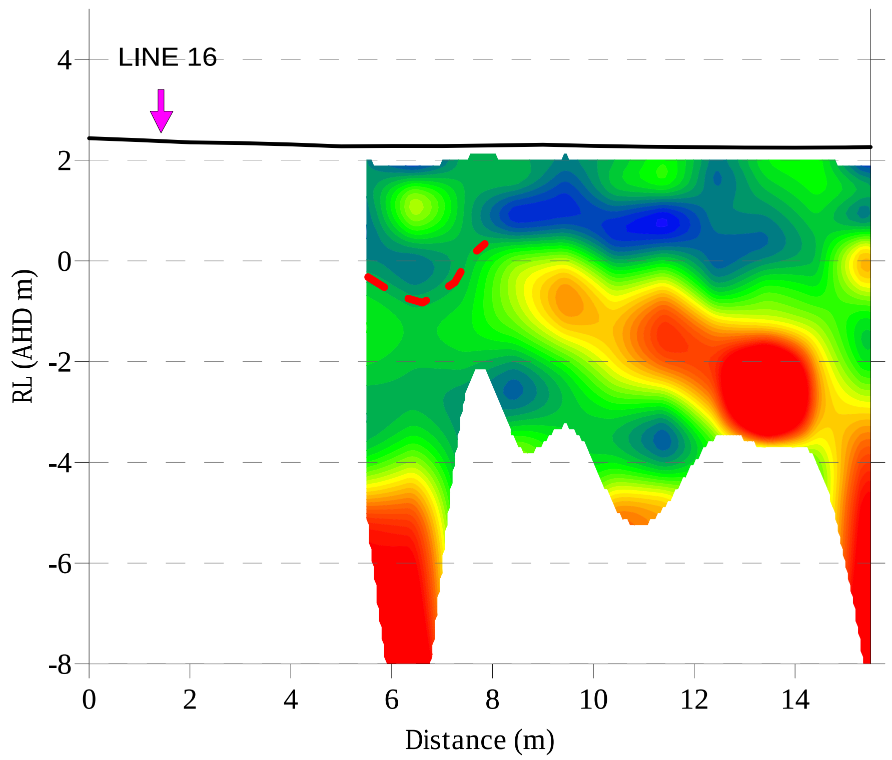
TITLE
MASW SECTION LINE 14 & 15

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	22

South-west **MASW - LINE 16** North-east



North-west **MASW - LINE J** South-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
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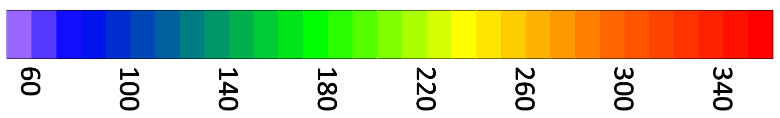
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

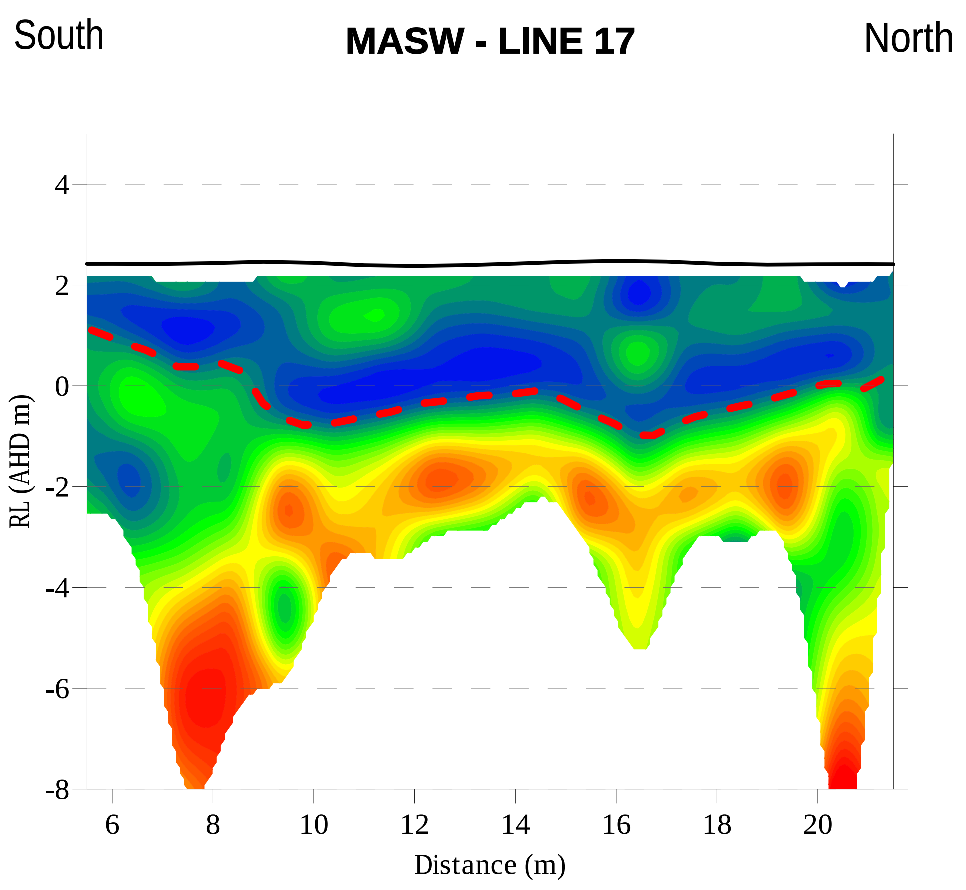
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

TITLE
MASW SECTION LINE 16 & J

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	23



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
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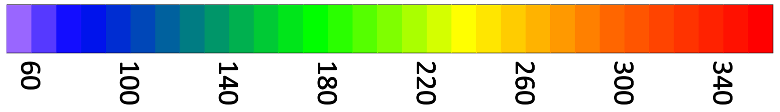
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

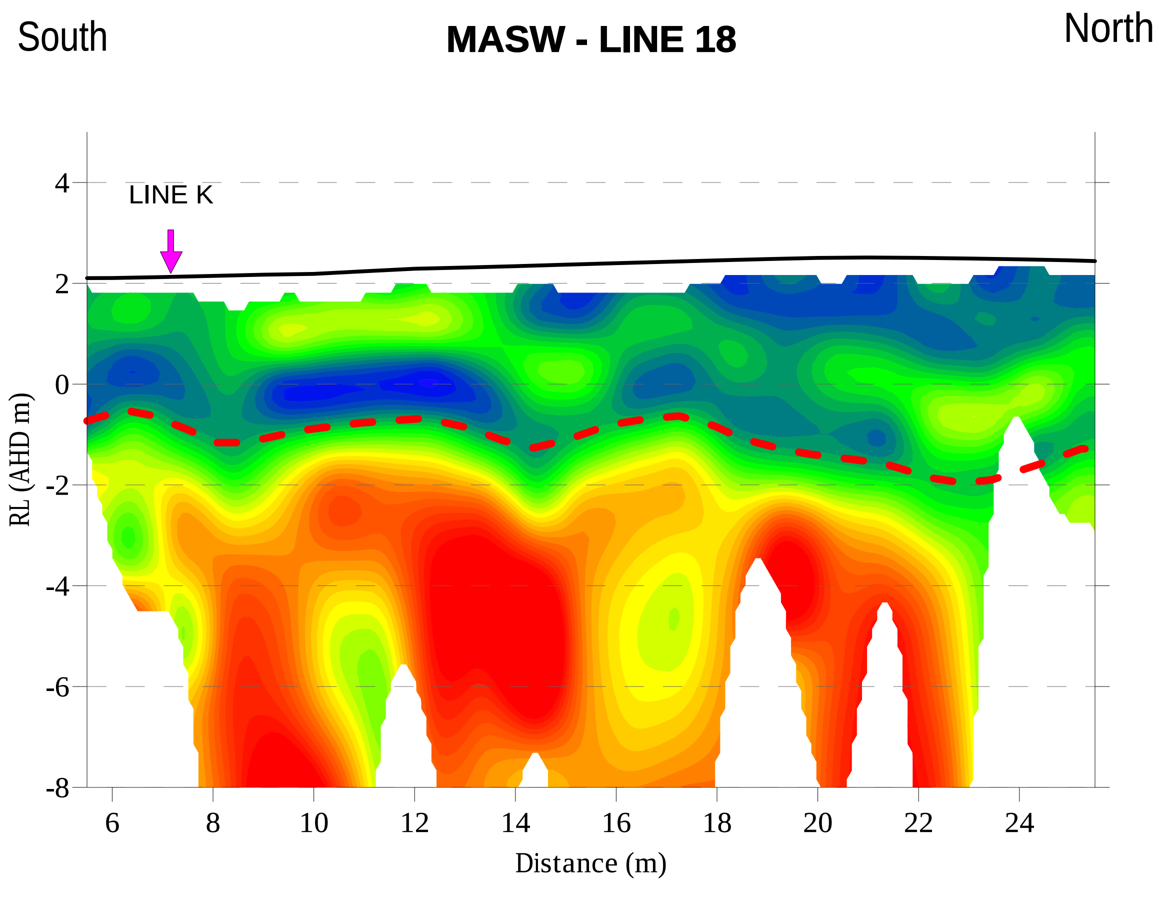
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

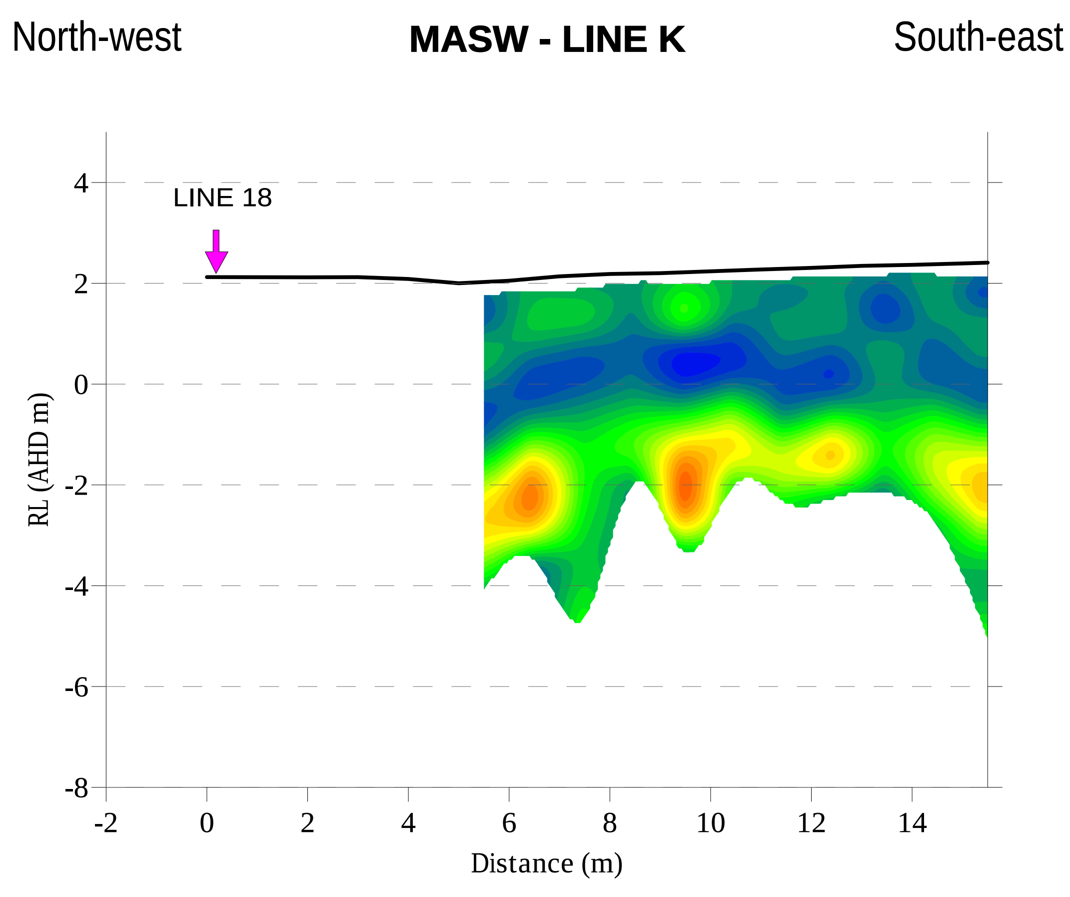
CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

TITLE
MASW SECTION LINE 17

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	24





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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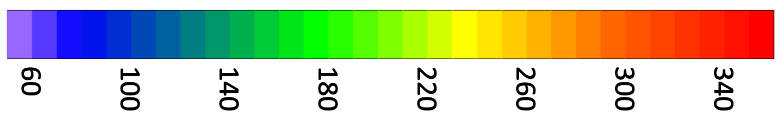
SEISMIC S-WAVE VELOCITY, V_S (m/s)



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REDLAND CITY COUNCIL

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

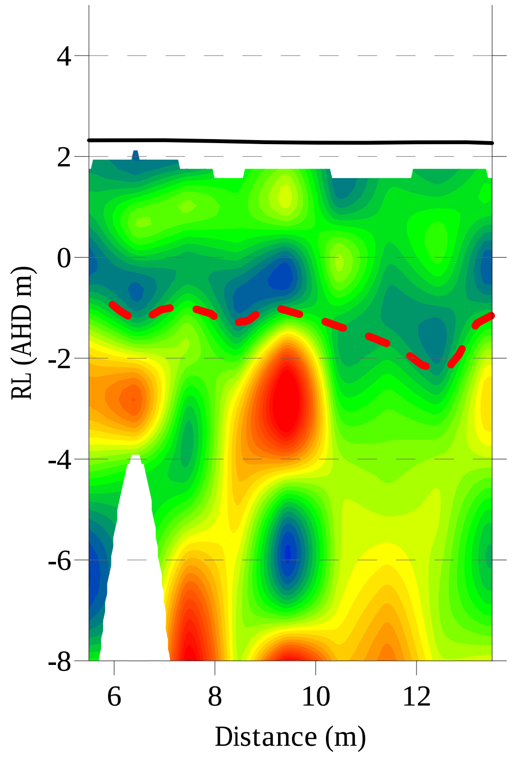
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
MASW SECTION LINE 18 & K

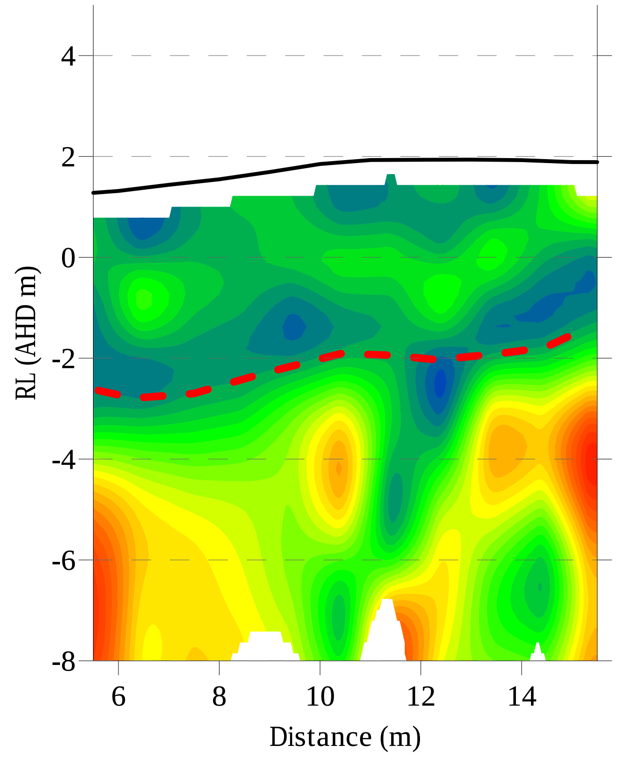
PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	25

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm
0

South-west **MASW - LINE 19** North-east



North-west **MASW - LINE L** South-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
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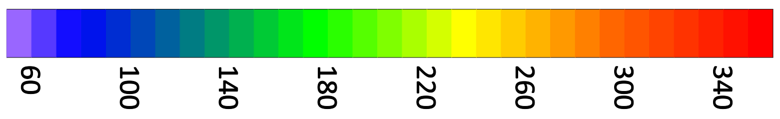
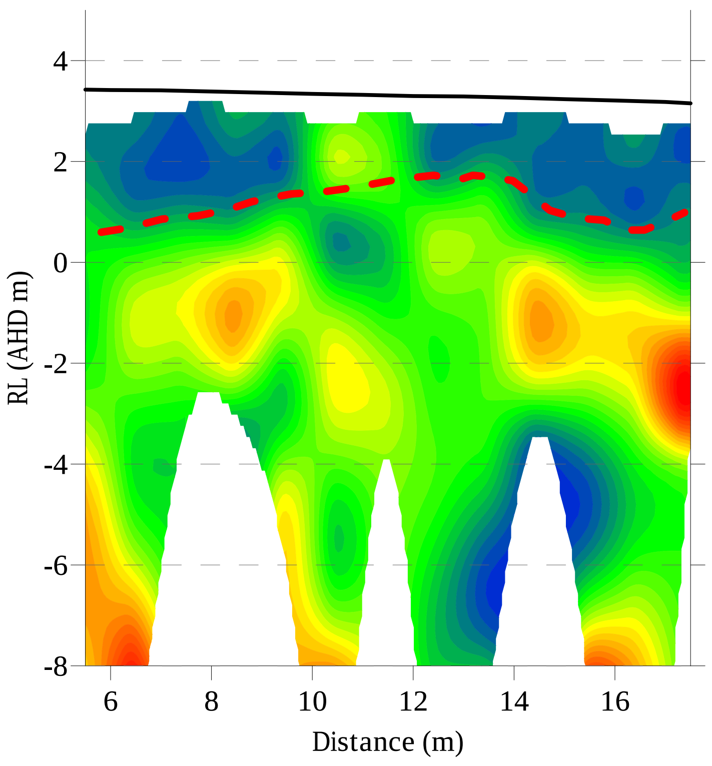
SEISMIC S-WAVE VELOCITY, V_S (m/s)

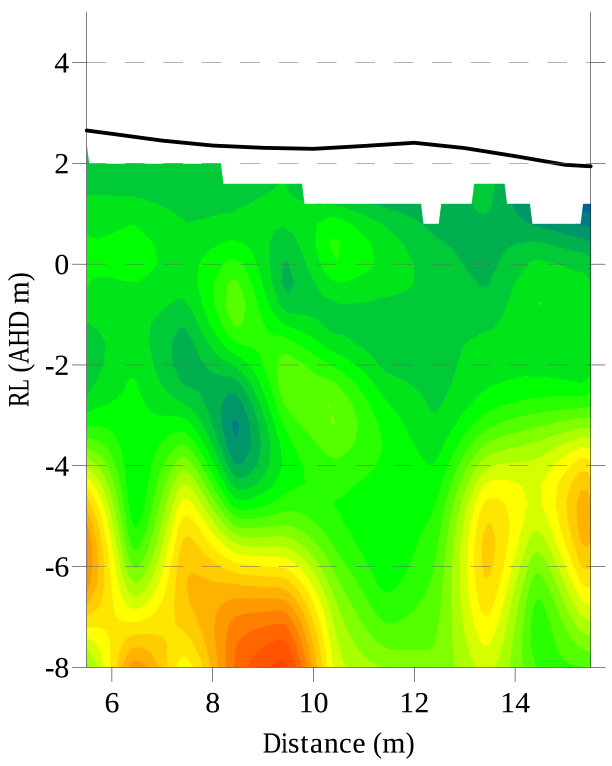


CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--
TITLE	MASW SECTION LINE 19 & L
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	26

South-west **MASW - LINE 20** North-east



North-west **MASW - LINE M** South-east



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
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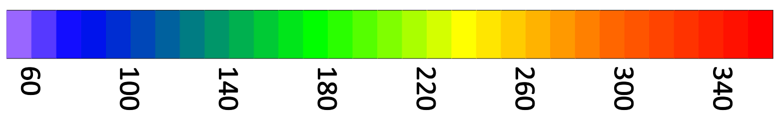
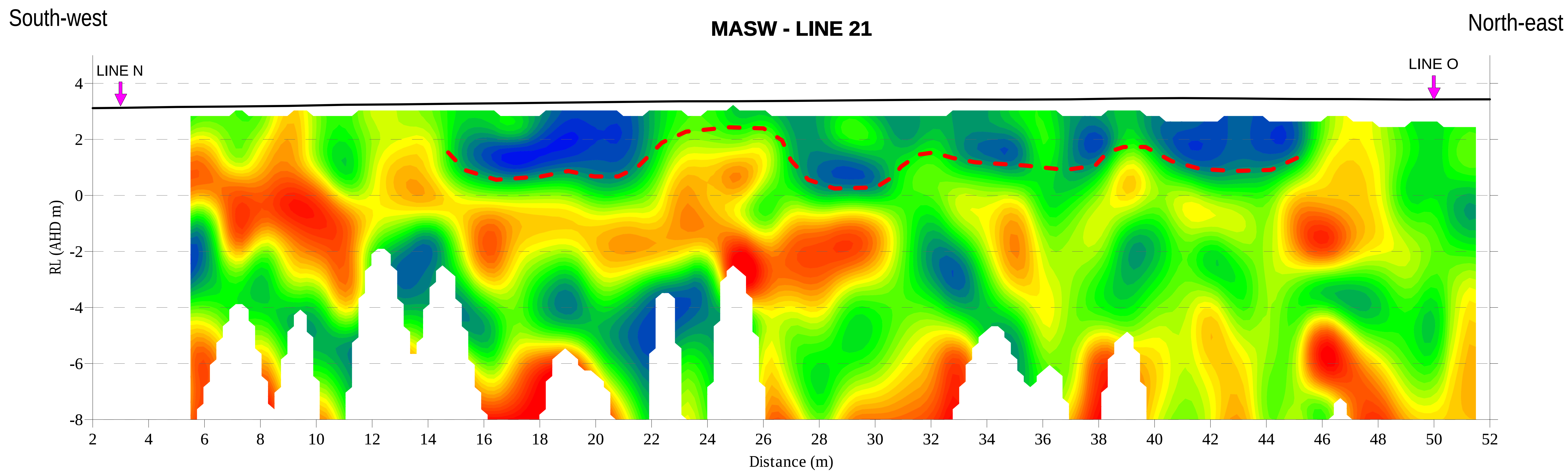
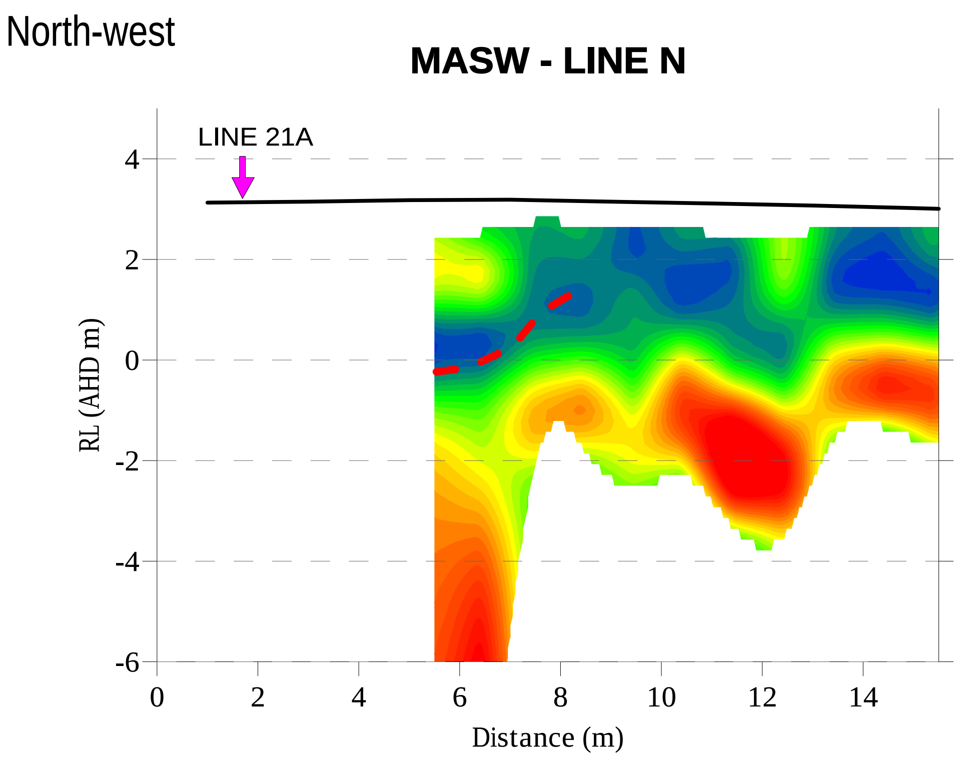
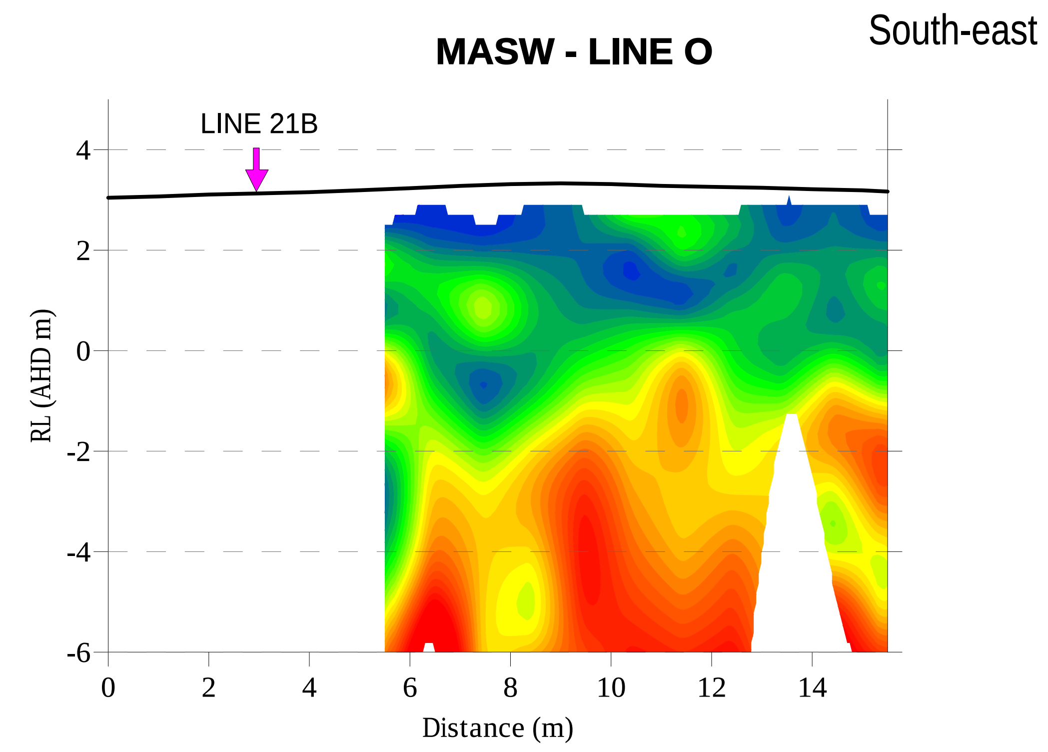
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD	2022-02-04	TITLE **MASW SECTION LINE 20 & M**
	DESIGNED	RR	
	PREPARED	SS	
	REVIEWED	TR	PROJECT NO. 21453805 · DELIVERABLE 001 · REV. Rev0 · FIGURE 27
	APPROVED	--	







LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

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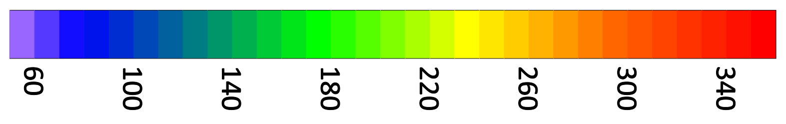
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

TITLE
MASW SECTION LINE 21, LINE N, and LINE O

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	28

LEGEND

MASW LINE

INTERPRETED FSB MATERIAL THICKNESS (m)

0.6 1 1.4 1.8 2.2 2.6 3 3.4 3.8 4.2 4.6 5 5.4

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REDLAND CITY COUNCIL

CONSULTANT
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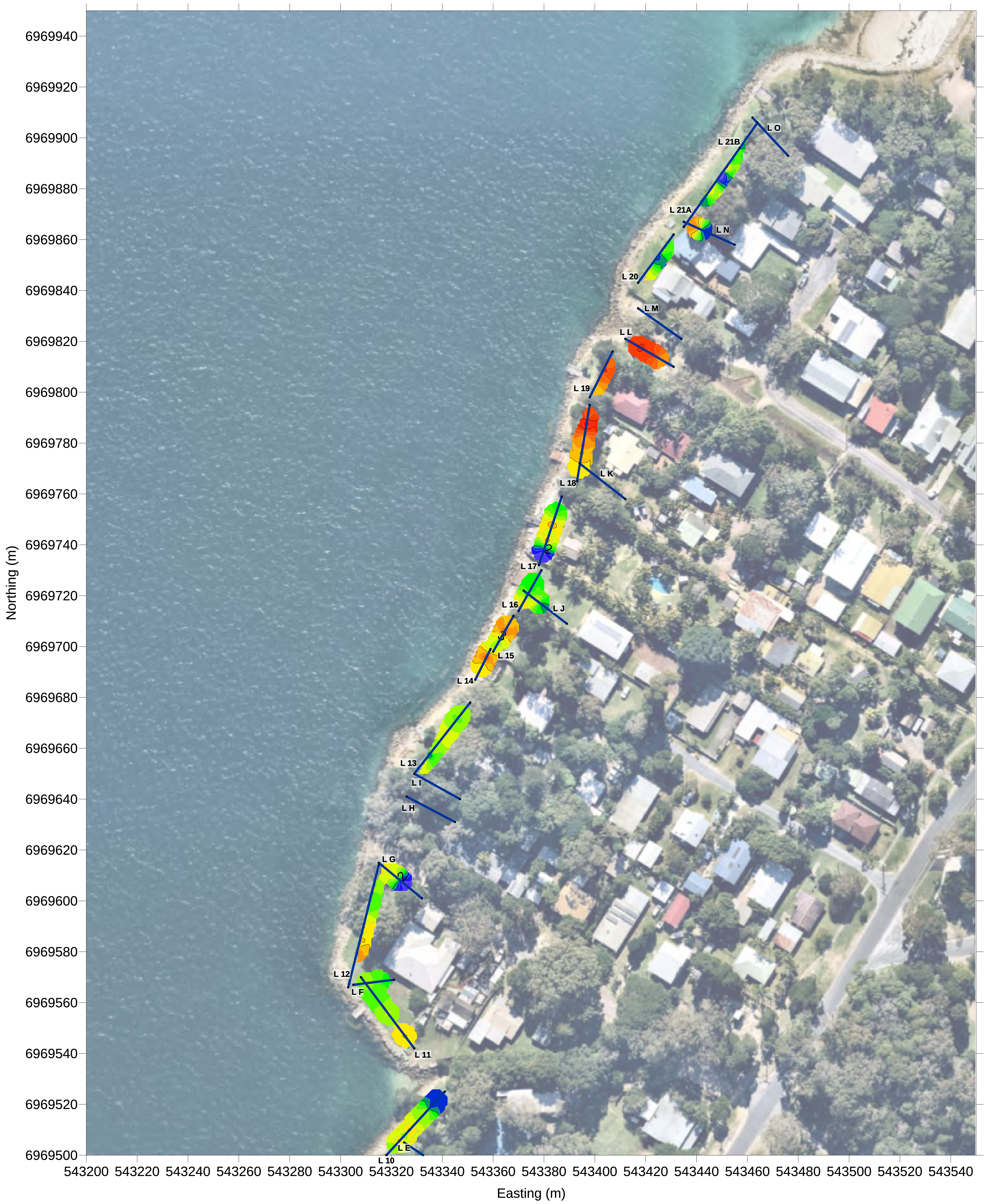
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
INTERPRETED MASW THICKNESS - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	29



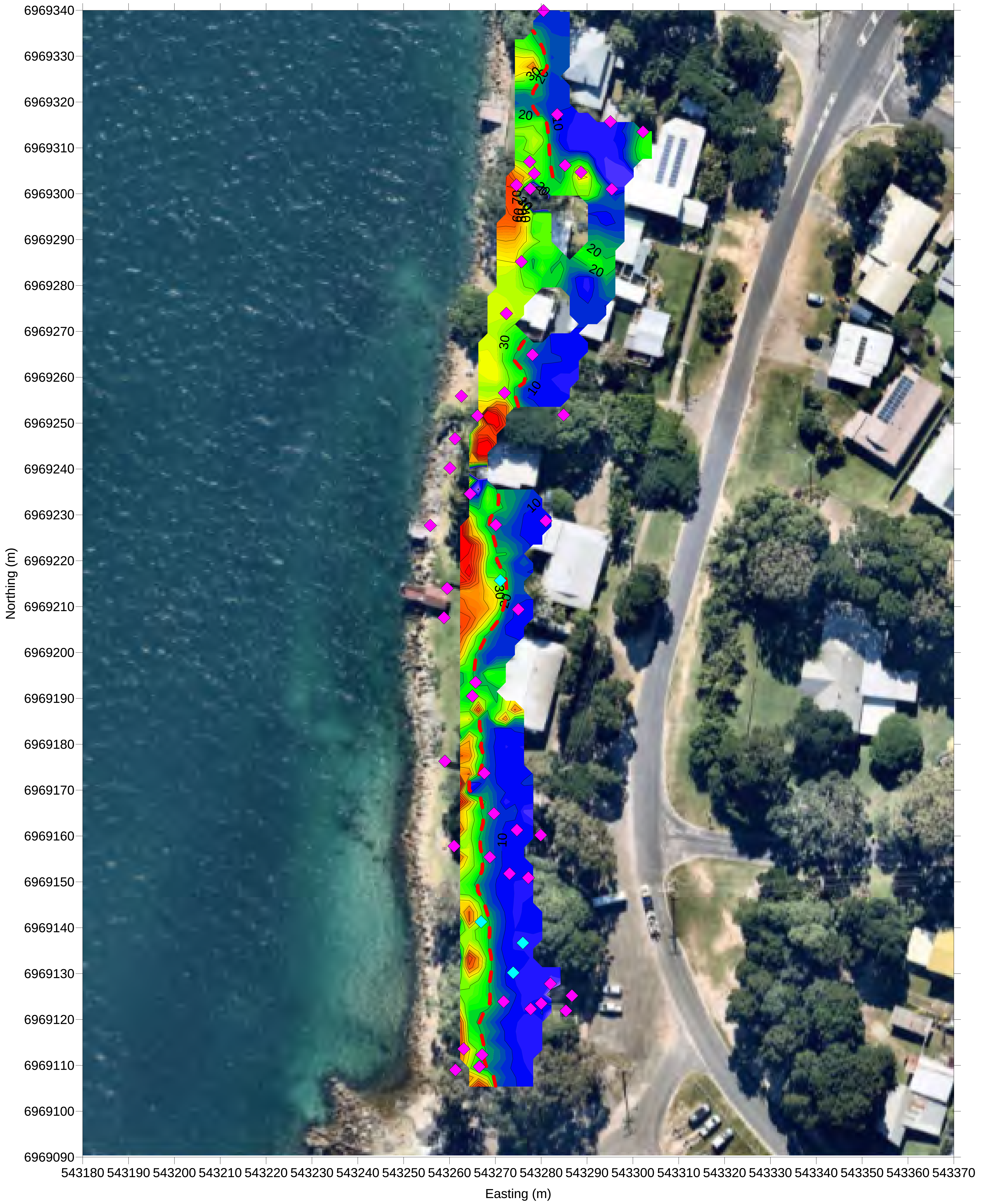
LEGEND

MASW LINE

INTERPRETED FSB MATERIAL THICKNESS (m)

0.6 1 1.4 1.8 2.2 2.6 3 3.4 3.8 4.2 4.6 5 5.4

CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR
TITLE	INTERPRETED MASW THICKNESS - NORTH
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	30



Legend

Interpreted lateral extent of rock armour

Surface feature: ferrous

Surface feature: non-ferrous

Apparent Conductivity (mS/m)

0 10 20 30 40 50 60 70 80 90 100

CLIENT
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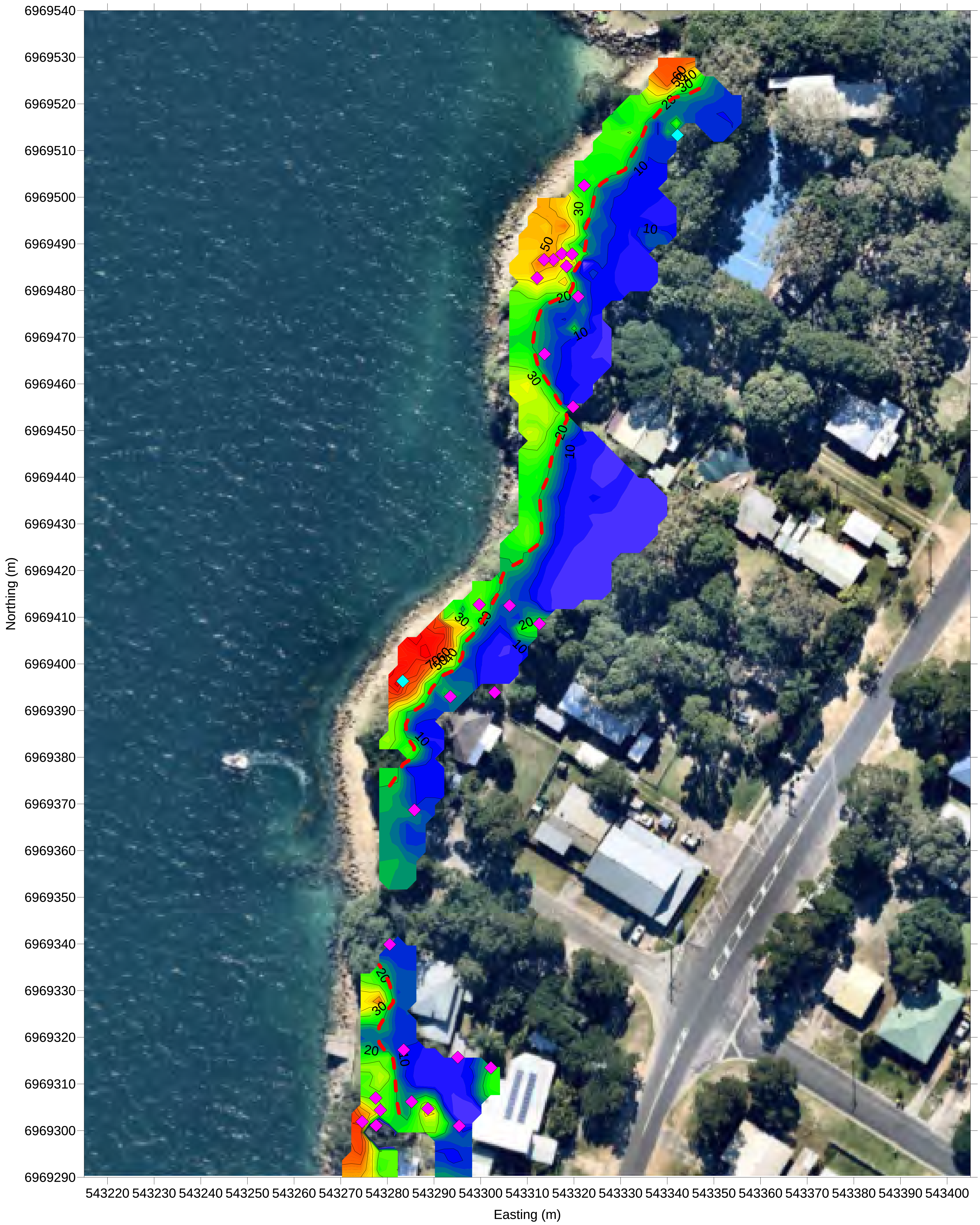
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR

TITLE
EM SURVEY RESULTS - 2.2 m DEPTH SLICE
AREA A - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	31



Legend

Interpreted lateral extent of rock armour

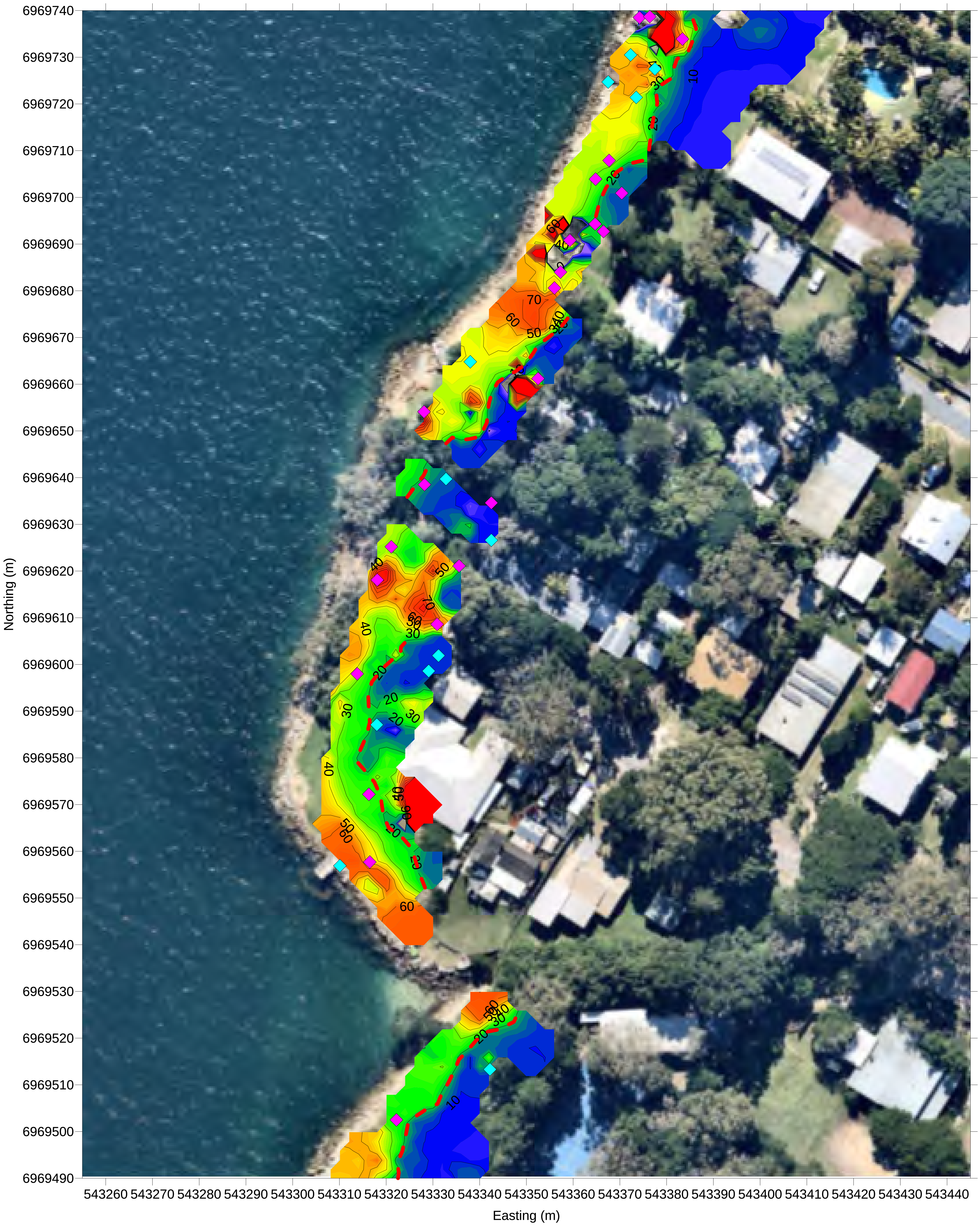
Surface feature: ferrous

Surface feature: non-ferrous

Apparent Conductivity (mS/m)

0 10 20 30 40 50 60 70 80 90 100

CLIENT REDLANDS CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD 2022-01-17 DESIGNED RR PREPARED LR REVIEWED TR APPROVED TR	TITLE **EM SURVEY RESULTS - 2.2 m DEPTH SLICE** **AREA B - CENTRAL SOUTH**	
		PROJECT NO. 21453805	DELIVERABLE 001
		REV. Rev0	FIGURE 32



Legend

Interpreted lateral extent of rock armour

Surface feature: ferrous

Surface feature: non-ferrous

Apparent Conductivity (mS/m)

0 10 20 30 40 50 60 70 80 90 100

CLIENT
REDLANDS CITY COUNCIL

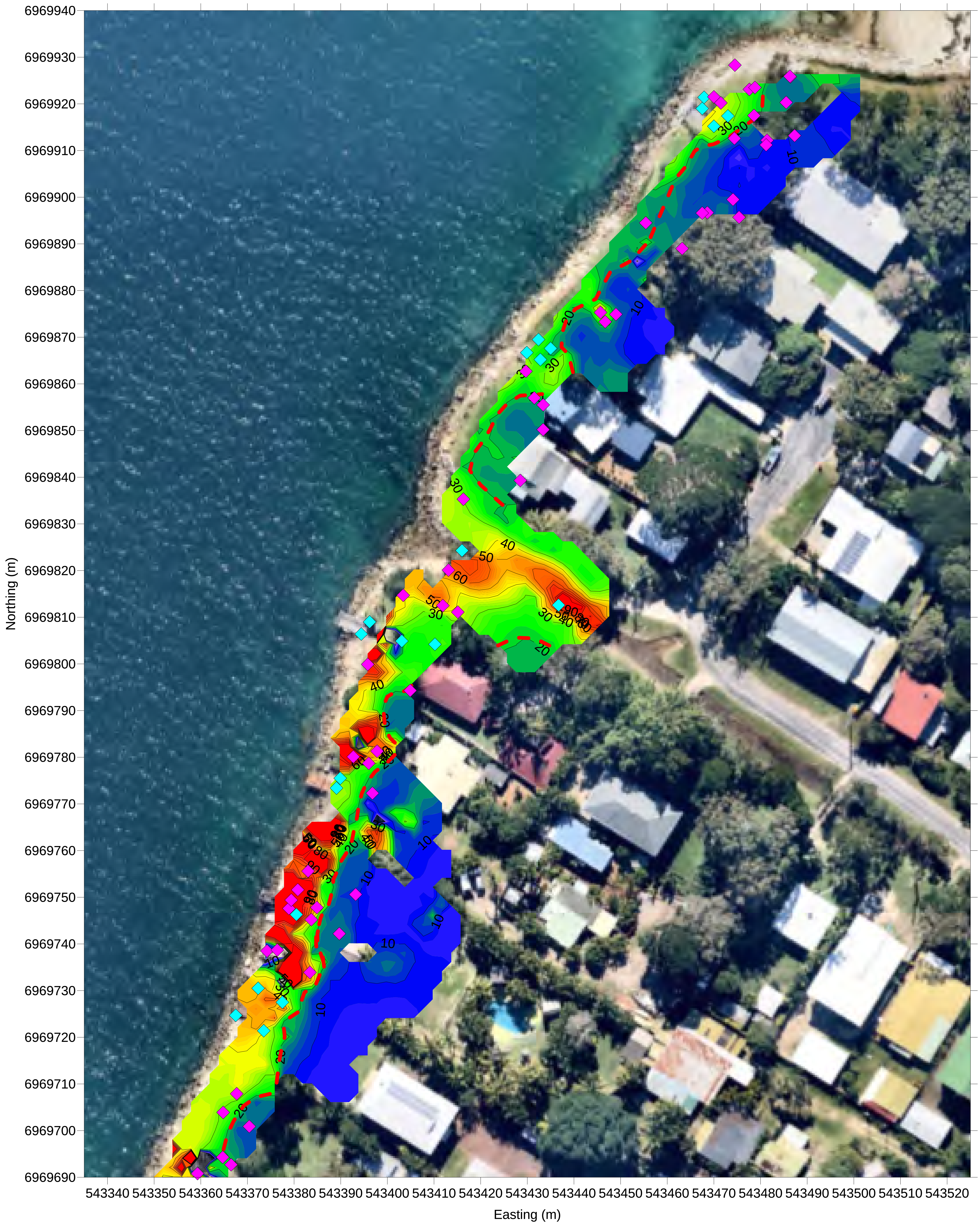
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR

TITLE
EM SURVEY RESULTS - 2.2 m DEPTH SLICE
AREA C - CENTRAL NORTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	33



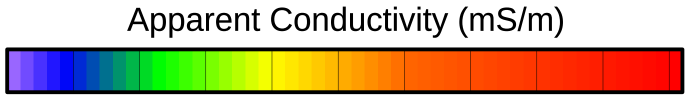
Legend

Interpreted lateral extent of rock armour

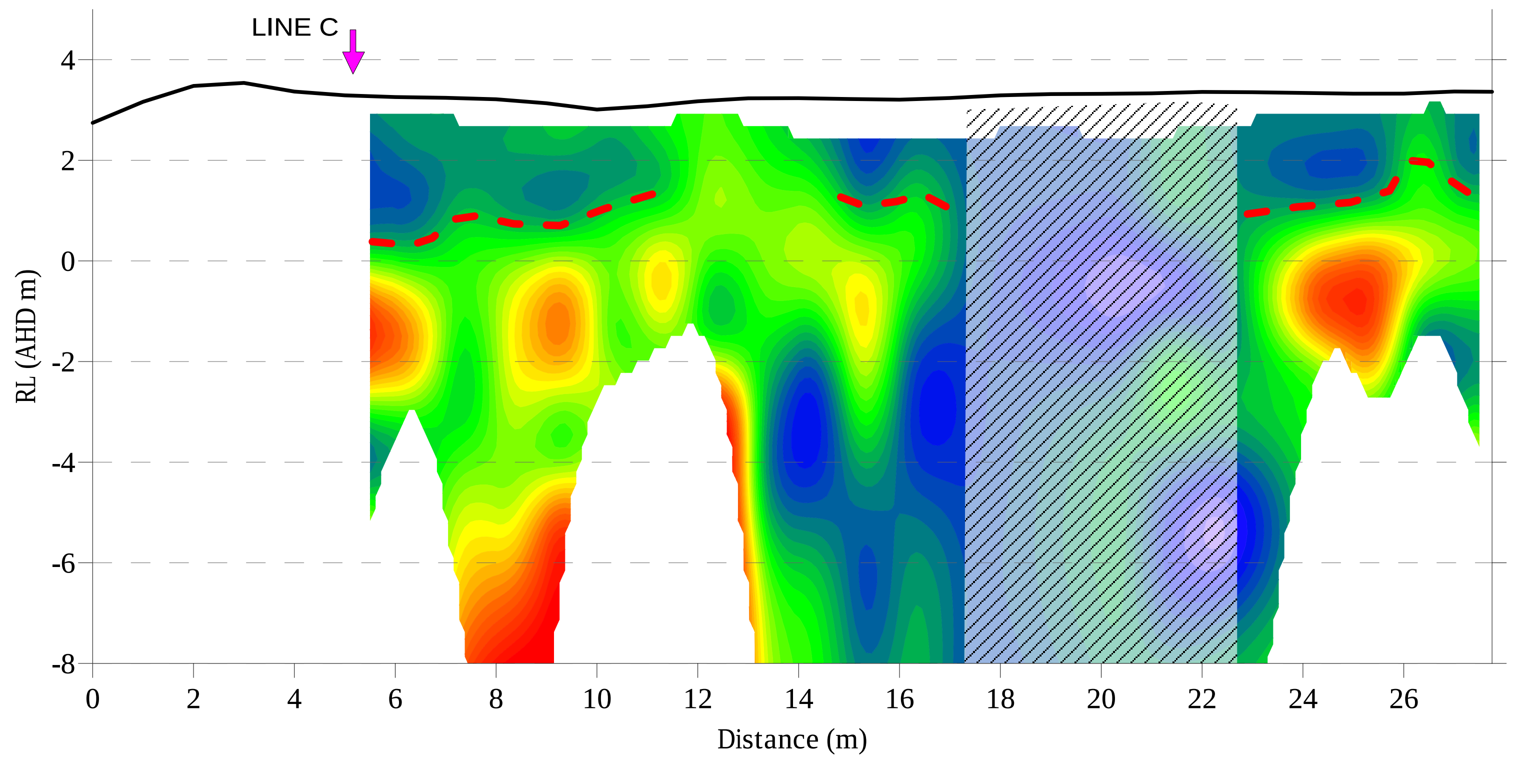
Surface feature: ferrous

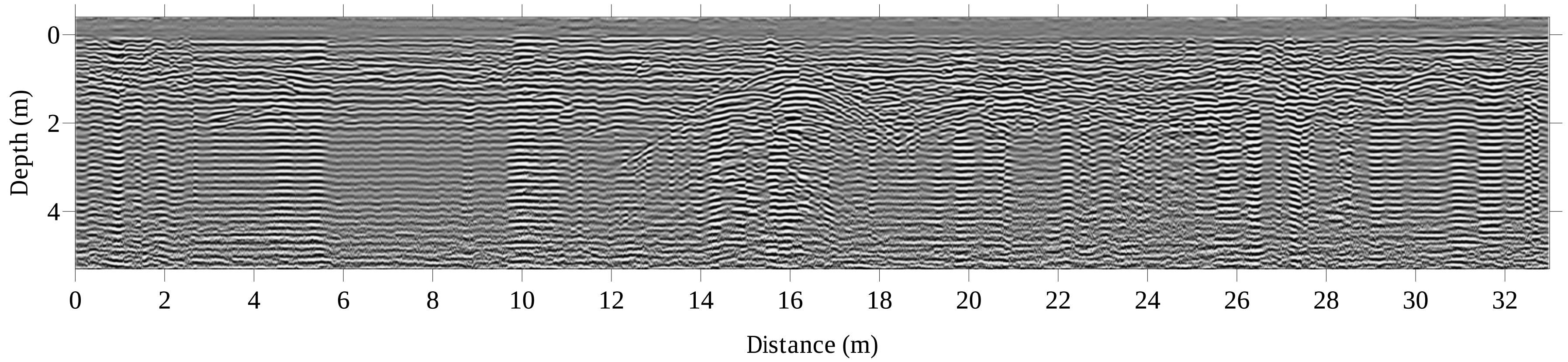
Surface feature: non-ferrous

Apparent Conductivity (mS/m)



CLIENT REDLANDS CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD 2022-01-17 DESIGNED RR PREPARED LR REVIEWED TR APPROVED TR	TITLE **EM SURVEY RESULTS - 2.2 m DEPTH SLICE** **AREA D - NORTH**
		PROJECT NO. 21453805 DELIVERABLE 001 REV. Rev0 FIGURE 34





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

MODEL CONSIDERED UNRELIABLE DUE TO POOR QUALITY SEISMIC SIGNAL

INTERPRETED TOP OF ROCK WALL - GPR

INTERPRETED BASE OF ROCK WALL - GPR

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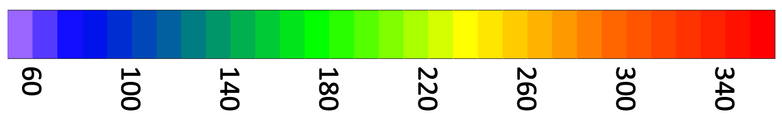
SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

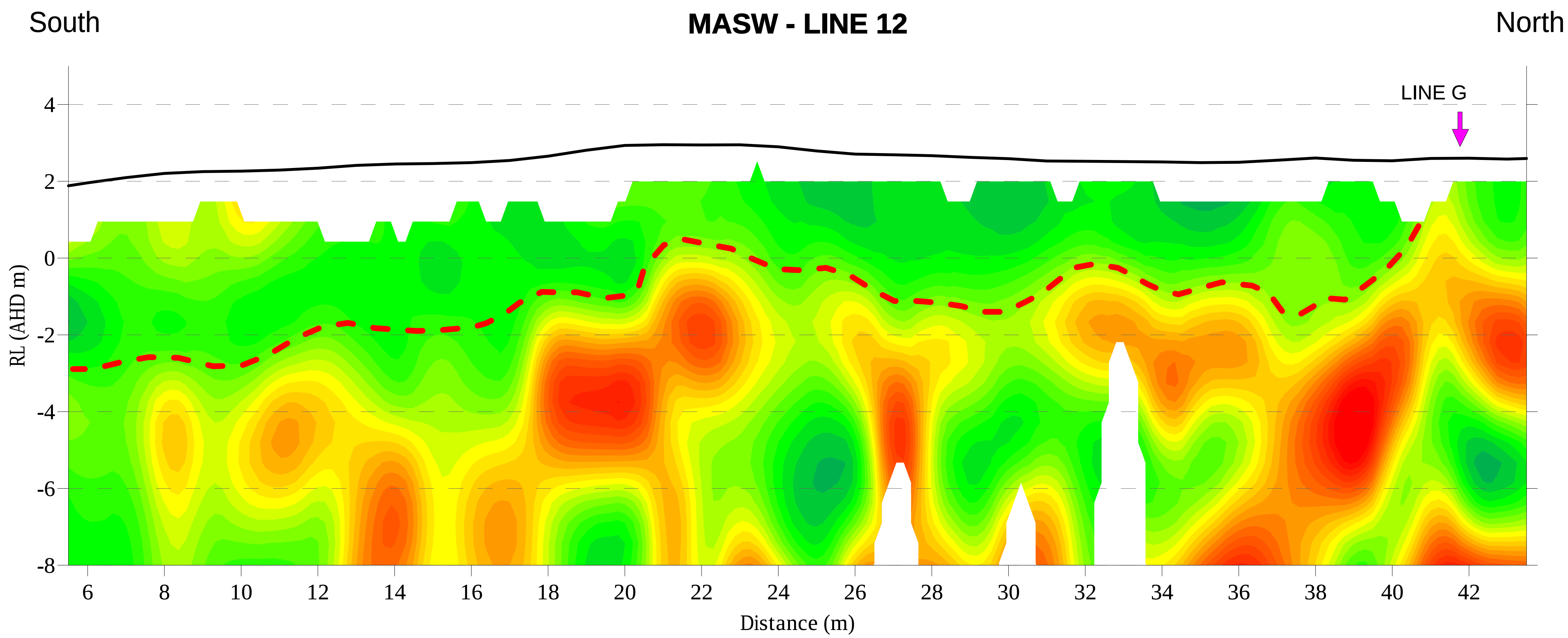
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

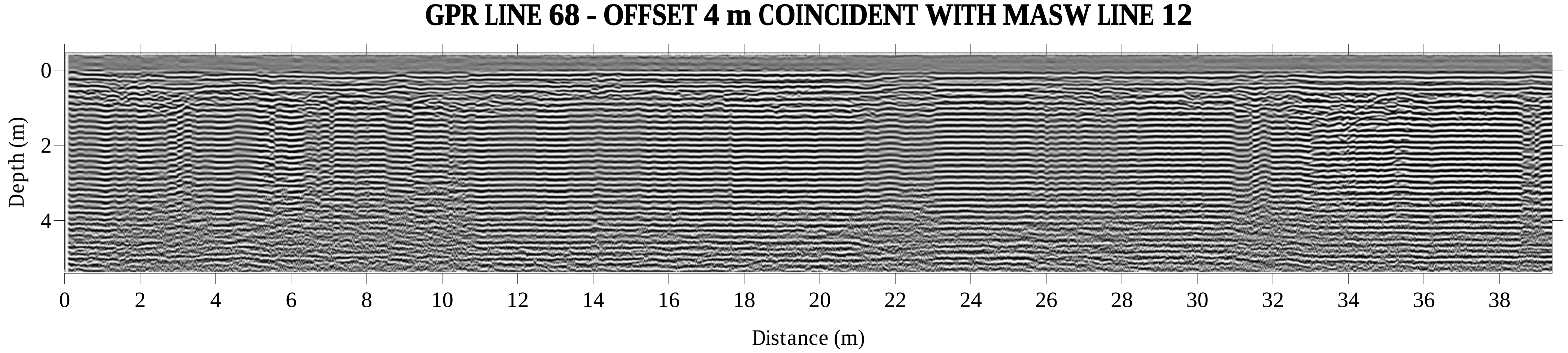
CONSULTANT
GOLDER

YYYY-MM-DD	2022-03-09
DESIGNED	RR
PREPARED	HJ
REVIEWED	TR
APPROVED	--

TITLE
GPR SECTION LINE 30 (MASW SECTION LINE 4)

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	RevA	35





LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

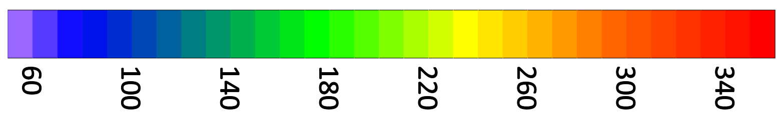
MODEL CONSIDERED UNRELIABLE DUE TO POOR QUALITY SEISMIC SIGNAL

INTERPRETED TOP OF ROCK WALL - GPR

INTERPRETED BASE OF ROCK WALL - GPR

NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

SEISMIC S-WAVE VELOCITY, V_S (m/s)



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-03-09
DESIGNED	RR
PREPARED	HJ
REVIEWED	TR
APPROVED	--

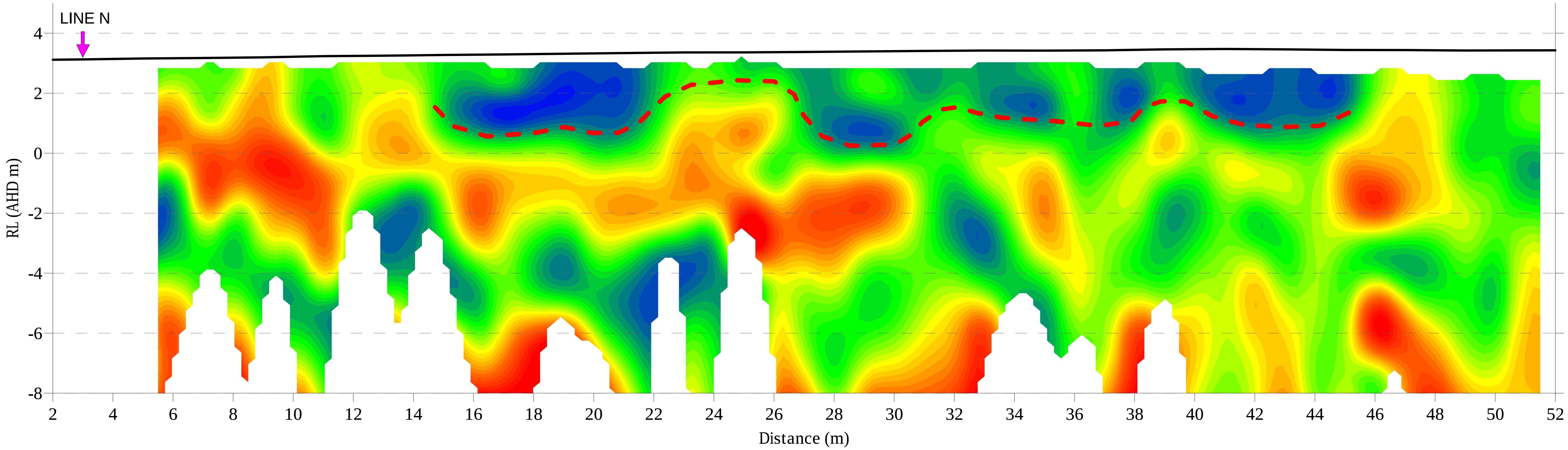
TITLE
GPR SECTION LINE 68 (MASW SECTION LINE 12)

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	RevA	36

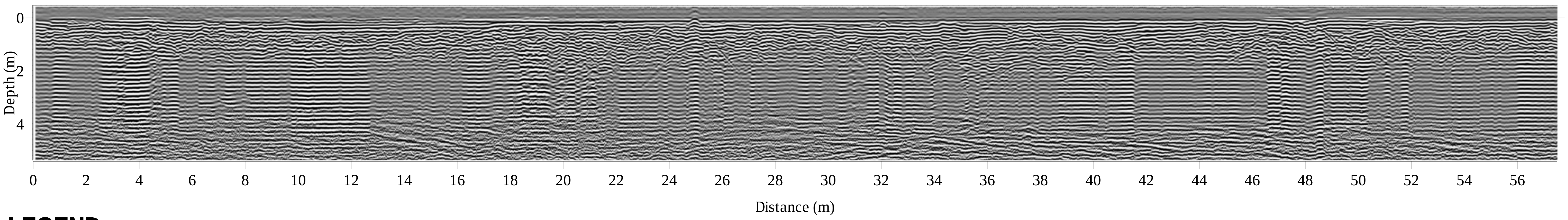
South-west

North-east

MASW - LINE 21



GPR LINE 135 - OFFSET 4 m WEST OF MASW LINE 21



LEGEND

INTERPRETED BASE OF ROCK ARMOUR

ORTHOGONAL LINE INTERSECTION

MODEL CONSIDERED UNRELIABLE DUE TO POOR QUALITY SEISMIC SIGNAL

INTERPRETED TOP OF ROCK WALL - GPR

INTERPRETED BASE OF ROCK WALL - GPR

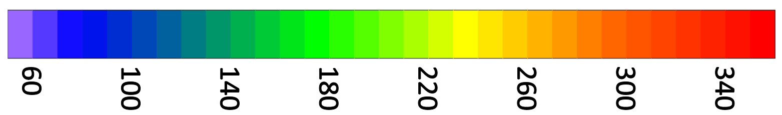
NOTES:
1. MASW data acquired using 24 geophones at 0.5 m spacing, with nominal 1 m spread advance.
2. MASW data processing was performed in Surfseis (KGS) software.
3. Elevations extracted from DEM data derived from Lidar supplied by Redland City Council.

LIMITATIONS
Golder Associates geophysical services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions and subject to the time limits, financial and physical constraints applicable to the services.

MASW is a remote sensing geophysical method that may not detect all subsurface features. Depth of penetration is dependent on the nature of the subsurface, acquisition parameters and data quality. Furthermore, it is possible that interpreted features such as stratigraphic boundaries, top of bedrock, faults, voids, other geologic hazards and utilities may, upon intrusive sampling, prove to have been misinterpreted.

MASW data are analysed using inverse modelling to provide a model of the subsurface conditions and geologic structure. This process does not necessarily produce a unique solution, i.e. a single geophysical dataset can produce multiple outputs that meet the specified constraints. Different modelling methods and software may produce different results. This inherent uncertainty in the results should be considered during the interpretation process. Accurate interpretation of geophysical data relies on the site-specific correlation of information with that obtained from borehole drilling, test pits or other direct observation methods.

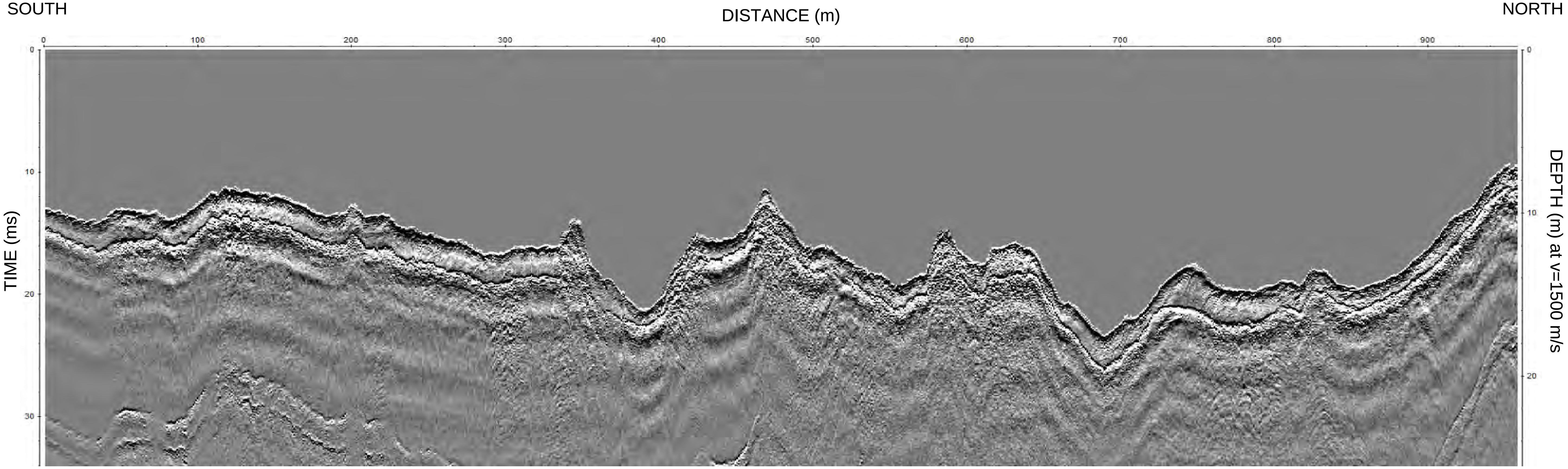
SEISMIC S-WAVE VELOCITY, V_S (m/s)

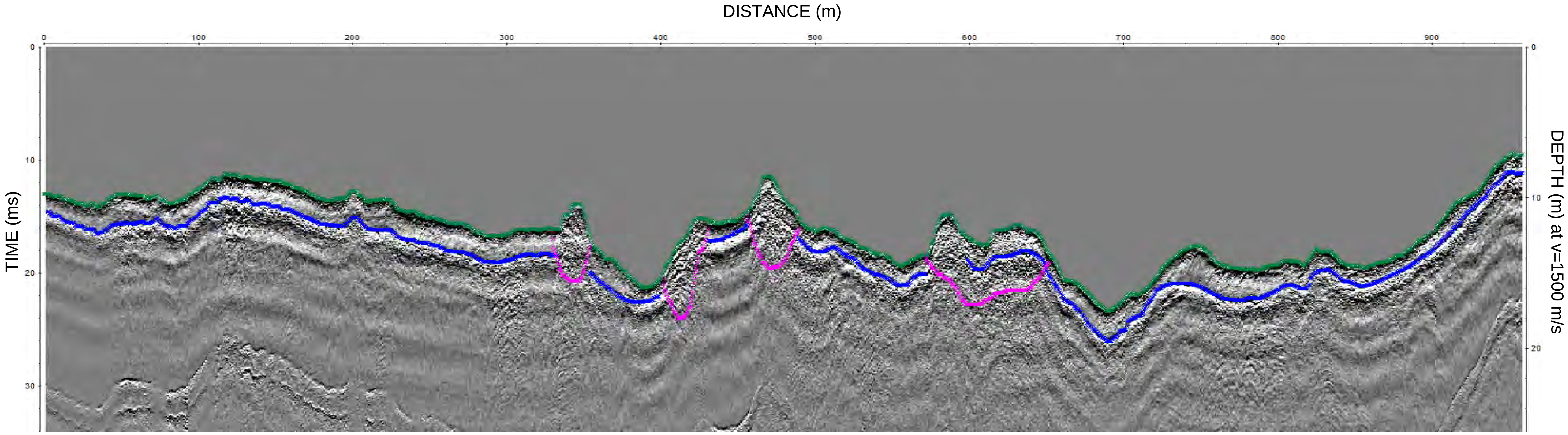


CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-03-09 DESIGNED: RR PREPARED: HJ REVIEWED: TR APPROVED: --	TITLE GPR SECTION LINE 135 (MASW SECTION LINE 21)	
		PROJECT NO. 21453805	DELIVERABLE 001 · REV. RevA · FIGURE 37

SOUTH

NORTH





LEGEND

- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

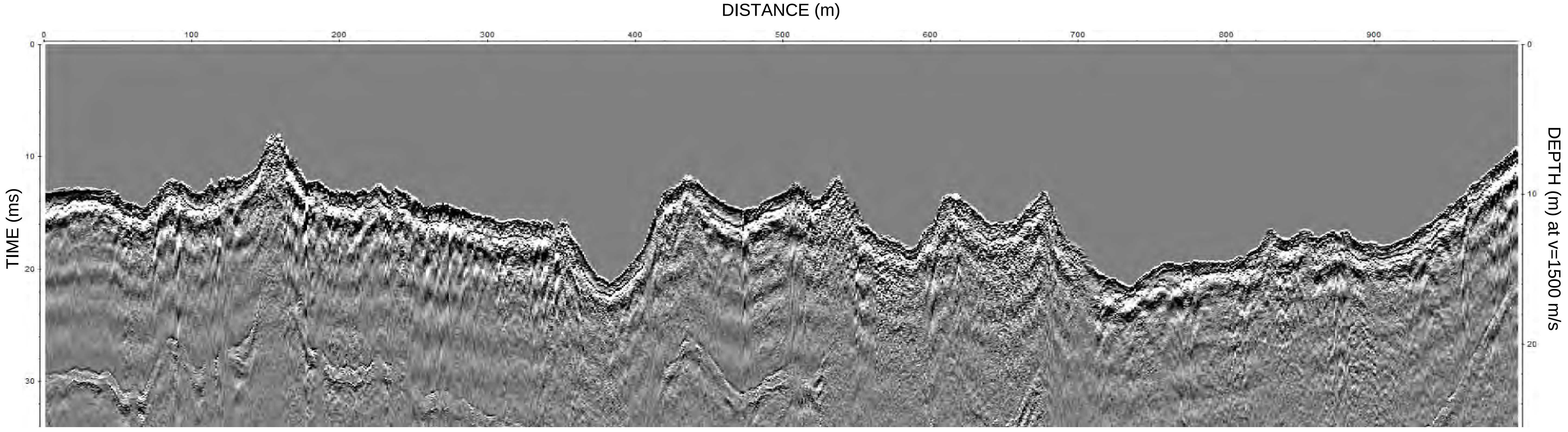
NOTES:
1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

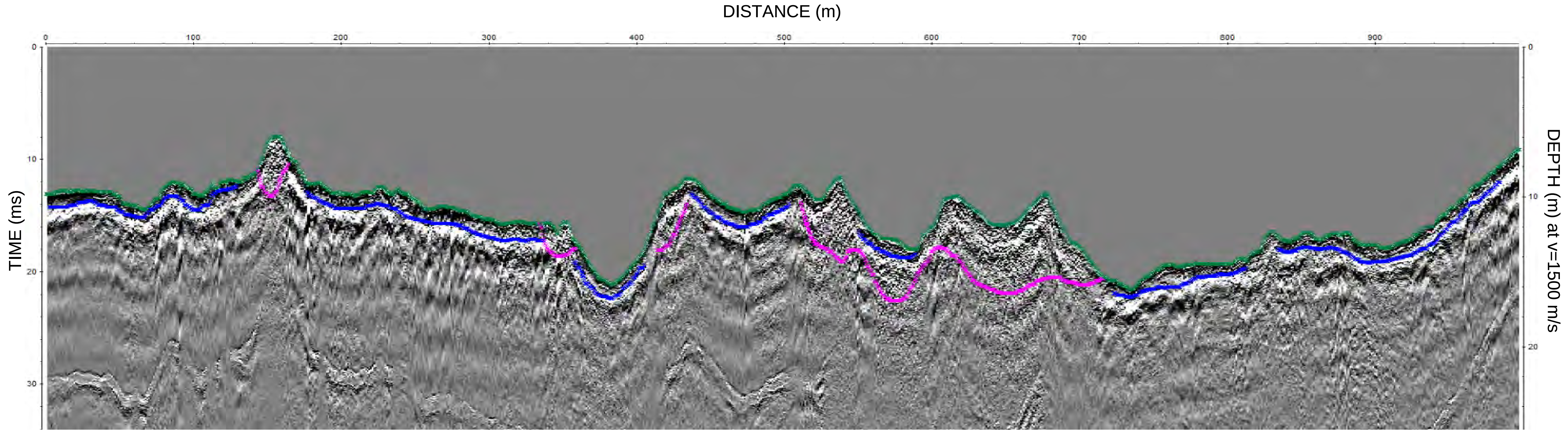
CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-03-11
DESIGNED	RR
PREPARED	RR
REVIEWED	TR
APPROVED	--
TITLE	**INTERPRETED SBP SECTION - LINE SBP-003**

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	38

SOUTH

NORTH





LEGEND

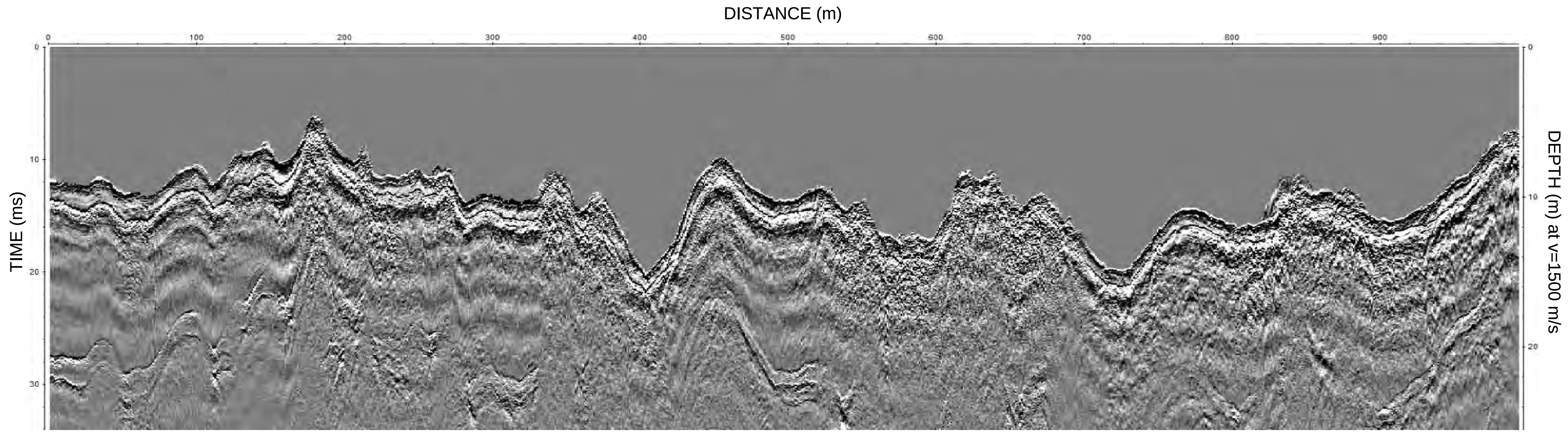
- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

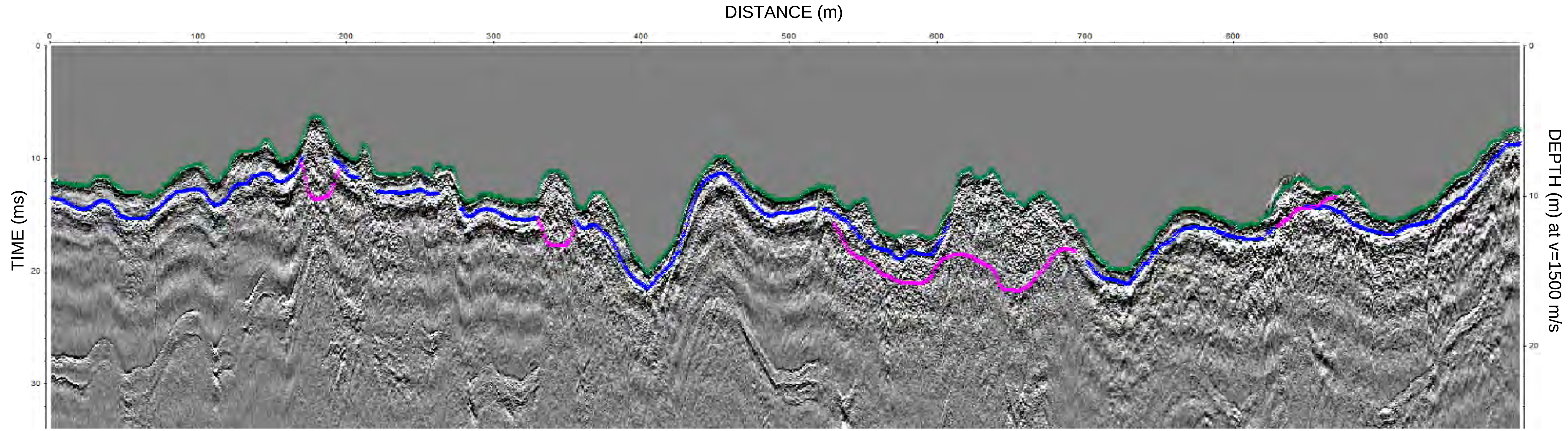
NOTES:
1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-03-11
DESIGNED	RR
PREPARED	RR
REVIEWED	TR
APPROVED	--
TITLE	**INTERPRETED SBP SECTION - LINE SBP-004**
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	39

SOUTH

NORTH



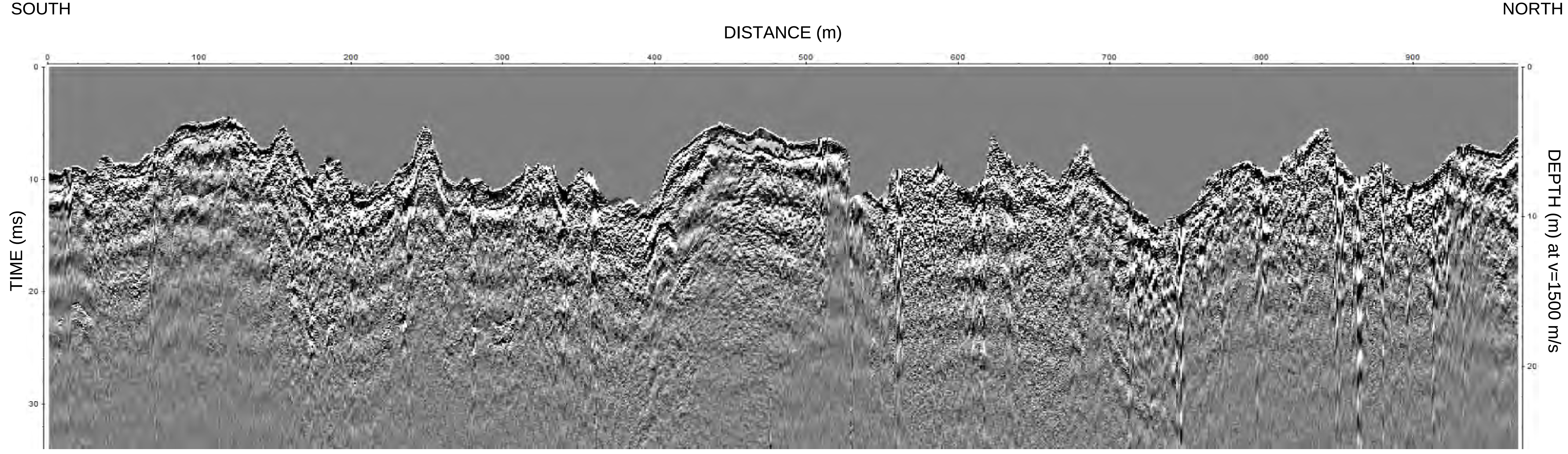


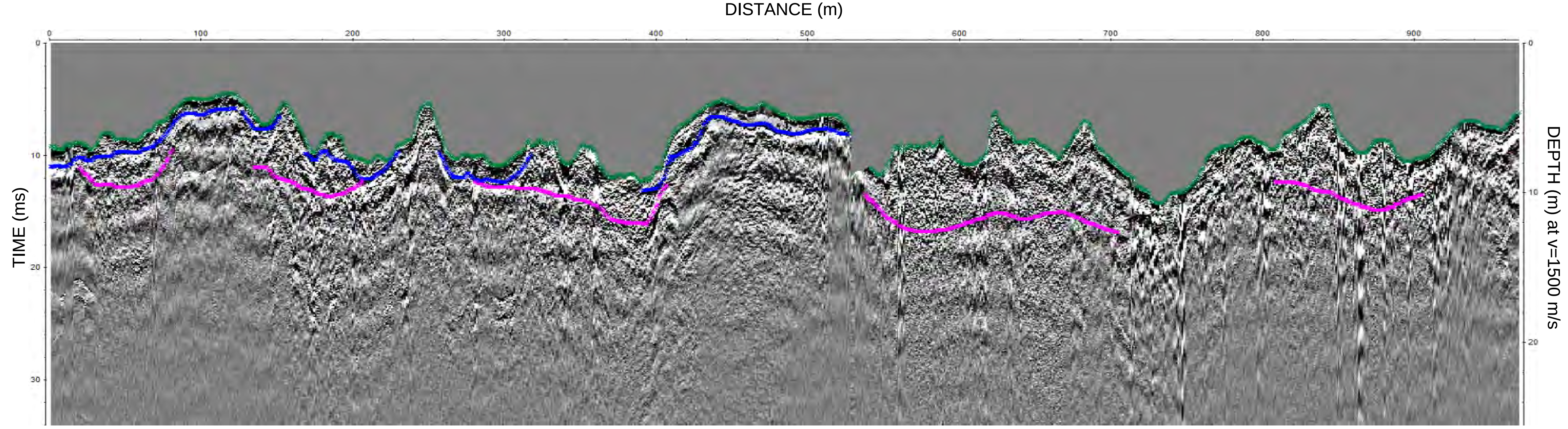
LEGEND

- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

NOTES:
1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

CLIENT REDLAND CITY COUNCIL			PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD	2022-03-11	TITLE **INTERPRETED SBP SECTION - LINE SBP-005**
	DESIGNED	RR	
	PREPARED	RR	
	REVIEWED	TR	PROJECT NO. 21453805 · DELIVERABLE 001 · REV. Rev0 · FIGURE 40
	APPROVED	--	



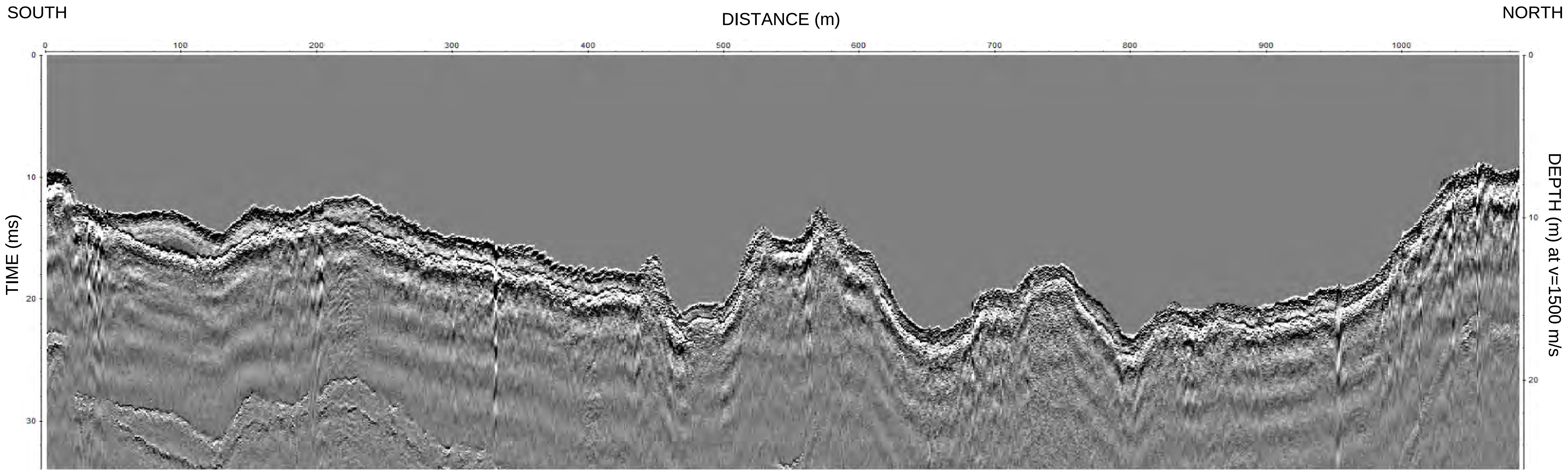


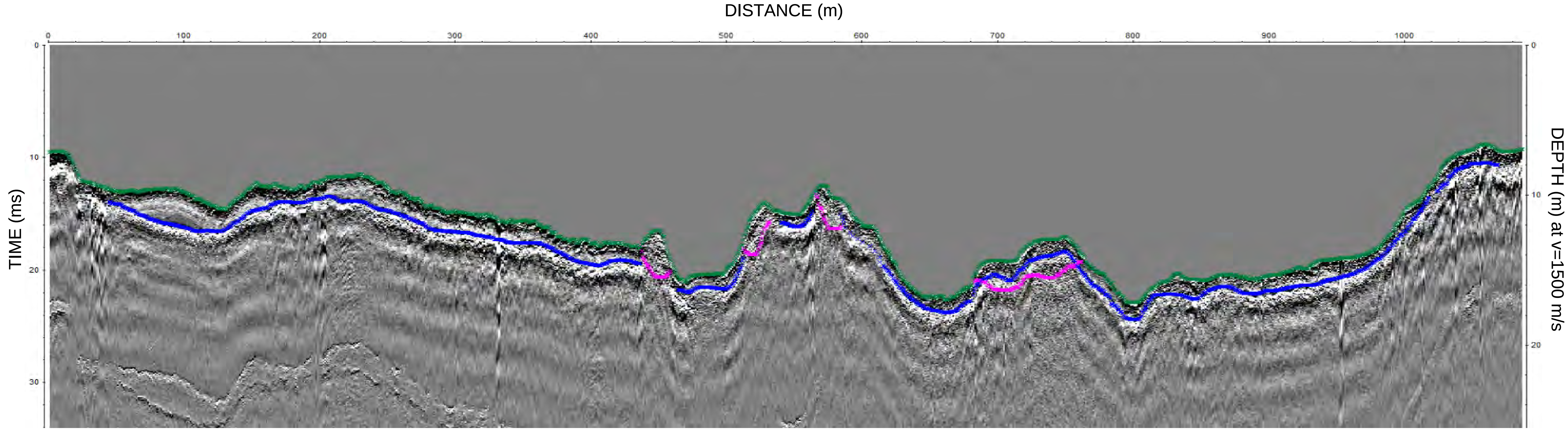
LEGEND

- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

NOTES:
1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-03-11 DESIGNED: RR PREPARED: RR REVIEWED: TR APPROVED: TR	TITLE **INTERPRETED SBP SECTION - LINE SBP-006**	
		PROJECT NO.: 21453805 DELIVERABLE: 001	REV.: Rev0 FIGURE: 41





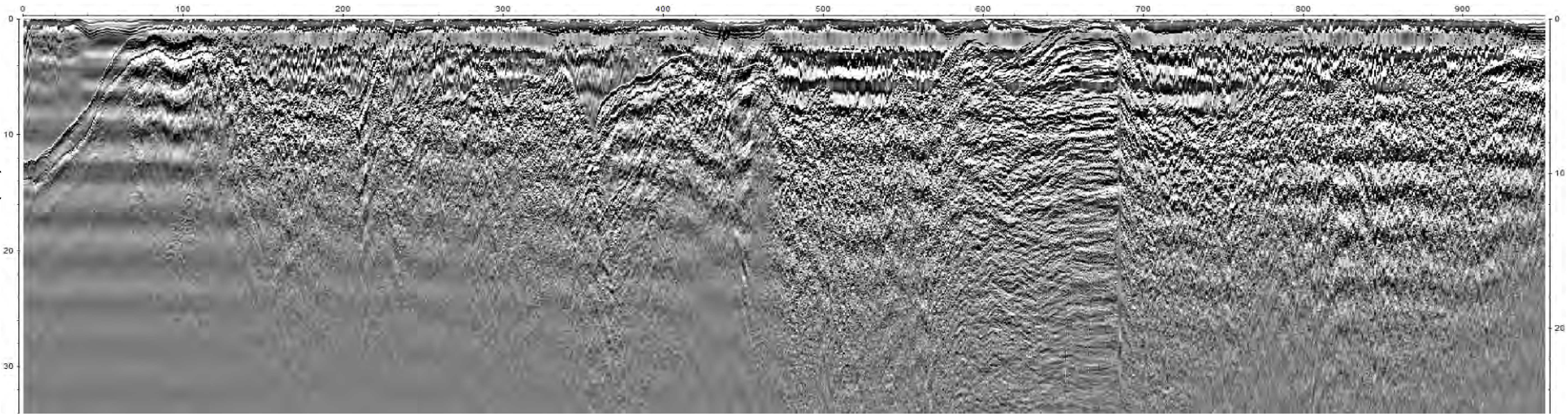
LEGEND

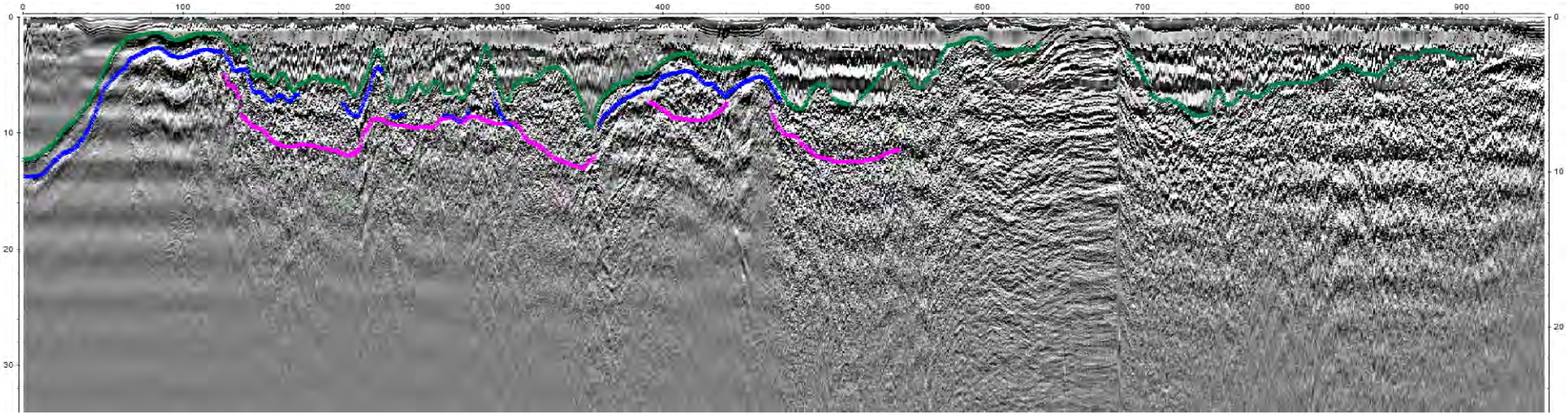
- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

NOTES:
1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-03-11
DESIGNED	RR
PREPARED	RR
REVIEWED	TR
APPROVED	TR
TITLE	**INTERPRETED SBP SECTION - LINE SBP-008**
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	42

SOUTH NORTH





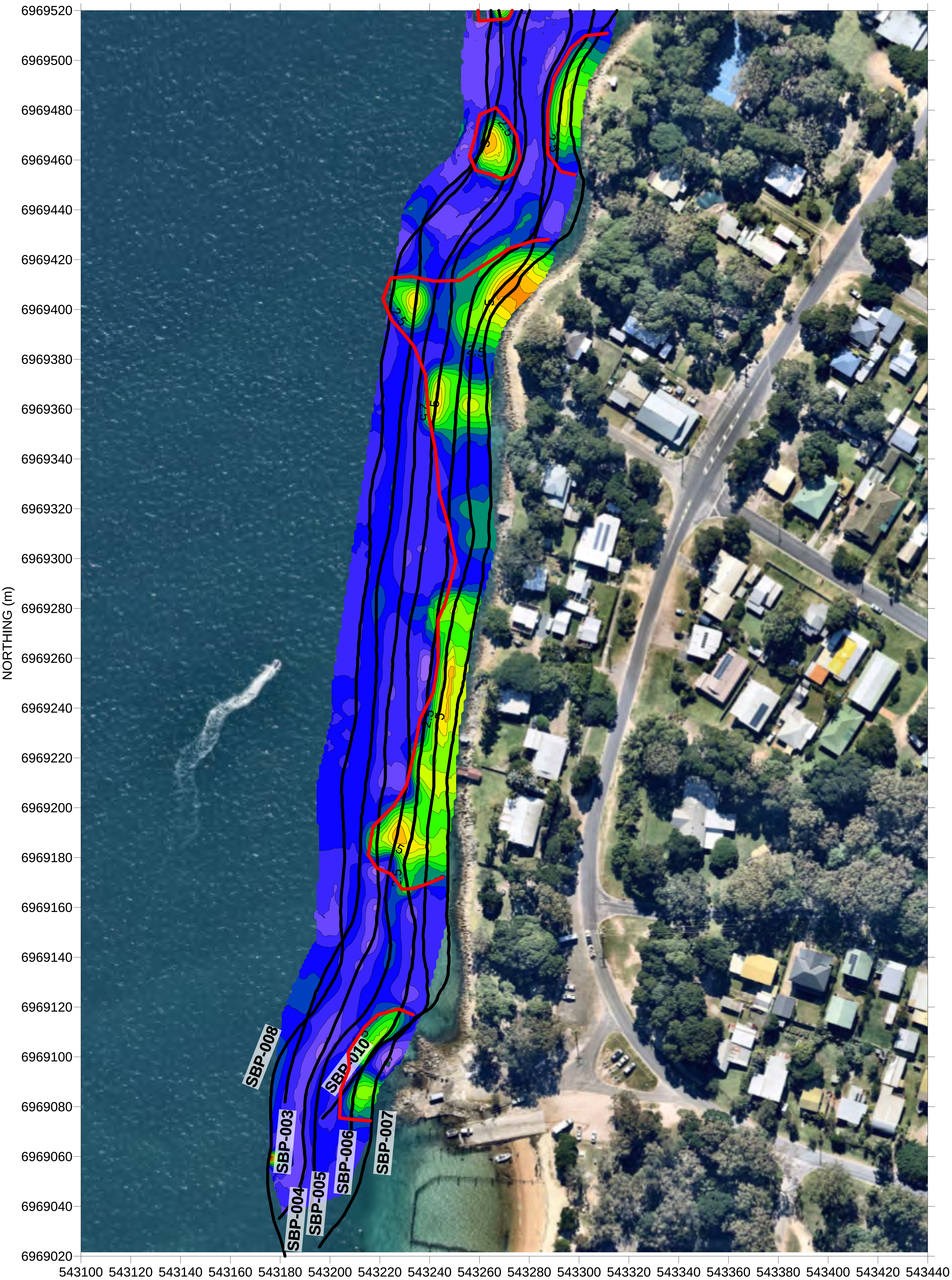
LEGEND

- INTERPRETED SEAFLOOR REFLECTOR
- INTERPRETED R1 REFLECTOR
- INTERPRETED R2 REFLECTOR

NOTES:

1. Data acquired with an Applied Acoustics SBP system using a Boomer source.
2. Data processing completed in Reflexw (ver. 8.1) software.

CLIENT	REDLAND CITY COUNCIL	PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	YYYY-MM-DD: 2022-03-11	TITLE	INTERPRETED SBP SECTION - LINE SBP-010
GOLDER MEMBER OF WSP	DESIGNED: RR		
	PREPARED: RR		
	REVIEWED: TR	PROJECT NO. 21453805	DELIVERABLE 001
	APPROVED: --	REV. Rev0	FIGURE 43



LEGEND

SBP LINE

EXTENT OF SCATTERED REFLECTION SIGNATURE (R2)

INTERPRETED REFLECTOR THICKNESS (m)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8

CLIENT
REDLAND CITY COUNCIL

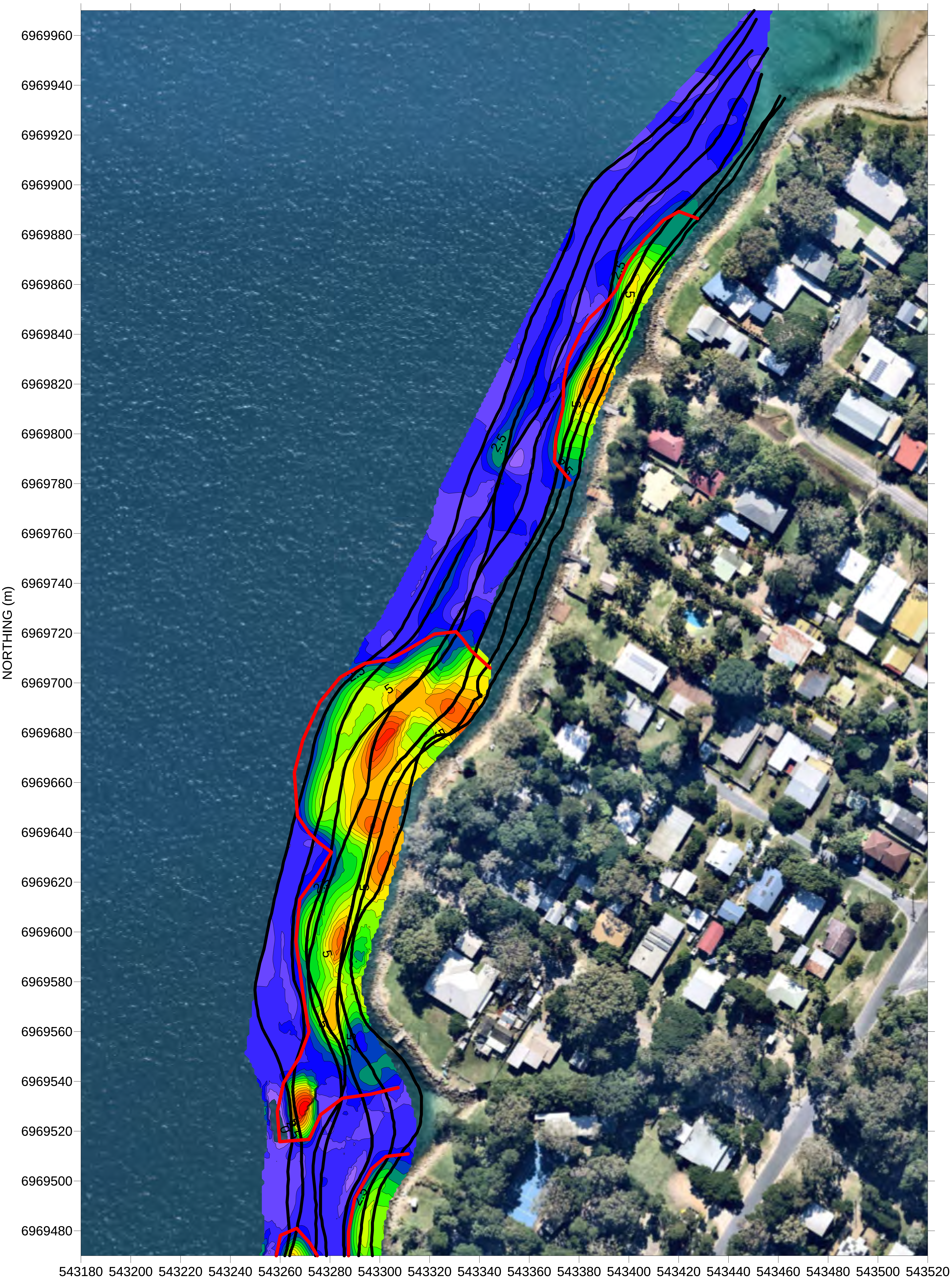
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR

TITLE
SBP R1 & R2 THICKNESS - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	44



LEGEND

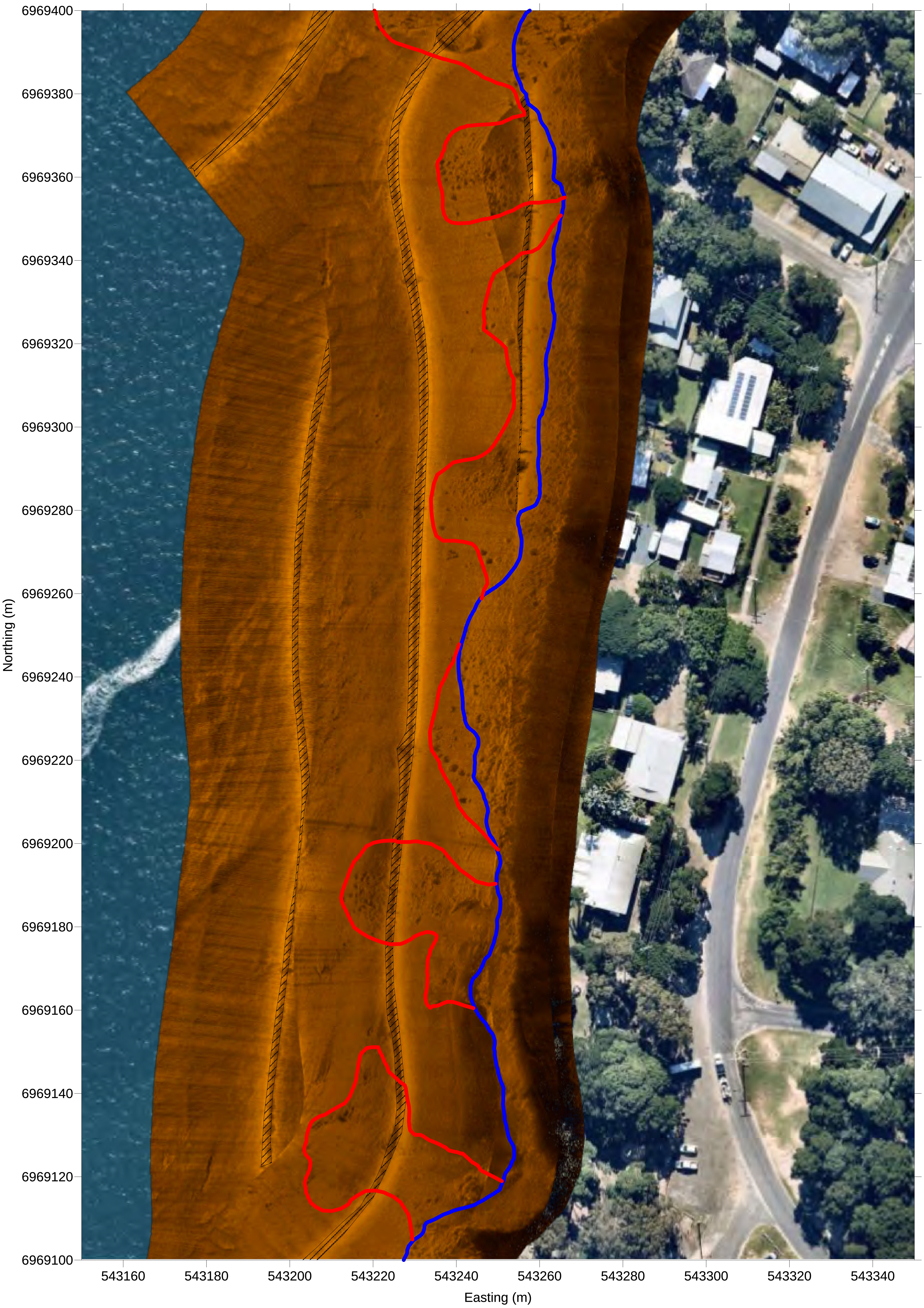
SBP LINE

EXTENT OF SCATTERED REFLECTION SIGNATURE (R2)

INTERPRETED REFLECTOR THICKNESS (m)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8

CLIENT	REDLAND CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR
TITLE	SBP R1 & R2 THICKNESS - NORTH
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	45



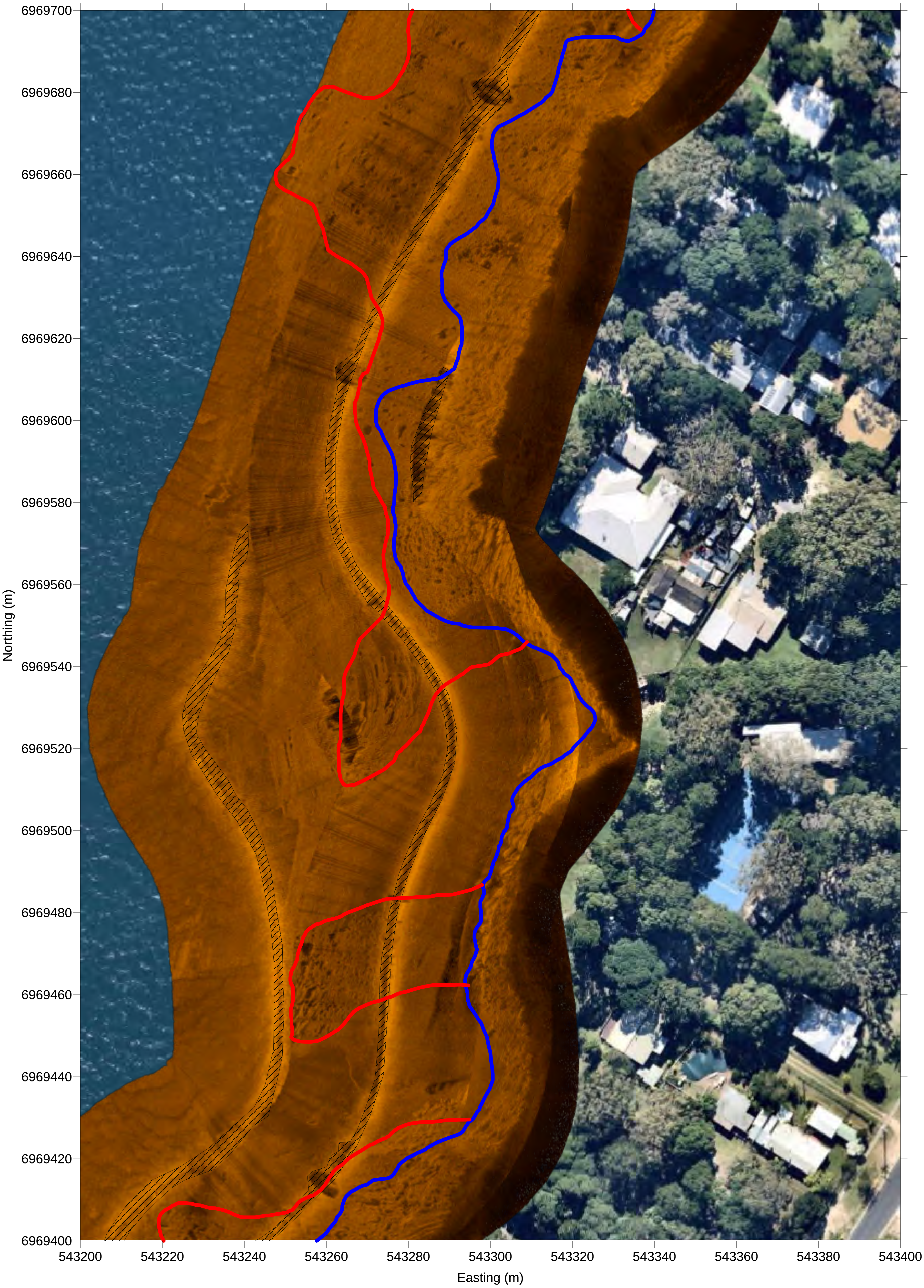
LEGEND

TOE OF EXPOSED FSB

EXPOSED FSB MATERIAL

SSS SWATHE EDGE EFFECT

CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-01-17 DESIGNED: RR PREPARED: JC REVIEWED: TR APPROVED: TR	TITLE SSS MOSAIC & INTERPRETATION - SOUTH	
PROJECT NO. 21453805	DELIVERABLE 001	REV. Rev0	FIGURE 46



LEGEND

- TOE OF EXPOSED FSB
- EXPOSED FSB MATERIAL
- SSS SWATHE EDGE EFFECT

CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR

TITLE
SSS MOSAIC & INTERPRETATION - CENTRE

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	47

LEGEND

- TOE OF EXPOSED FSB
- EXPOSED FSB MATERIAL
- SSS SWATHE EDGE EFFECT

CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

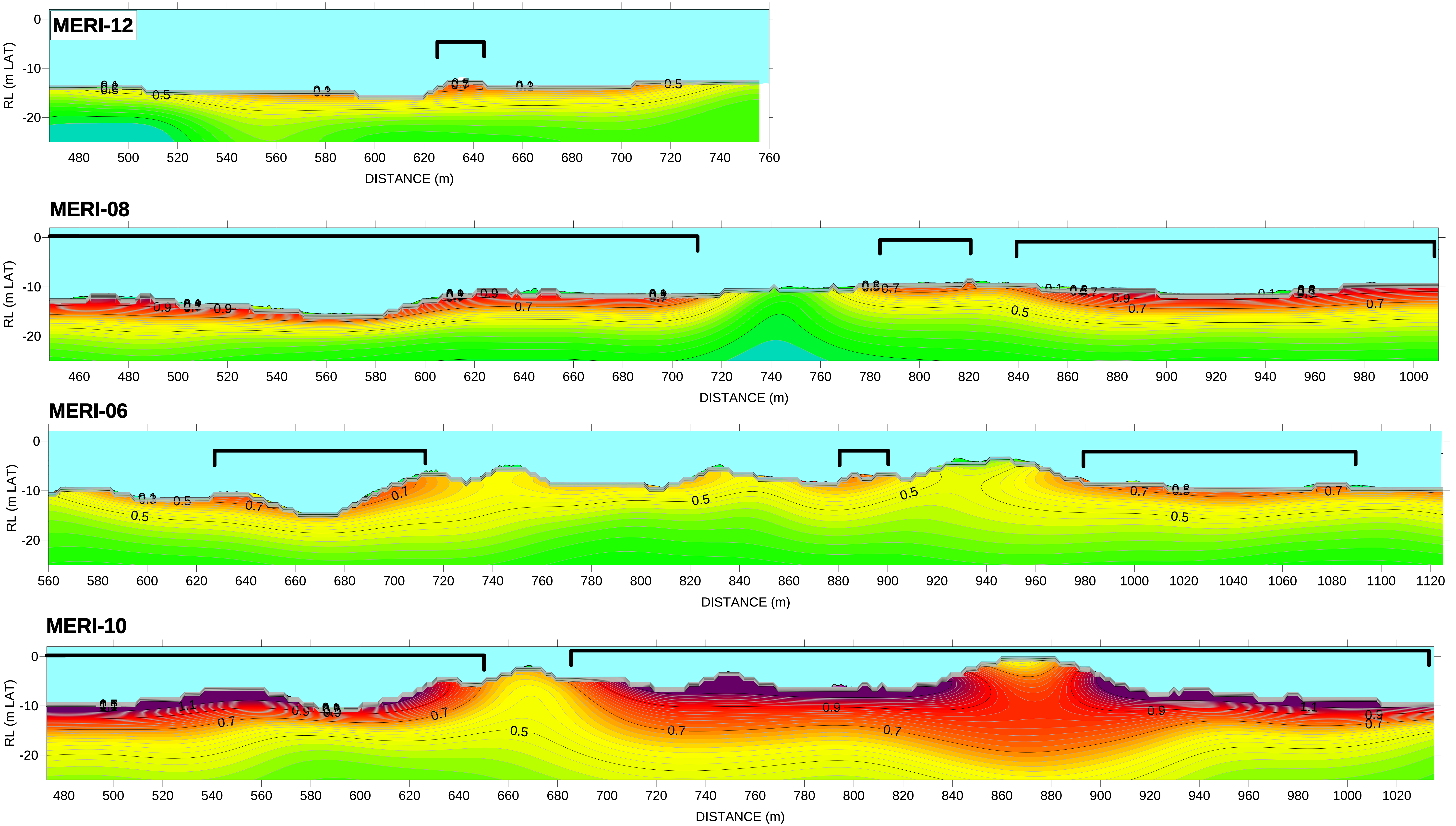
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	JC
REVIEWED	TR
APPROVED	TR

TITLE
SSS MOSAIC & INTERPRETATION - NORTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	48

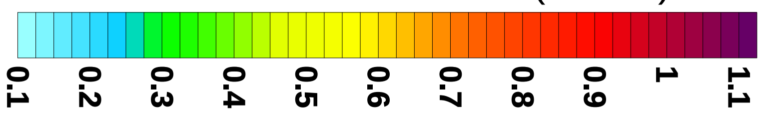
NORTH SOUTH



LEGEND

SURFACE EXTENT OF INTERPRETED HIGH RESISTIVITY ZONE

APPARENT RESISTIVITY (ohm.m)



CLIENT
REDLAND CITY COUNCIL

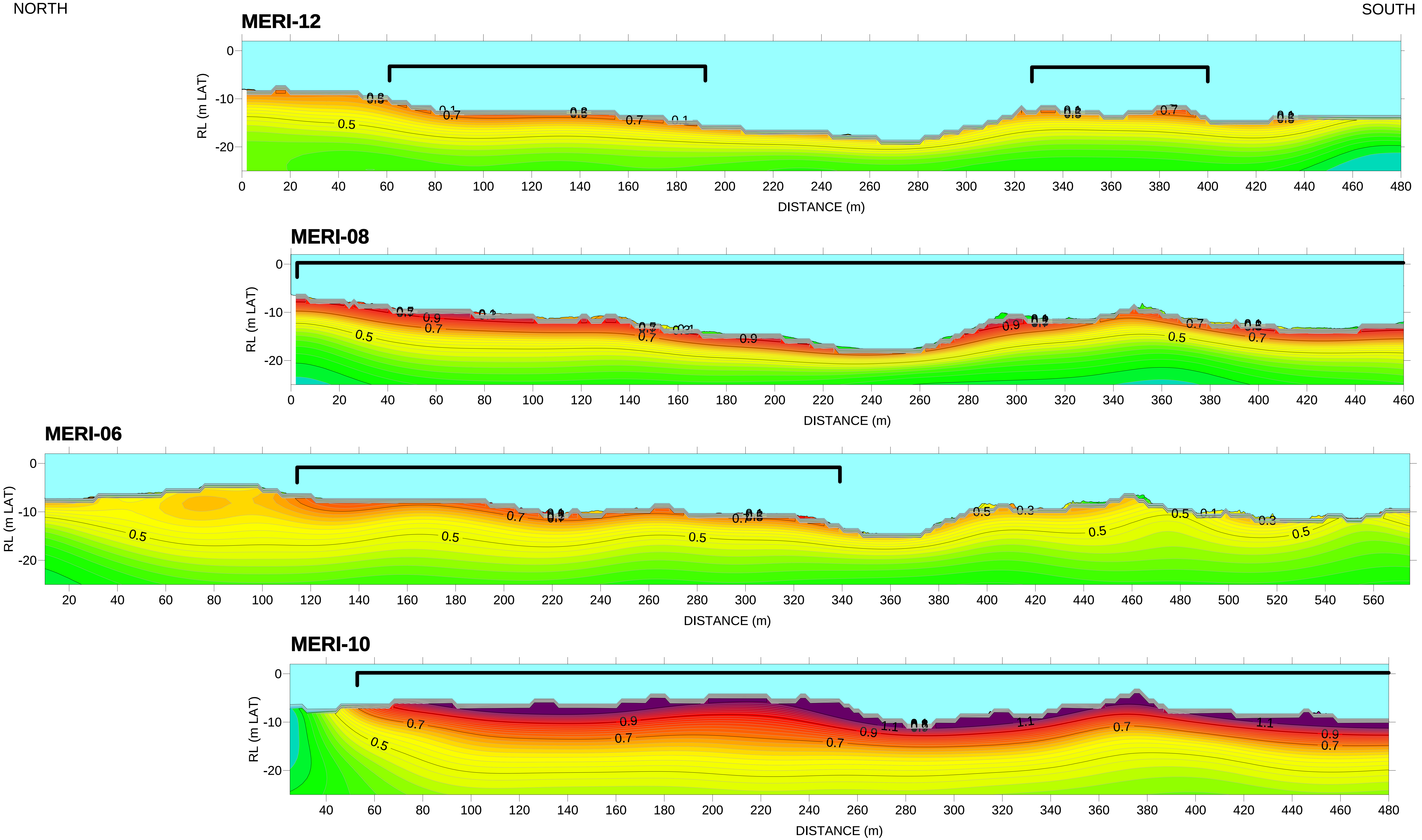
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	--

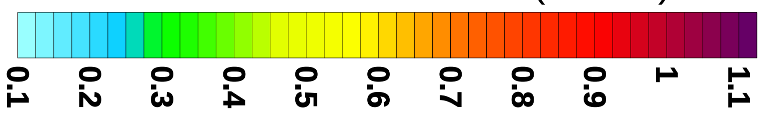
TITLE
MERI RESISTIVITY SECTIONS - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	49



LEGEND

SURFACE EXTENT OF INTERPRETED HIGH RESISTIVITY ZONE



CLIENT
REDLAND CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

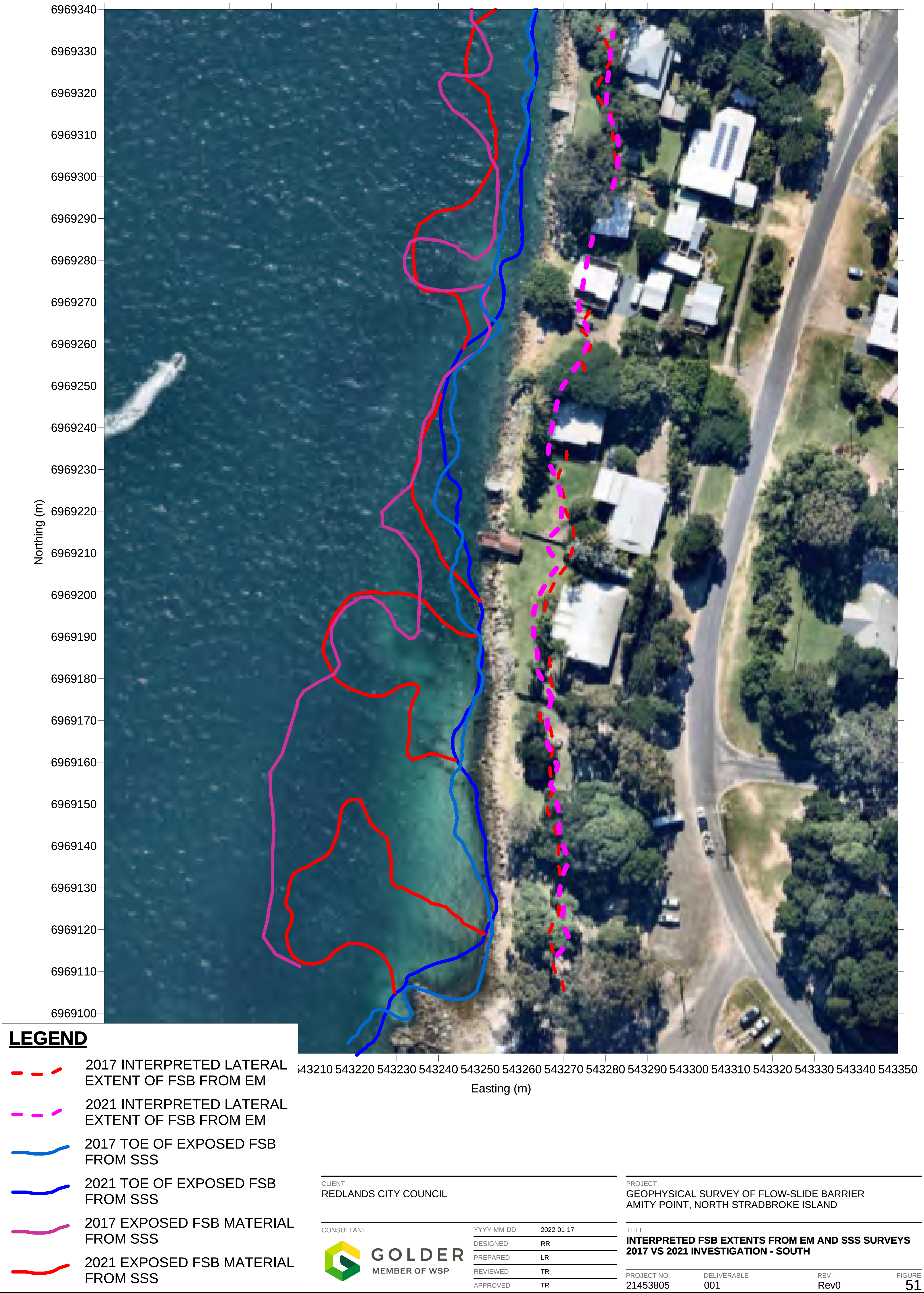
CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-04
DESIGNED	RR
PREPARED	SS
REVIEWED	TR
APPROVED	TR

TITLE
MERI RESISTIVITY SECTIONS - NORTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	50



CLIENT
REDLANDS CITY COUNCIL

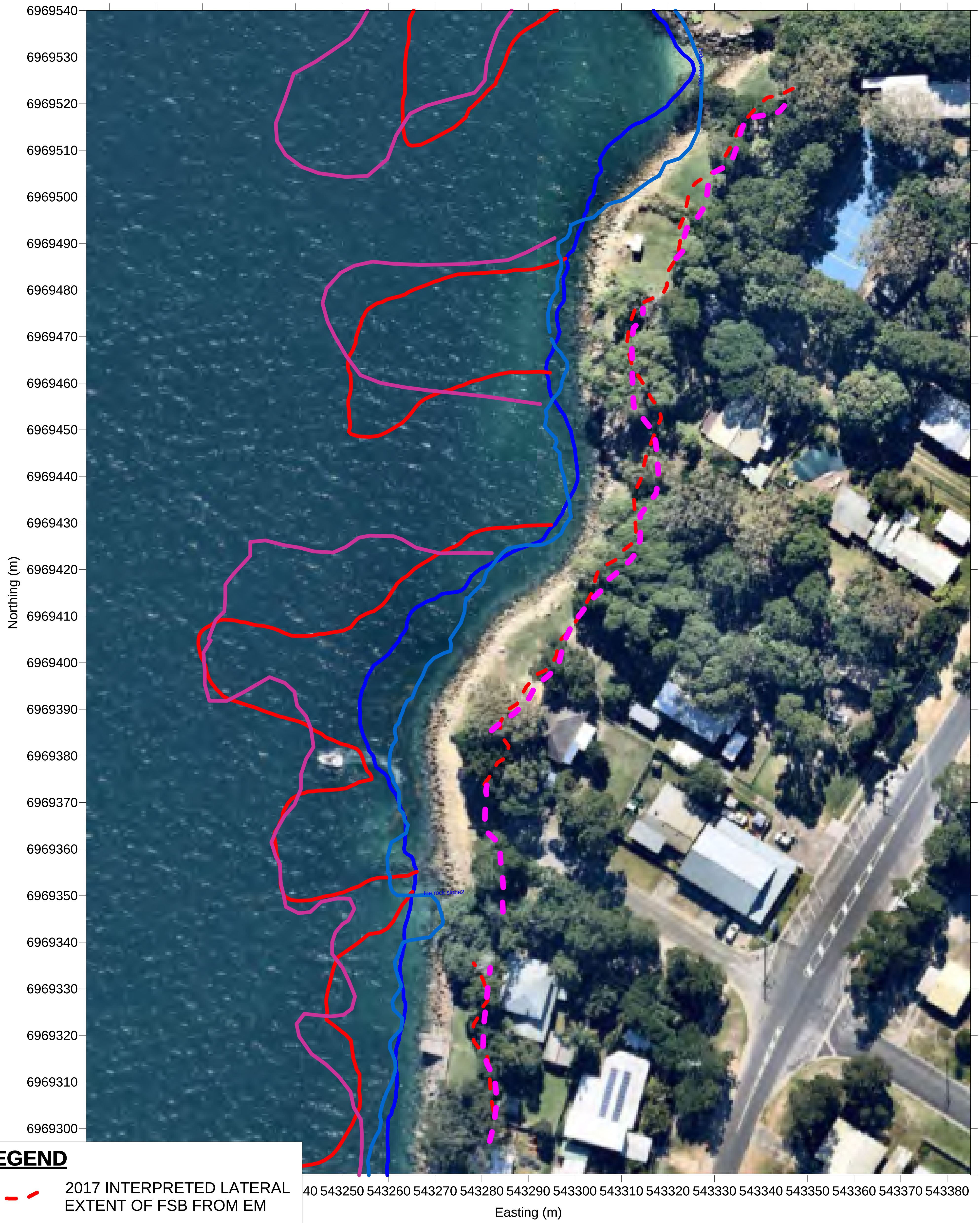
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR

TITLE
INTERPRETED FSB EXTENTS FROM EM AND SSS SURVEYS 2017 VS 2021 INVESTIGATION - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	51



LEGEND

- 2017 INTERPRETED LATERAL EXTENT OF FSB FROM EM
- 2021 INTERPRETED LATERAL EXTENT OF FSB FROM EM
- 2017 TOE OF EXPOSED FSB FROM SSS
- 2021 TOE OF EXPOSED FSB FROM SSS
- 2017 EXPOSED FSB MATERIAL FROM SSS
- 2021 EXPOSED FSB MATERIAL FROM SSS

CLIENT
REDLANDS CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

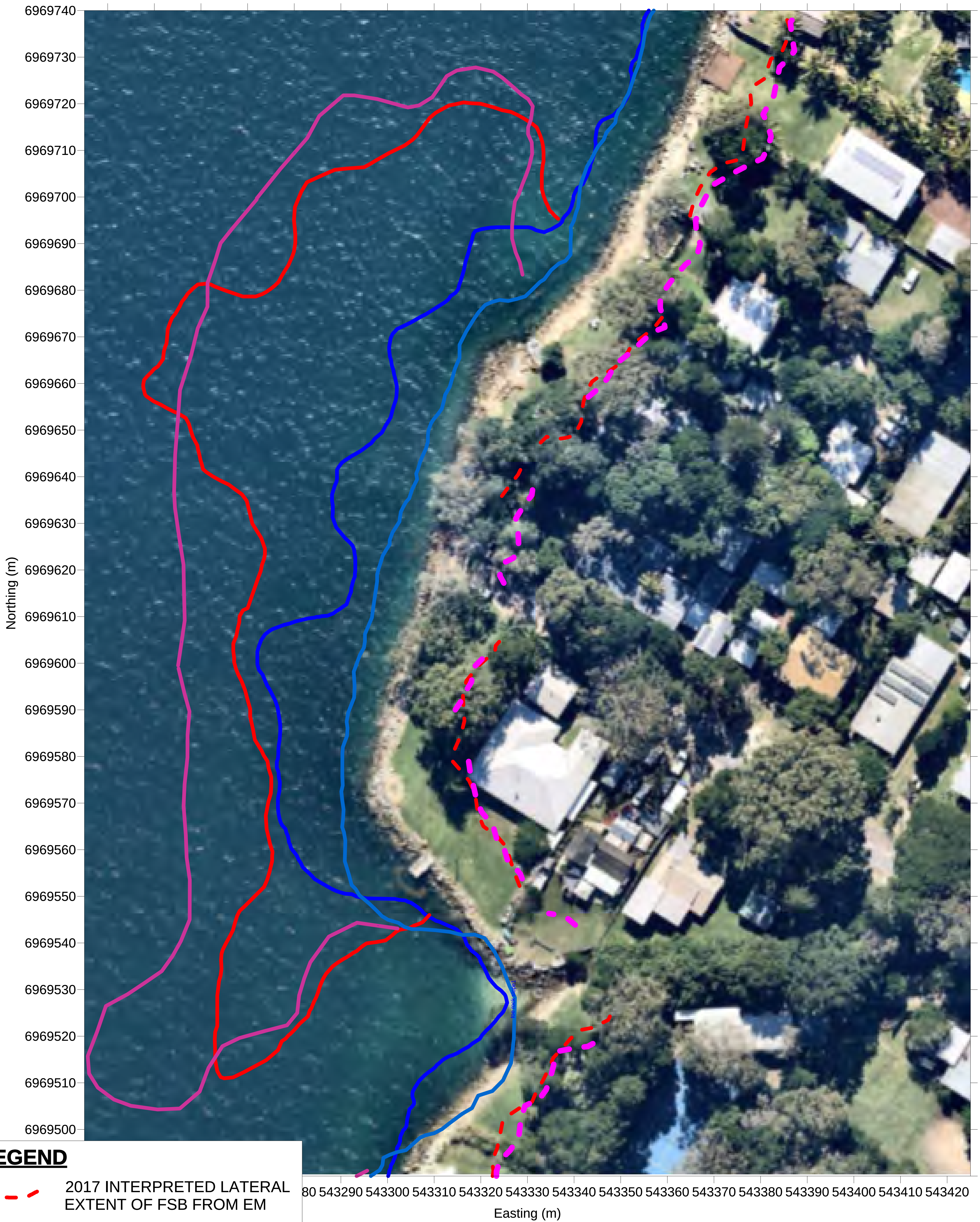
CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR

TITLE
INTERPRETED FSB EXTENTS FROM EM AND SSS SURVEYS 2017 VS 2021 INVESTIGATION - SOUTH CENTRAL

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	52



LEGEND

2017 INTERPRETED LATERAL EXTENT OF FSB FROM EM

2021 INTERPRETED LATERAL EXTENT OF FSB FROM EM

2017 TOE OF EXPOSED FSB FROM SSS

2021 TOE OF EXPOSED FSB FROM SSS

2017 EXPOSED FSB MATERIAL FROM SSS

2021 EXPOSED FSB MATERIAL FROM SSS

CLIENT
REDLANDS CITY COUNCIL

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR

TITLE
INTERPRETED FSB EXTENTS FROM EM AND SSS SURVEYS 2017 VS 2021 INVESTIGATION - NORTH CENTRAL

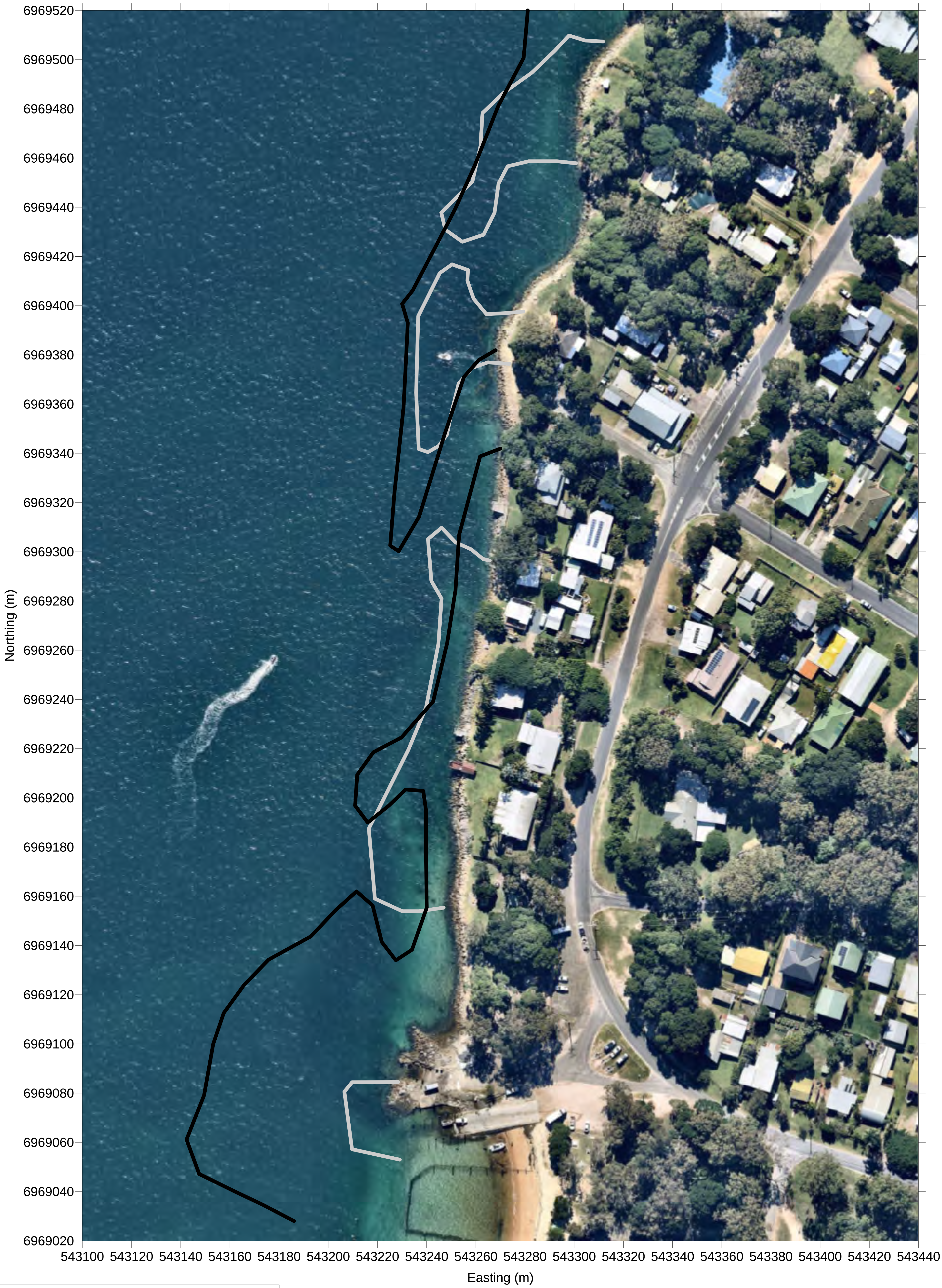
PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	53

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm
0

LEGEND

- 2017 INTERPRETED LATERAL EXTENT OF FSB FROM EM
- 2021 INTERPRETED LATERAL EXTENT OF FSB FROM EM
- 2017 TOE OF EXPOSED FSB FROM SSS
- 2021 TOE OF EXPOSED FSB FROM SSS
- 2017 EXPOSED FSB MATERIAL FROM SSS
- 2021 EXPOSED FSB MATERIAL FROM SSS

CLIENT	REDLANDS CITY COUNCIL
PROJECT	GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2022-01-17
DESIGNED	RR
PREPARED	LR
REVIEWED	TR
APPROVED	TR
TITLE	**INTERPRETED FSB EXTENTS FROM EM AND SSS SURVEYS 2017 VS 2021 INVESTIGATION - NORTH**
PROJECT NO.	21453805
DELIVERABLE	001
REV.	Rev0
FIGURE	54



LEGEND

2017 INTERPRETED RESISTIVE ZONE

2021 INTERPRETED RESISTIVE ZONE

CLIENT REDLAND CITY COUNCIL	PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND

CONSULTANT		
GOLDER MEMBER OF WSP	YYYY-MM-DD	2022-01-17
	DESIGNED	RR
	PREPARED	JC
	REVIEWED	TR
	APPROVED	TR

TITLE
MERI INTERPRETED RESISTIVE ZONES - SOUTH

PROJECT NO.	DELIVERABLE	REV.	FIGURE
21453805	001	Rev0	55

LEGEND

2017 INTERPRETED RESISTIVE ZONE

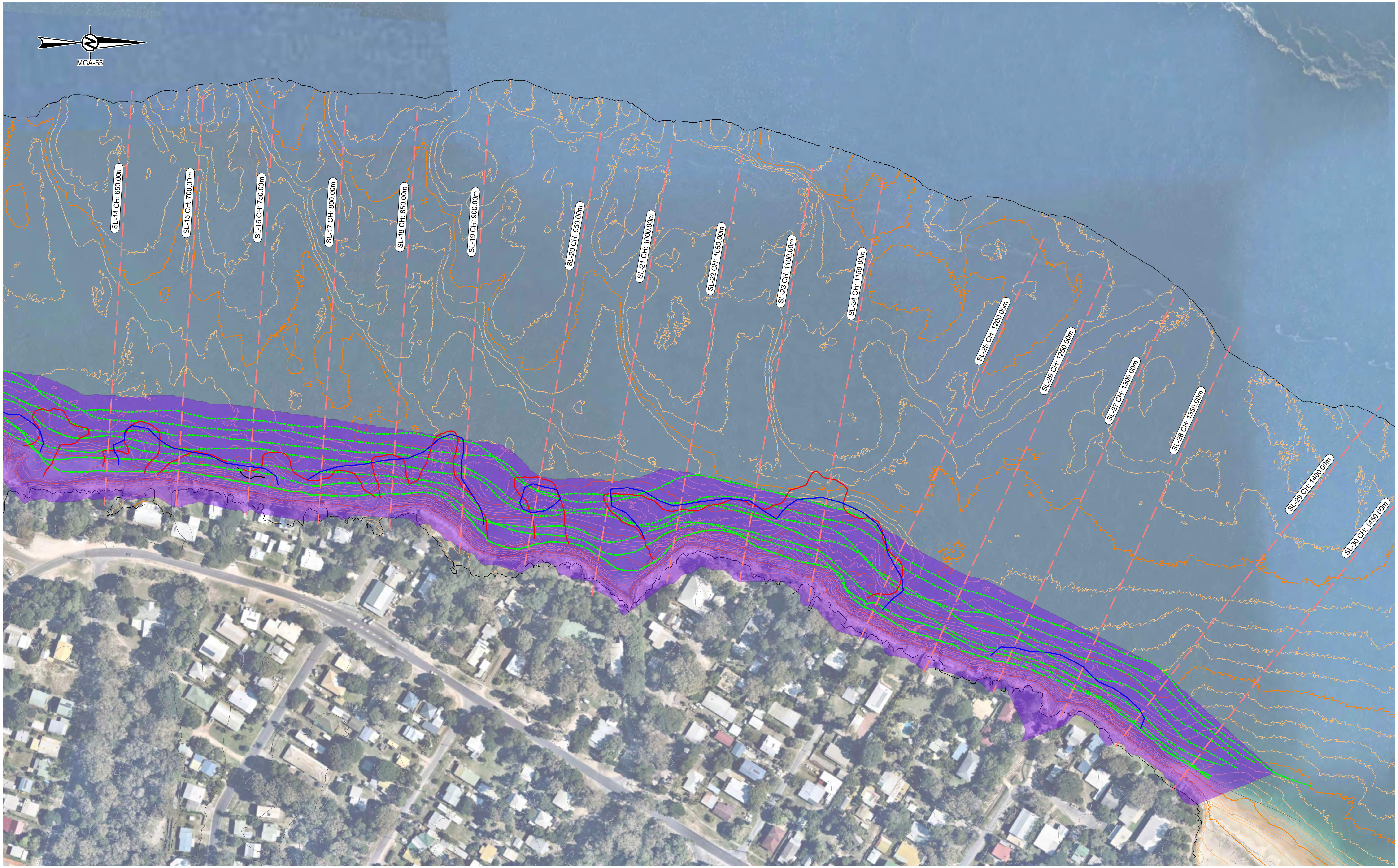
2021 INTERPRETED RESISTIVE ZONE

CLIENT REDLAND CITY COUNCIL		PROJECT GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER AMITY POINT, NORTH STRADBROKE ISLAND	
CONSULTANT GOLDER MEMBER OF WSP	YYYY-MM-DD: 2022-01-17 DESIGNED: RR PREPARED: JC REVIEWED: TR APPROVED: TR	TITLE **MERI INTERPRETED RESISTIVE ZONES - NORTH**	
		PROJECT NO. 21453805	DELIVERABLE 001 · REV. Rev0 · FIGURE 56

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

0



LEGEND

- UPDATED BATHYMETRY 2020-03-25
- SBP LINES
- SEAWARD TOE
- INTERPRETED EXTENTS OF MIXED SAND AND BOULDER MATERIAL
- PREDOMINANTLY BOULDER MATERIAL

NOTES

1. FACTUAL DATA IS AT SBP AND MASW LINE LOCATIONS. ELSEWHERE DATA IS INFERRED
2. UNCERTAINTY RANGE IN THICKNESS OF ROCK ARMOUR
   LAND SECTION: ± 20%
   OVERWATER SECTION: ±40%

0 50 100
1:2,500 METRES

CLIENT
REDLAND CITY COUNCIL

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-04-06
DESIGNED	-
PREPARED	SD
REVIEWED	TR
APPROVED	TR

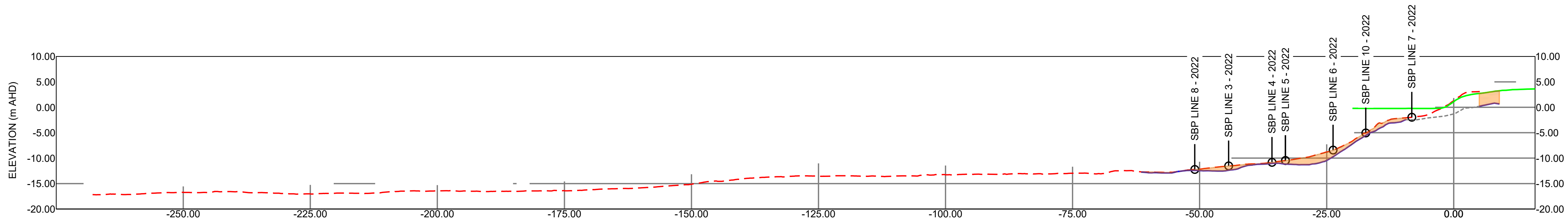
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
ROCK ARMOUR EXTENTS PLAN AND CROSS SECTION LOCATIONS

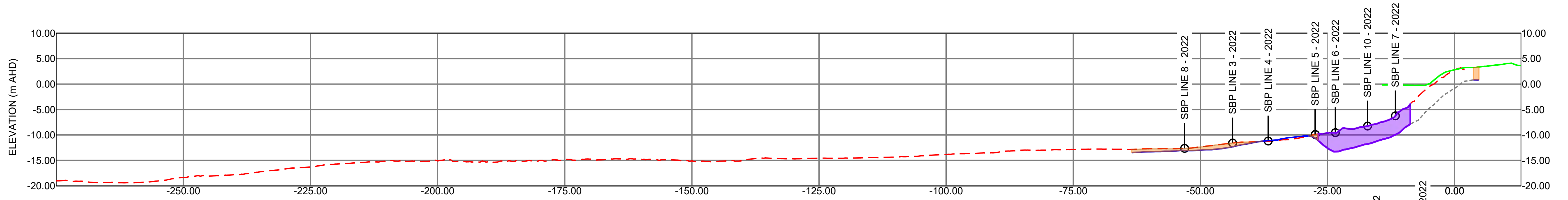
PROJECT NO.	CONTROL	REV.	FIGURE
1650770	001	0	057

Path: \\golder.gds\gap\Brisbane\Geomatics\REDLAND CITY COUNCIL\AMITY POINT NORTH STRADBROKE ISLAND\99_PROJECTS\1650770-GEOPHYSICS-NTH STRADBROKE\02_PRODUCTION\DWG\ | File Name: 1650770-004-F-001_005.dwg

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
0



CH 650



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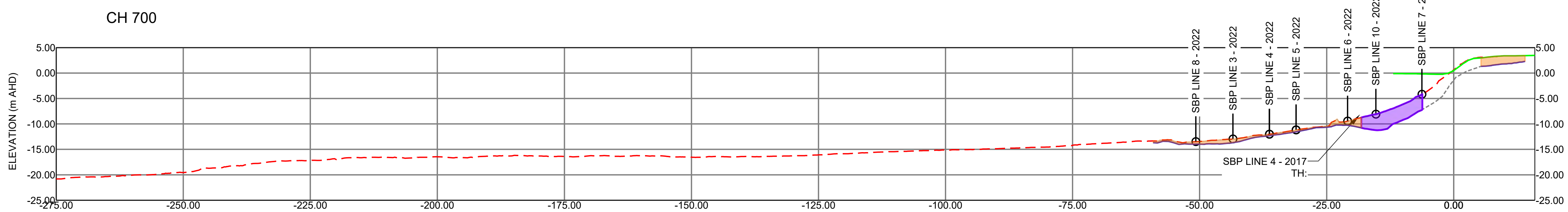

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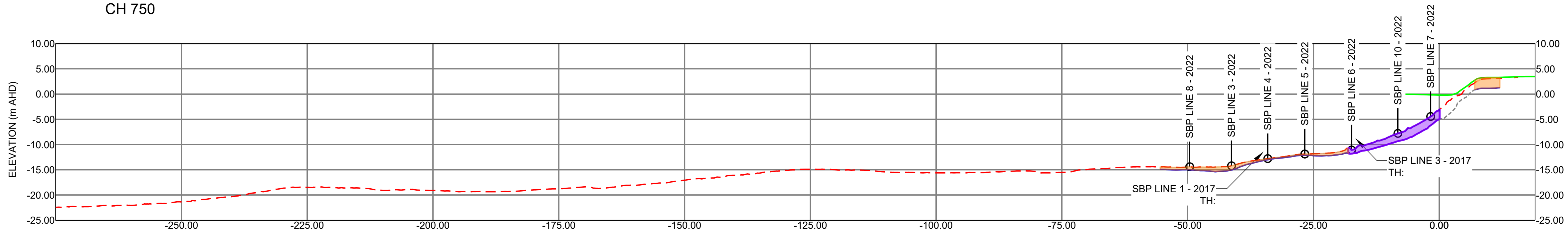

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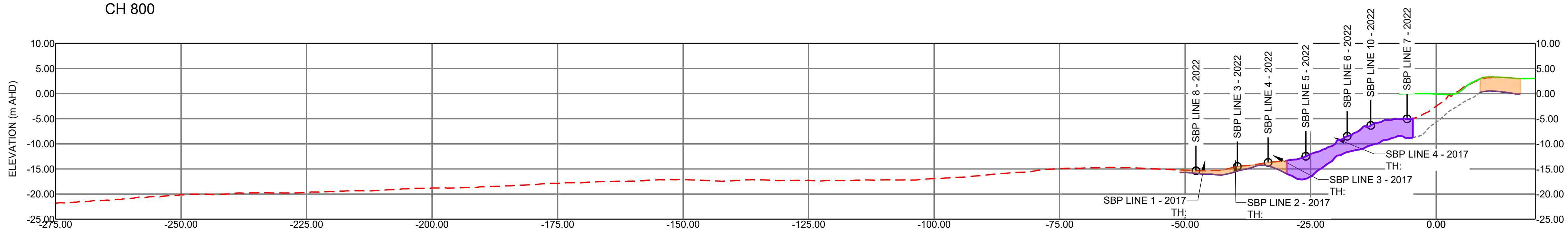


CH 850

LEGEND

- UPDATED BATHYMETRY 2020-03-25
- EXISTING GROUND 2009
- INTERPRETED EXTENTS OF MIXED SAND AND BOULDER MATERIAL
- PREDOMINANTLY BOULDER MATERIAL
- MIXED SAND AND BOULDER MATERIAL

NOTES

1. FACTUAL DATA IS AT SBP AND MASW LINE LOCATIONS. ELSEWHERE DATA IS INFERRED
2. UNCERTAINTY RANGE IN THICKNESS OF ROCK ARMOUR
   LAND SECTION: ± 20%
   OVERWATER SECTION: ±40%

0 25 50
1:1,000 METRES

CLIENT
REDLAND CITY COUNCIL

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-04-06
DESIGNED	-
PREPARED	SD
REVIEWED	TR
APPROVED	TR

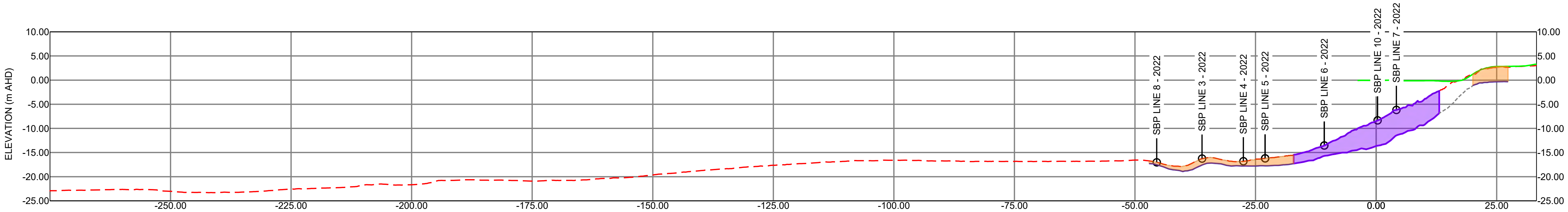
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
ROCK ARMOUR CROSS SECTIONS SHEET 1 OF 4

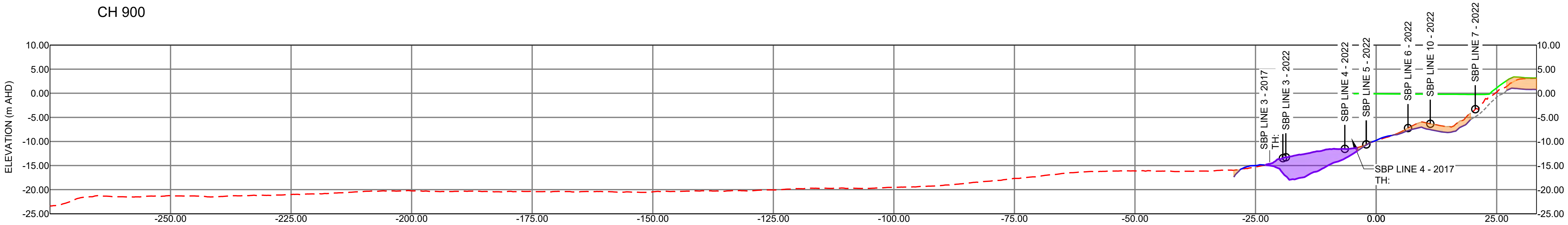
PROJECT NO.	CONTROL	REV.	FIGURE
1650770	001	0	058

Path: \\golder.gds\gap\Brisbane\Geomatics\REDLAND CITY COUNCIL\AMITY POINT NORTH STRADBROKE ISLAND\99_PROJECTS\1650770-GEOPHYSICS-NTH STRADBROKE\02_PRODUCTION\DWG\ | File Name: 1650770-004-F-001_005.dwg

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3



CH 900



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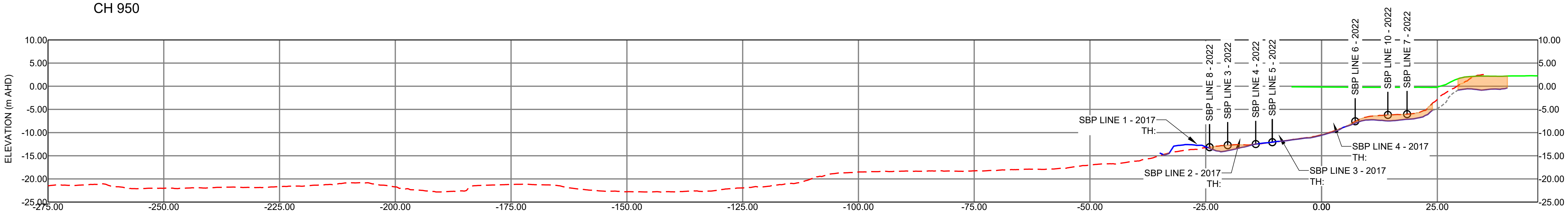

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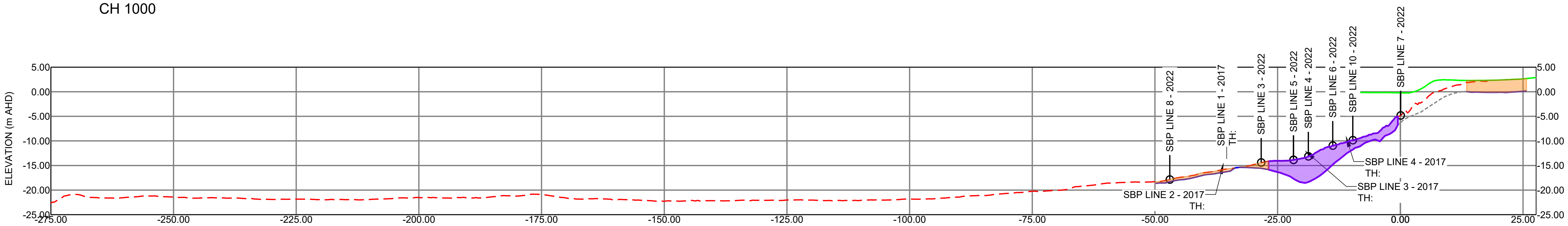
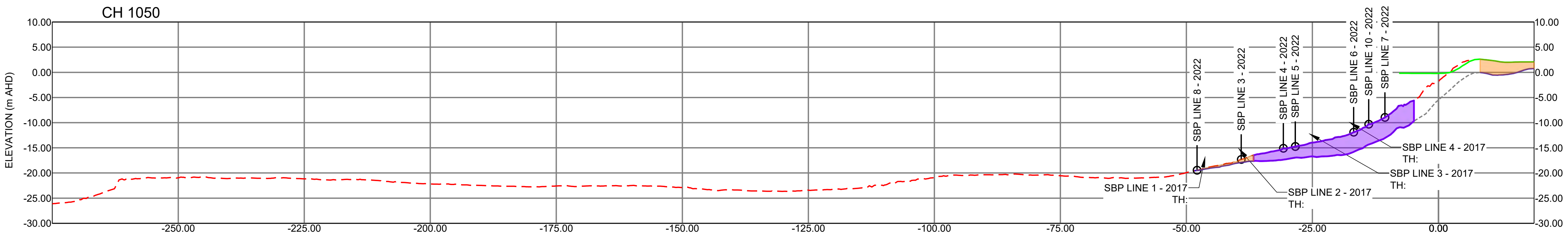


CH 1050



CH 1100

LEGEND

- UPDATED BATHYMETRY 2020-03-25
- EXISTING GROUND 2009
- INTERPRETED EXTENTS OF MIXED SAND AND BOULDER MATERIAL
- PREDOMINANTLY BOULDER MATERIAL
- MIXED SAND AND BOULDER MATERIAL

NOTES

1. FACTUAL DATA IS AT SBP AND MASW LINE LOCATIONS. ELSEWHERE DATA IS INFERRED
2. UNCERTAINTY RANGE IN THICKNESS OF ROCK ARMOUR
   LAND SECTION: ± 20%
   OVERWATER SECTION: ±40%

0 25 50
1:1,000 METRES

CLIENT
REDLAND CITY COUNCIL

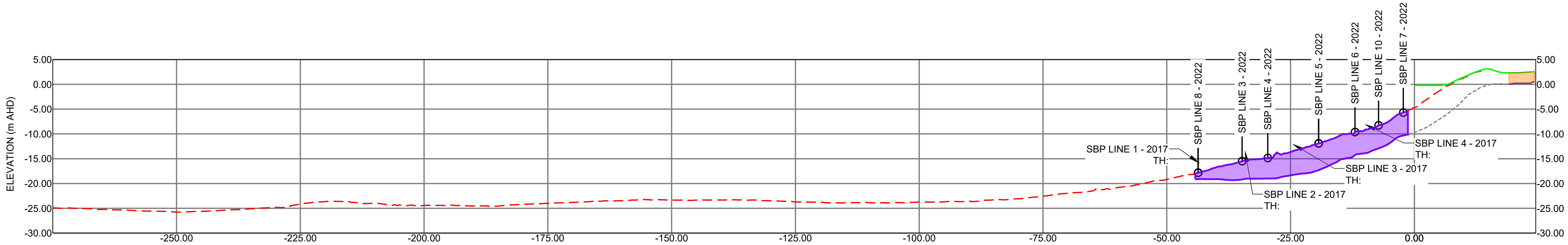
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-04-06
DESIGNED	-
PREPARED	SD
REVIEWED	TR
APPROVED	TR

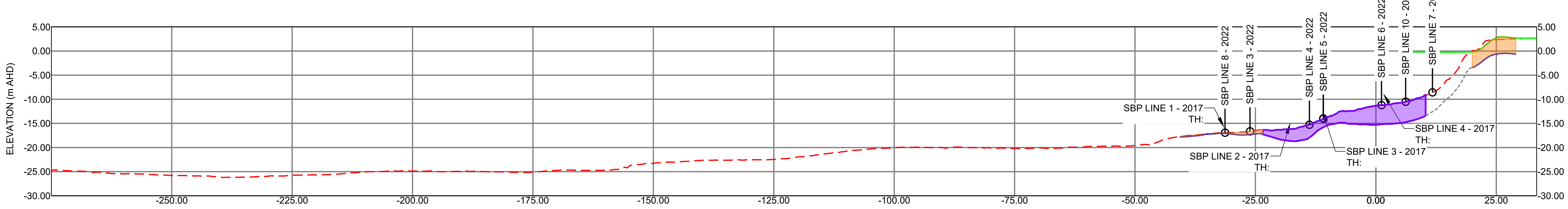
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
ROCK ARMOUR CROSS SECTIONS SHEET 2 OF 4

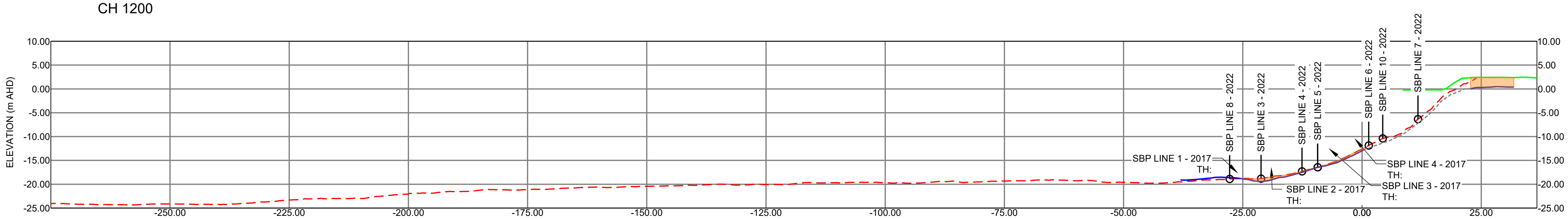
PROJECT NO.	CONTROL	REV.	FIGURE
1650770	001	0	059



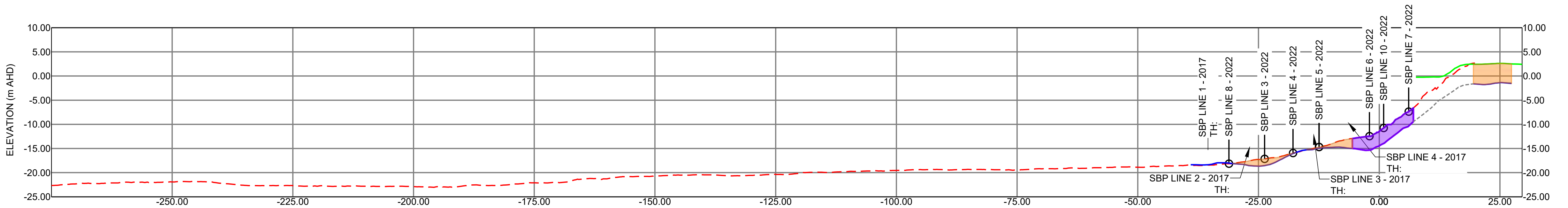
CH 1150



CH 1200



CH 1250



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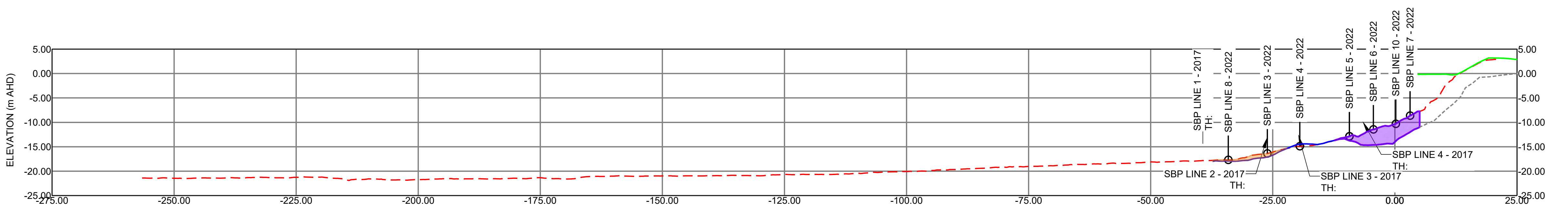

LEGEND

- UPDATED BATHYMETRY 2020-03-25
- EXISTING GROUND 2009
- INTERPRETED EXTENTS OF MIXED SAND AND BOULDER MATERIAL
- PREDOMINANTLY BOULDER MATERIAL
- MIXED SAND AND BOULDER MATERIAL

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0 25 50
1:1,000 METRES

CLIENT
REDLAND CITY COUNCIL

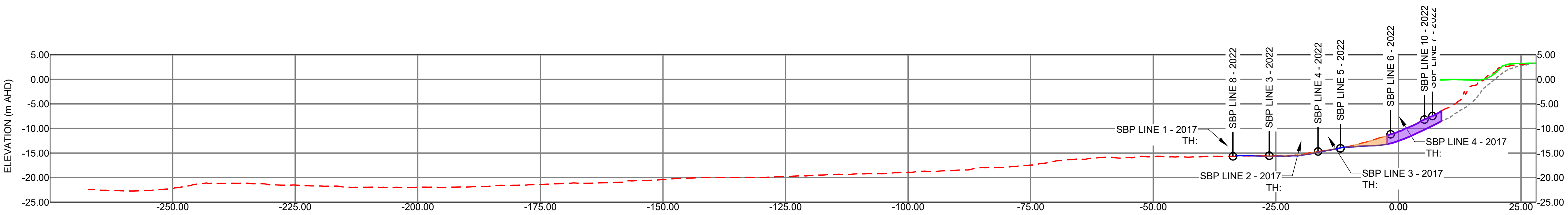
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-04-06
DESIGNED	-
PREPARED	SD
REVIEWED	TR
APPROVED	TR

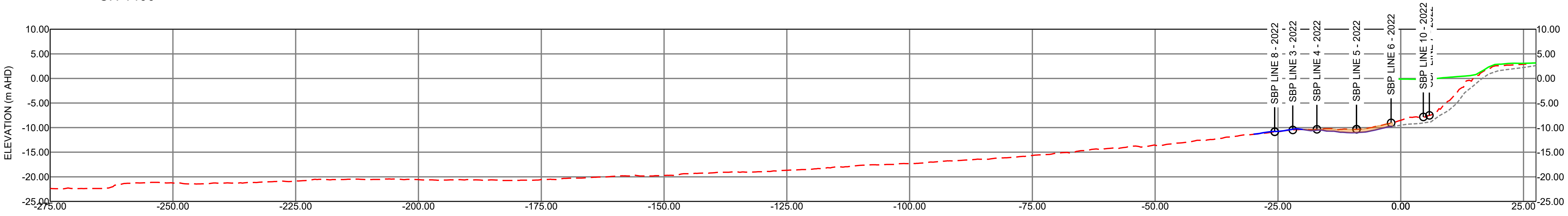
PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
ROCK ARMOUR CROSS SECTIONS SHEET 3 OF 4

PROJECT NO.	CONTROL	REV.	FIGURE
1650770	001	0	060



CH 1400



CH 1450

LEGEND

- UPDATED BATHYMETRY 2020-03-25
- EXISTING GROUND 2009
- INTERPRETED EXTENTS OF MIXED SAND AND BOULDER MATERIAL
- PREDOMINANTLY BOULDER MATERIAL
- MIXED SAND AND BOULDER MATERIAL

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0 25 50
1:1,000 METRES

CLIENT
REDLAND CITY COUNCIL

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-04-06
DESIGNED	-
PREPARED	SD
REVIEWED	TR
APPROVED	TR

PROJECT
GEOPHYSICAL SURVEY OF FLOW-SLIDE BARRIER
AMITY POINT, NORTH STRADBROKE ISLAND

TITLE
ROCK ARMOUR CROSS SECTIONS SHEET 4 OF 4

PROJECT NO.	CONTROL	REV.	FIGURE
1650770	001	0	061

APPENDIX A

Important Information Relating to this Report

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

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Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

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Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

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