Marine Geophysics Survey

Final Interpretative Report

Port of Hastings Development Authority

10 October 2014
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In May 2016 the Special Minister of State asked Infrastructure Victoria to provide advice on the future capacity of Victoria's commercial ports. Specifically, the Minister has asked for advice on when the need for a second container port is likely to arise and which variables may alter this timeline. The Minister has also asked for advice on where a second container port would ideally be located and under what conditions, including the suitability of, and barriers to investing in, sites at the Port of Hastings and the Bay West location.

In undertaking this task, Infrastructure Victoria reviewed work that was completed as part of the Port of Hastings development project before it was cancelled in 2014. This document forms part of the initial work undertaken for the proposed port development at Hastings. Infrastructure Victoria considers that much of the previous Hastings work, although preliminary in nature, is relevant and suitable for informing a strategic assessment. Therefore, Infrastructure Victoria has made the reports previously commissioned for the development project part of the evidence base on which Infrastructure Victoria will use in providing the Minister with advice.

The opinions, conclusions and any recommendations in this document are based on conditions encountered and information reviewed at the date of preparation of the document and for the purposes of the Port of Hastings Development Project.

Infrastructure Victoria and its consultants have used the information contained in these reports as an input but have not wholly relied on all the information presented in these reports.

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1. Introduction

Aurecon Australia Pty Ltd (Aurecon) was commissioned by the Port of Hastings Development Authority (The Authority) to undertake an offshore geophysics survey for the Port of Hastings Container Expansion Project, Victoria. Aurecon engaged geophysical specialists Marine and Earth Sciences (M&ES) to perform the data acquisition, interpretation and reporting.

The purpose of the geophysics survey investigation was to provide and inform the engineering design and planning for the Port of Hastings Container Expansion Project. The results will provide additional geotechnical information for the interpretation of subsurface conditions within the survey extents. This geophysics information will assist in the design for the proposed structures as well as aiding in the design and programming of dredging works. Aurecon in conjunction with M&ES proposed the survey lines in each port area as well as the preferred survey methodology for the investigation

1.1 Project background

Western Port is a large shallow bay connected to the Bass Strait by two channels. The main channel is on the western side of the bay between Flinders and Phillip Island and a narrow channel is located on the eastern side of the bay between San Remo and Phillip Island.

Western Port is a Ramsar-listed wetland with diverse habitat types including, deep channels and seagrass flats, extensive mangroves and saltmarsh vegetation. The Western Port is also utilised by the local community for recreational boating and fishing activities

The Port of Hastings is an existing commercial port facility situated in Western Port, Victoria. Currently the port facilities are used for the import and export of fossil fuels and general cargo. The port is also involved in ship-to-ship transfers, pipe laying operations and the lay-up/repair of oil rigs/floating platforms. Approximately 100-150 vessels, ranging in size up to 100,000 tonnes, utilise the Port of Hastings each year.

There are several existing marine structures located in the Port of Hastings including berthing facilities at Long Island and Crib Point, jetty structures at Stony Point and the BlueScope Steel wharf. The Defence's navy base (Cerberus) is located to the south of the commercial berths at Stony Point.

Since the late 1960s, the land surrounding the Port of Hastings has been reserved for future development and port related uses. As the Port of Melbourne reaches capacity, the Port of Hastings has been identified as a key port for development and expansion to accommodate anticipated growth. The Port of Hastings Development Authority (The Authority) has been established to progress the proposed expansion.

1.2 Description of works

The Marine geophysical survey comprised of seismic reflection / sub bottom profiling survey and a side scan sonar survey as well as a bathymetric survey. Additional surveys were also undertaken to refine the data collected during the seismic reflection survey.

1.3 Historical data

The findings of the geophysical survey have been interpreted incorporating relevant historical borehole data from previous ground investigations undertaken at the Port and provided by The Authority. These include:

- AECOM (2009) Port of Hastings stage one scoping – geotechnical and environmental investigation report

- Maunsell and Partners (1978) Public Works Department Victoria, Port and harbour Division, Westernport site investigation for I.P.E.C. Terminal
- Public Works Department (1974) Ports and Harbours Division, Westernport Bay, Victoria. Report on sea-bed investigation
- Macdonald, Wagner and Priddle (1967) Long island point liquids pier, site investigation

1.4 Recent geotechnical investigation

In addition to the historical data the findings of the geophysical survey have also been interpreted incorporating the 2014 offshore geotechcnial investigation undertaken between 14 December 2013 (drilling of first borehole) and 24 July 2014 (completion of the last borehole) by Worley Parsons. The investigations comprised the following:

- Cone penetrometer testing (CPT) at twenty one (21) locations;
- Near-shore geotechnical borehole drilling/coring operations at ninety four (94) locations using a drilling rig mounted on the JUB capable of wash boring and rotary coring, including Standard Penetration Testing (SPT)

The locations of the boreholes are provided on the various plans in the Appendices.

1.5 Purpose of this report

This report is the Final Interpretative Report as agreed under variation V006 of the PoHDA 2013 003 Contract.

2. Works program

Aurecon was engaged by The Authority as the provider of a geophysical survey for the proposed Port of Hastings Container Expansion Project. The engagement was based on the following survey spread:

- **SBP** - Sub Bottom Profiler, Side scan sonar, single beam bathymetry and marine magnetics survey (information to be collected to assist in interpretation of sub bottom profiling but does not need to be processed for deliverables).

In addition to the SBP, targeted seismic refraction was also discussed and considered appropriate for the project. The following items were added to the contract schedule of rates.

- **DMR** – Deep Marine Refraction targeting 80m penetration and single beam bathymetry.
- **SMR** – Shallow Marine Refraction targeting 15m penetration and single beam bathymetry.

The geophysics survey was performed in all areas as shown on the large Figure 1.

2.1 Change in scope

2.1.1 Additional SBP work

As preliminary data became available, The Authority requested additional SBP survey works in the Western Channel and North Arm Channel, to better meet the objectives of the investigation (Variations 002 and 004). This additional SBP survey works targeted areas identified during the seismic data processing and interpretation. These areas were identified due to the complex series of reflectors in the SBP interpretation and the variability in the subsurface conditions in the area. This interpretation indicates possible rock close to surface and within the proposed dredge depths.

2.1.2 Seismic refraction and change in methodology

The original discussed scope of work included a variation for a bottom towed seismic refraction survey along a series of lines in the intertidal zone and possible structures in the port area, aimed at investigating sub-surface seismic velocities for foundation assessment. After mobilising to site to undertake the seismic refraction survey, The Authority in discussion with the Aurecon and M&ES during the pre-start meeting, was drawn to the seismic refraction survey methodology, as outlined in the tender documents. This involved towing equipment on the sea floor. It was then brought to Aurecon's and M&ES's attention that the permit to undertake the survey did not cover any direct contact with the sea floor and that it would not be possible to undertake the planned seismic refraction survey.

At the request of The Authority an alternate plan to meet the projects objectives and keep equipment off the sea floor was drafted. This plan involved towing the hydrophone array and sled unit through the water column at a constant altitude off the sea floor. During Phase 1 survey operations, this alternate plan was considered not feasible due to very shallow water areas and very variable sea floor levels at the site. M&ES could not guarantee that the equipment would remain above the sea floor and altitude control of both sled and hydrophone array would result in unreliable data collection.

After consideration of the site constraints, a new alternate plan was drafted. This involved undertaking a multi-channel seismic reflection survey (MCS) over the planned seismic refraction lines. This technique is similar to the single channel sub-bottom profiling technique yet has the advantage of better penetration levels as well as the ability to undertake more sophisticated signal and velocity analysis.

This method was approved by The Authority (Variation 002) and MCS was undertaken. Survey operations involved the use of a surface towed boomer system (seismic source) as well as a surface

towed 24 channel hydrophone streamer (seismic receivers) eliminate the risk of dragging anything on the sea floor.

A summary of the actual program timing is provided in Table 1.

Table 1 Summary of survey operations timing

Date Range	Activity	Areas Surveyed
10 to 13 December 2013	Mobilisation of Survey Vessel and Equipment by Road from Brisbane to Site for commencement of Seismic Refraction Surveys and Pre Start Meetings	Nil
14 to 15 December	Personnel Demobilise and Standby	Nil
16 to 17 December	Personnel Remobilise to commence Seismic Refraction Surveys. Pre Start Meetings and Review of Operations	Nil
18 December	Demobilise Personnel and store survey vessel and equipment.	Nil
5 January	Remobilise Personnel	
6 to 20 January 2014	Setup and Test Equipment Sub-bottom Profiling (Boomer and Chirp), Side Scan Sonar, Single Beam Echo Sounder	Western Channel, North Arm Channel, Port Area, North Port Area
21 to 23 January 2014	Demobilise Personnel and Demobilise seismic refraction equipment with survey vessel by road to Brisbane.	Nil
10 to 13 February 2014	Setup and Test Equipment Sub-bottom Profiling (Boomer), Side Scan Sonar, Single Beam Echo Sounder	Anchorage Area Infill Lines in Western Channel and North Arm Channel Tie Lines and Infill in Port Area
14 to 20 February 2014	Setup and Test Equipment Multi-Channel Seismic Reflection	Port Area
21 February 2014	Demobilise all personnel and equipment	Nil

All operations were carried out as per Aurecon's CEMP and SMP. No incidents or accidents occurred for the duration of surveys.

There was very limited downtime associated with inclement weather and sea state, however periods of high temperatures were experienced and equipment overheating and shutdowns were required. Installation of exhaust fans on the vessel to cool electronic equipment was undertaken and this resolved this issue.

3. Equipment and field procedures

3.1 Bathymetric survey and positioning

A Ceeducer Ceescope data measurement and recording system interfaced to a 200kHz single beam echo sounder was operated at 20 pings per second. Bar checks were undertaken prior to data acquisition as well as calibration and positioning check with the COR networked Lieca 1200 RTK positioning system with a local benchmark as well as periodic checks with the harbour master on readings from the local tide gauge. The system provided a horizontal accuracy of +/- 0.025m and vertical accuracy of +/-0.05m and was interfaced to the data acquisition software and sensors.

The 200kHz transducer was mounted over the side of the survey vessel with the RTK antennae located directly above on a pole. Vertical accuracy of the 200 kHz single beam transducer at 8 degree beam width is 0.02% of depth or 1cm whichever is greater.

3.1 Side scan sonar

A high resolution digital CMax CM2 was used to collect sea floor sonar data to define the likely nature of the materials and objects on the sea bed across the site. The side scan sonar towfish was towed at various altitudes off the sea floor due to the variability of the sea floor levels yet generally targeted a altitude of 10m and was operated at a frequency of 325khz with a beam range of 100m. The towfish was interfaced with Chesapeake software which provided real time mosaic and digitally records the data to hard drive along with time stamps and navigation data in accordance with accepted practice. Positioning of the towfish was referenced to the GPS antenna.

3.2 Sub-bottom profiling

Two different sub-bottom profiling (SBP) systems were available on the vessel for the duration of the survey to suit the variable conditions over the site. They included a high frequency Chirp profiler and a lower frequency Boomer profiler system. Generally the Chirp system was used in the deeper water areas (predominately Western Channel) where very thin dredging is expected. The Boomer system was used in the more shallow water areas where deeper levels of penetration are required to achieve information to dredge levels.

3.2.1 Chirp sub-bottom profiler

The higher frequency chirp system used was an EdgeTech 3200 sub-bottom profiling system with a 2-16kHz SB216s model towfish. The system is a wideband frequency modulated (FM) sub-bottom profiler utilizing full spectrum CHIRP technology.

The Chirp towfish was towed at various altitudes off the sea floor due to the variable sea floor levels and operated with a ping rate of 6Hz and frequency sweep of 2kHz to 10kHz. The system was interfaced to GPS positioning the system with position, heading, speed and ping number appended to the seismic digital record. The seismic records were recorded in the industry standard Segy format in accordance with accepted practice. The SBP system was interfaced with Chesapeake acquisition software which digitally records the seismic data to hard drive along with time stamps and navigation data. Layback and offset corrections, band pass filtering, time variable gains and stacking to optimise the appearance of the seismic record were performed during post processing.

3.2.2 Boomer sub-bottom profiler

The lower frequency boomer system used was an Applied Acoustics boomer and receiver and operated at energy levels ranging from 200 to 300 joules and a firing rate of 3pps. The streamer and transducer catamaran were towed 20m behind the vessel with a separation of approximately 5m. The

vessel speed was maintained at 3 to 4.5 knots for the majority of the survey yet on outgoing tides the vessel speed traveling with the current was up to 5 knots. Return signals were received via the 12 element hydrophone array streamer and recorded digitally to Chesapeake Technology acquisition system. The seismic acquisition system was interfaced to the GPS system with position, heading, speed and ping number appended in the segy seismic file. Layback and offset corrections, band pass filtering, time variable gains and stacking to optimise the appearance of the seismic record were performed during post processing.

3.3 Multi-channel seismic reflection

The Multi-Channel Seismic Reflection (MCSR) survey data was acquired with a Geometrics NZXP digital enhancement seismograph. Acquisition parameters for the seismograph were configured with a sampling interval of 0.125 milliseconds and a record length of 160ms. The system was interfaced via serial cable to the GPS system for accurate time stamps and navigation data and was backed up on a daily basis on digital medium for post processing.

The MCSR survey used a 24 channel hydrophone streamer array with sensor intervals of 1m and was towed 30m behind the survey vessel and 10m behind the source. Seismic energy was provided by an Applied Acoustics boomer operating at 300 Joules towed at 20m behind the survey vessel. The trigger system was interfaced to both the recording seismograph and boomer PSU to provide accurate synchronisation and was time based at 1.2 seconds per shot.

3.3.1 Vessel

The survey operations were carried on the “Flying Fish” operated by Western Port Fishing Charters.

Figure 1 below shows the vessel setup with equipment spread on back deck.

Figure 1 Example of vessel setup during the geophysical survey

4. Site geology

Reference to the 1:250,000 scale geological map for the area, Queenscliff (Sheet SJ 55-9, Geological survey of Victoria, Edition 2 May 1997), indicates that the geological conditions at the site of the geophysical survey may vary from Quaternary-aged unconsolidated deposits to Silurian-aged sandstone and siltstone, based on interpreting the onshore surface geological conditions.

An excerpt from the Queenscliff map is provided in Figure 2

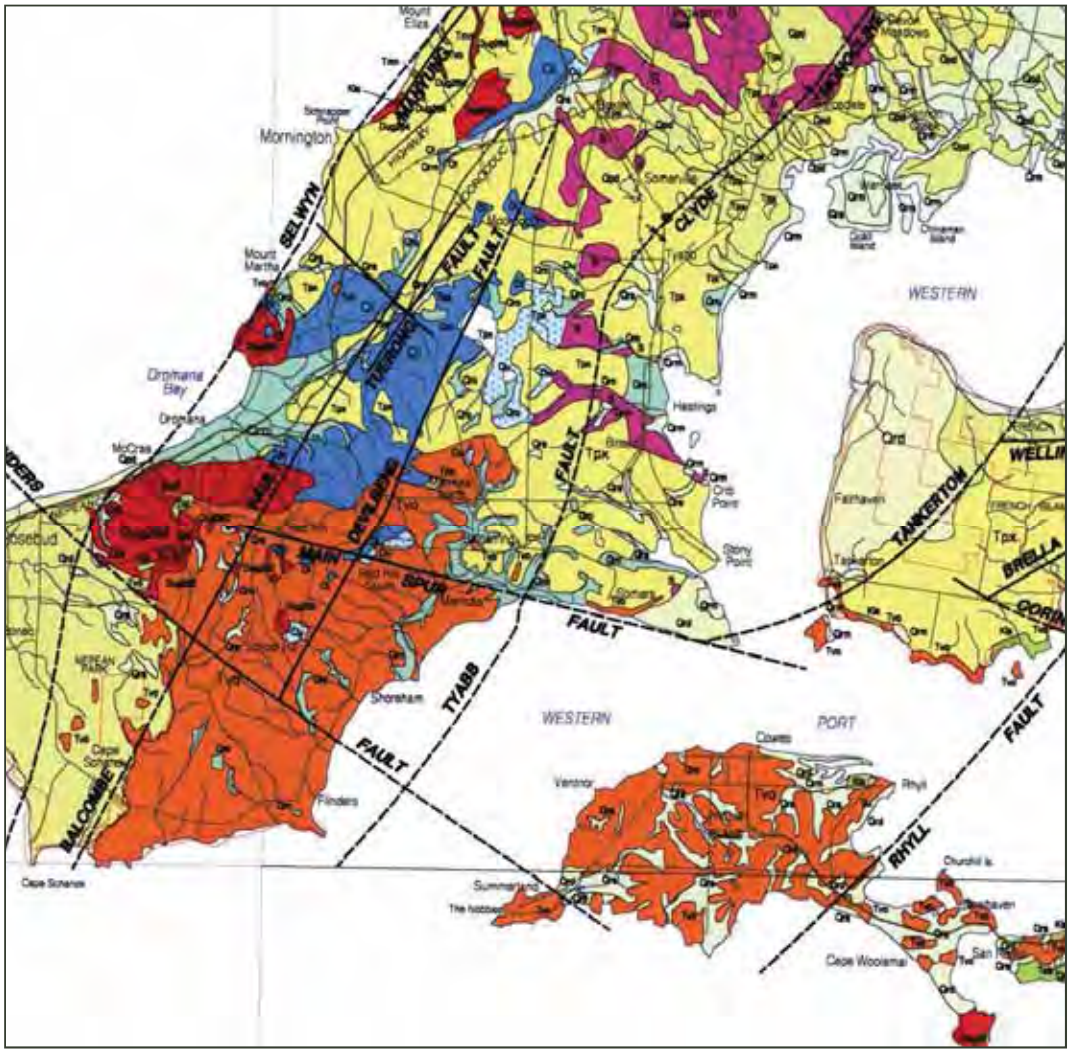

Figure 2 Excerpt from the Queenscliff 1:250,00 scale geological map (not to scale)

A generalised summary of ground conditions encountered during previous investigations within the study area were provided by the Port of Hastings Development Authority Marine Geophysics Survey, Part B Specification (Marine Geophysics Survey, Tender Reference: PoHDA 2013 003). This summary, provided below, was based on historical borehole information to allow definition of the following stratigraphical units:

Unit 1 Reclamation Fill (located at the Old Tyabb site) – Comprising variable deposits of fill. No reclamation records have been sourced but it is thought that the fill was likely placed in an

uncontrolled manner (i.e. not systematically placed and compacted in a controlled manner). Lower levels of fill are soft/ loose and compressible.

Unit 2 Quaternary Marine Deposits - Variable very loose and loose silts and sand, and very soft and soft clay. These materials are dark grey/ black and commonly contain shell fragment, and organic matter near surface. Due to their low strength, Unit 2 materials, in combination with overlying low strength fills, will likely be compressible if subjected to any significant external loading. In terms of distribution, the Unit 2 deposits are present (where they were left in place) beneath the existing reclamation fill, and are also present within the intertidal zone. It is also possible that softer materials encountered in some of the offshore boreholes represent recent marine sediments draped over palaeo erosion surfaces/ channels cut into the underlying Baxter or Sherwood Formation. Such materials may include the dark grey loose silty sand and soft and firm dark grey clays, for example, as encountered in AECOM 2009 BH5 to RL -20 mCD, and the apparent soft materials to RL -17.5 m CD at the abandoned AECOM 2009 BH6.

Unit 3 Tertiary Baxter Formation - Comprising medium dense and dense clayey sand and stiff to very stiff sandy clay materials. These materials are typically relatively competent and are commonly grey mottled red and orange brown and locally contain gravel and iron cementation. The Baxter Formation is encountered beneath the Quaternary marine deposits in the area of existing reclamation. In the offshore boreholes differentiation between the terrestrially deposited Baxter Formation and the underlying marine deposited Sherwood Formation appears to be indistinct.

Unit 4 Tertiary Sherwood Formation - Comprises pale grey and green grey silty sand and sandy clay with shell fragment. These materials are typically relatively competent and were encountered in a number of offshore boreholes e.g. in AECOM 2009 BH4 and BH 5 below RL -20 mCD. As mentioned above, differentiation of the Sherwood Formation from the Baxter Formation would appear to be difficult. By comparing adjacent borehole descriptions (albeit some 200 to 300 m apart) there does not appear to be an obvious continuity or consistency of material type across the site. The reason for this is not known but may be due to a number of factors including i) the presence of recent sediments deposited in eroded channels derived from re-working of the Baxter and/ or Sherwood Formations, ii) varied lateral extent of the respective formations, iii) varied depositional environment and transitional boundary that may have included both marine and terrestrial episodes, and iv) subaerial weathering and oxidation of the green grey Sherwood Formation during periods of exposure and erosion when sea levels were lower.

Unit 5 Silurian Siltstone and Sandstone – Encountered at depth in boreholes at Long Island Point, as a variably weathered basement rock.

Unit 6 Tertiary Basalt – Encountered at depth in the boreholes at Crib Point and Stony Point and near surface in the boreholes between The Nobbies and Sandy Point, as a variably weathered material ranging from fresh to extremely weathered boulders and cobbles in a clay matrix.

5. Processing and interpretation procedures

5.1 Bathymetric survey

The bathymetric data has been manually edited and quality checked with Hypack hydrographic software with some minor edits undertaken to remove obvious outliers. The data has been reduced to lowest astronomical tide and presented as contour plans.

5.1 Side scan sonar

The SSS data has been processed by digitising the sea floor, applying layback and offset corrections as well as beam angle corrections. Full coverage of the survey area was achieved with the SSS system except in the North Port Area where lines were widely spaced and on the northern most line at the Anchorage site where part of this digital file has been corrupted and is unusable. The data has been presented as a mosaic along with preliminary interpretation of sea bed features and character.

5.2 Sub-bottom profiling

The interpretation process involved replaying the digital seismic data using Chesapeake software, and applying layback corrections, band pass filters and time variable gains to the seismic data to optimise the detection of reflectors from subsurface layers.

An interpretation of the SBP records has been undertaken to map sub-surface reflectors related to geology and this involved replaying the records to identify and digitise coherent laterally continuous reflectors. The digitised reflector information contains the position and two way travel time of the reflector. The position is corrected for layback behind the DGPS antenna and the two-way travel time is converted to depth with an assigned velocity. The average seismic velocity assigned for time conversion to depth is 1,600 meters per second. This velocity was assigned after analysis of the shallow borehole data. If the actual seismic velocity of sub bottom material is lower than this value, the depth calculation to reflector/s would be overestimated and vice versa for a higher actual seismic velocity. The fact that the velocity profile may vary laterally along the alignment will also affect the calculated distance from the sea floor to reflectors when assigning an average near surface velocity, especially if the investigation area is large and comprises long lines. It must be borne in mind that the interpretation of seismic reflection data is subjective. Alternative assessments of the presence, location and nature of seismic reflectors are possible, and could produce interpretations different to those presented here. This subjectivity may be increased where data quality varies on adjacent survey lines and cross-lines as a result of sea conditions. The expected accuracy of the interpreted seismic reflectors levels are in the order of +/- 5% of depth.

There are potential errors associated with the determination of strata thickness due to the inherent relatively long wavelength of the boomer seismic signal (up to several metres) rendering it very difficult to detect accurately layers shallower than 1.0 to 1.5m. The Chirp system in general has very limited penetration across the survey areas due to the seafloor material being predominantly of sandy material and as such was only utilised in deeper water areas where very shallow dredging is expected.

6. Port Area (Appendix A)

6.1 Bathymetry

The bathymetric data has generally agreed well with the previous bathymetric survey data set at this site and has identified sea bed levels ranging from -19m LAT in a localised hole at the north eastern corner of the site and 1m LAT over shallow banks at the western shore line. The contoured bathymetric data has been provided in Figure A1.

6.2 Sub-bottom profiling

The SBP interpretation has identified two major continuous reflectors across the port site. These are assigned Reflector R1 and Reflector R2.

The material between the sea floor and the R1 reflector is interpreted as Recent deposits and the seismic character of this layer is variable and is expected to represent clays and silts and fine sands. Calibration of the sub-bottom profiling character with the geotechnical borehole logs has been undertaken and has been somewhat successful in delineating three (3) identifiable units within this near surface layer. These units are as follows:

1. Clays, Silty Clays and Sandy Clays
2. Clayey Silt, Clayey Sand and Sandy Silt
3. Sands and Silty Sands

The top of the R1 reflector is irregular in level and in places appears to have minor erosional features which may have been infilled with Recent material. The material between the R1 reflector and the R2 reflector is interpreted to be interbedded sands, silts and clays. The CPT data in this interval displays a saw toothed appearance indicative of interbedded materials and agrees well with the seismic interpretation. The geotechnical borehole logs however do no detect this interbedded material well, as the recovery technique effectively mixes individual layers and the logged material within this interval is simplified to represent a composite unit.

The R2 reflector underlies the R1 reflector and displays more simple parallel reflections. The material immediately below R2 is interpreted to be predominately represented by interbedded fine-grained materials such as clays and silts and is variable in thickness. The base of R2 is difficult to detect in all places due the presence of the sea floor multiple, however material below these depths is generally well below expected dredge levels.

In the southern extent of the Port Area which adjoins the North Arm Channel, a series of horizontal reflectors have been interpreted which dip in a northerly direction intersecting the sea floor in this location. The near surface material of this series of parallel reflectors appears to be coarse with the material at depth being seismically transparent, which is indicative of silts and clays.

A rock reflector has been interpreted on the seismic records and is only mapped reliably along the western extent of the site where the rock is relatively shallow. The rock reflector is very variable in level and correlates well with rock levels encountered in the geotechnical boreholes.

The SBP vessel trackplots are shown in Figures A2 and A3 with the interpreted seismic sections shown on Figures A4 to A9. The two major continuous reflectors R1 and R2 have been contoured and presented on Figures A10 and A11. The rock reflector contour plan is shown in Figure F3 and includes the rock levels interpreted from the multi-channel seismic survey (Appendix F).

6.3 Side scan sonar

The side sonar has identified variable sea floor sonar character with the results shown on the side scan sonar mosaic in Figure A12. Figure 13 provides a correlation of the side scan sonar with sub-bottom profiling and the borehole data.

7. North Arm Channel (Appendix B)

7.1 Bathymetry

The bathymetric data has generally agreed well with the previous bathymetric survey data set along the North Arm Channel and has identified sea bed levels ranging from -25m LAT at the southern end of the North Arm South Channel and -12m LAT at the Crib Point wharf area.

The North Arm South Channel is dominated by sand waves which range in height from crest to trough of approximately 1m to 5m high. The lee side of the sand waves appears to be on the southern side indicating the dominant flow direction, which is north to south.

The contoured bathymetric data has been provided in Figure B1 and B2.

7.2 Sub-bottom profiling

The SBP interpretation has identified four major reflectors in the North Arm Channel. These are assigned Reflector R1, Reflector R2, Reflector R3 and the interpreted Rock Reflector.

The summary of interpretation for the North Arm Channel is divided into three areas and is provided below:

7.2.1 North Arm North Channel (NANC)

The interpreted seismic sections in the North Arm North Channel are presented on Figure B5 and B6. The northern extent of the channel adjoins the Port Area with the dipping parallel reflectors interpreted in the southern extent of the Port Area continuing for approximately 1000m south before abruptly discontinuing. This may represent a geological boundary.

The material between the sea floor and the discontinuous R1 is interpreted as Recent deposits dominated by fine material such as clays and silts with a thin veneer of overlying recent sandy material. The seismic character of this layer is predominantly reflection free, which is indicative of fine materials such as silts.

The top of the R1 reflector is irregular in level and in places appears to have minor erosional features which have been infilled with recent material. The material between the R1 reflector and the R2 reflector is interpreted as interbedded sands, silts and clays and laps onto R3 in the southern end of this channel.

The material immediately below the R2 reflector is interpreted to be interbedded finer materials such as clays and silts. R2 underlies R1 and laps onto R3 in the southern end of this channel.

R3 is a very irregular reflector and interpreted as a predominantly silt and clay layer. This reflector also displays numerous diffractions indicative of gravels, cobbles and boulders.

A rock reflector has been interpreted underlying the R3 reflector and is detected in the southern extents of the North Arm North Channel (Figure B6).

7.2.2 North Arm Channel Crib Point Wharf

This area is adjacent to the Crib Point wharf and includes a series of short lines off the main shipping channel.

The R1 reflector, interpreted as an interbedded sands, silts and clays layer is discontinuous and overlies R3.

The R3 reflector is interpreted as the top of a silt and clay layer which shallows to the north. This R3 reflector also displays numerous diffractions indicative of gravels, cobbles and boulders. The material between the R3 reflector and the sea floor is expected to be predominately fine material such as silts and clays.

A rock reflector is interpreted and is shallowing toward the north end of the site.

7.2.3 North Arm South Channel (NASC)

This channel adjoins the Western Channel with seafloor levels deeper than -20m LAT in the southern extents.

The interpreted seismic data in this part of the channel is very complex and has identified numerous reflectors including discontinuous R1 and R2 reflectors, R3 and interpreted Rock Reflectors.

The R1 reflector is limited to the northern extents of the channel with the interpreted material between the sea floor and this reflector expected to be predominantly fine material such as clays and silts in the northern extents and grading to silty and sandy material in the southern extents.

The interpreted levels of R3 are very variable and intersect the sea floor at approximately 1600m and 3400m from the southern end of this channel. This reflector overlies the rock reflector with the unit between these two reflectors interpreted as a predominantly silt and clay layer with some localised diffraction zones indicative of gravels, cobbles and or boulders. This unit has two major channel features identified at approximately 2600m and 4200m from the southern end of this channel. These channels are infilled with interbedded fine and coarse deposits and exhibit a series of dipping and onlapping reflectors which terminate on the unit between R3 and the rock reflector.

The rock reflector continues from the North Arm North Channel and Crib Point area into this channel but is not detectable continuously and is very variable in level. The interpreted rock reflector, where detectable, is well below expected dredge levels.

The material within the near surface is appearing to grade to a coarser material towards the southern end of the channel and coincides with the presence of the sand wave area which is limited to the southern half of the channel. The shallow discontinuous horizontal reflector immediately beneath the sand waves is interpreted to represent the boundary between the recently accumulated sand deposits on the sea floor and the underlying finer clay and silt layers.

The SBP vessel trackplots are shown in Figures B3 and B4 with the interpreted seismic sections shown on Figures B5 to B9. The interpreted rock levels are contoured and presented on Figure B10 and B11.

7.3 Side scan sonar

The side scan sonar has identified variable seafloor sonar character. As shown on the seismic sections, sand waves are prevalent within the North Arm Channel, with sea grass dominating to the north near the Port Area. A potential wreck was recorded just outside the shipping channel to the south of the NASC. The side scan sonar mosaics are presented in Figures B12 and B13.

8. Western Channel (Appendix C)

8.1 Bathymetry

The bathymetric data has generally agreed well with the previous bathymetric survey data set and has identified sea bed levels ranging from -34m LAT and -13m LAT.

The majority of the Western Channel is below expected dredge levels with localised high spots targeted with denser coverage to achieve a better appreciation of conditions.

The contoured bathymetric data has been provided on Figures C1 to C3.

8.2 Sub-bottom profiling

The SBP interpretation has identified variable conditions in the Western Channel which include rock at shallow depths within dredge levels and dense seafloor materials.

The summary of the Western Channel interpretation is divided up into three sections and provided below:

8.2.1 Western Channel North (WCN)

In general the seafloor multiple is very strong in this area which is indicative of dense seafloor materials. The higher frequency Chirp system used in this area had limited penetration as a result of this and the Boomer system was subsequently used to target areas where more dredging may be expected. Two localised high spots are located in the middle of the channel and these areas have been targeted with denser line spacing to achieve a better appreciation of conditions.

The material at the sea floor is interpreted as predominately coarse material such as sands and gravels. The interpreted rock levels over this area are variable and the penetration with the seismic systems below this reflector is limited. Rock is shallowest on the eastern side of the channel at the northern most extent and is at a reduced level of -15m LAT. A clayey layer is interpreted immediately overlying the rock reflector in places and could represent extremely weathered rock or residual soil material.

A shallow bank that extends into the channel from the eastern side has a very strong and pronounced first arrival from seafloor and seafloor multiple, which could indicate a cemented material or dense gravels at the surface in the area. At a few locations, the seismic records showed a very high amplitude reflector and is interpreted as an indurated or cemented layer (Figure C8, C9 and C10).

8.2.2 Western Channel Mid (WCM)

This part of the channel has deep water levels over the majority of the site and adjoins the Anchorage area to the east. There are however numerous localised high spots in this area and these have been targeted with further survey lines to achieve a better appreciation of conditions. Rock levels within or close to dredge limits have been identified around the following locations:

1. 340411.5E, 5742921.8N, -19.5m LAT
2. 339801.9E, 5742107.7N, -21.7m LAT
3. 339801.9E, 5741858.6N, -18.9m LAT
4. 341437.7E, 5742776.9N, -21.2m LAT
5. 342742.6E, 5743446.0N, -19.8mLAT

Geotechnical borehole number WC3 is located in this channel and has identified basalt at the surface, which is consistent with the seismic interpretation at this location.

The Chirp system has limited penetration over the majority of this area due to the very dense sea floor material. Where penetration was achieved and reflectors observed at depth, the material overlying is expected to be relatively less dense. The Boomer system provided good penetration to map the rock surface more effectively in critical areas where dredging may be expected, yet this boundary was indistinct in places. This is likely to be a result of a small density and velocity contrast between the near surface dense materials and the underlying weathered rock surface.

The seismic character of the material between the sea floor and the interpreted rock reflector is very variable and lacks internal reflections. This material is expected to be very dense and represent clays, sands, gravel and or cobbles.

The sea floor multiple is very strong which is indicative of dense seafloor materials.

8.2.3 Western Channel South (WCS)

This is the southernmost area of the shipping channels at Port of Hastings and is located in generally deep water greater than -20m LAT. There is a localised band of higher sea floor level that crosses the channel as well as a number of localised high spots and these have been targeted with further survey lines to achieve a better appreciation of conditions. The interpreted rock levels over this area are very variable with numerous high spots identified.

High rock levels have been identified around the following locations:

1. 339471.1E, 5741718.4N, -19.9m LAT
2. 338558.4E, 5740974.9N, -21.6m LAT
3. 336120.1E, 5738483.7N, -19.5m LAT
4. 335965.0E, 5738536.5N, -21.0m LAT
5. 335785.3E, 5738363.9N, -18.8m LAT
6. 335658.5E, 5738617.6N, -20.8m LAT
7. 335351.9E, 5738328.6N, -19.6m LAT
8. 335408.3E, 5737803.5N, -17.7m LAT

The Chirp system has limited penetration over the majority of this area due to the very dense material at the sea floor, with the reflectors from the chirp records being generally weak. Where reflectors are observed at depth, the material overlying is expected to be relatively less dense. The Boomer system provided good penetration to map the rock surface more effectively in critical areas where dredging may expected, yet this boundary was indistinct in places. This is likely to be a result of a small density and velocity contrast between the near surface dense materials and the underlying weathered rock surface.

The seismic character of the material between the sea floor and the interpreted rock reflector is very variable and in general lacks internal reflections. This material is expected to be very dense and represent clays, sands, gravel and or cobbles.

The SBP vessel trackplots are shown in Figures C4 to C6 with the interpreted seismic sections shown on Figures C7 to C16. The interpreted rock levels, where available, are contoured and presented on Figures C17 to C19.

8.3 Side scan sonar preliminary results

The side sonar has identified variable sea floor sonar character with the results shown on the side scan sonar mosaic in Figure C20, C21 and C22. Sand wave zones are interpreted, especially within

the WCN area. The high reflectivity feature from the shallow bank, interpreted as being an indurated layer, is shown on Figure C20.

9. North Port Area (Appendix D)

9.1 Bathymetry

The bathymetric data has generally agreed well with the previous bathymetric survey data set and has identified sea bed levels ranging from -25m LAT and -0m LAT on the northern extents on the site.

The contoured bathymetric data has been provided on Figure D1.

9.2 Sub-bottom profiling

The SBP interpretation has identified two major continuous reflectors across the North Port site. These are assigned Reflector R1 and Reflector R2.

The material between the sea floor and R1 is interpreted as Recent deposits. The seismic character of this layer is very variable and is expected to represent soft clays and loose silts and sands. There are localised discontinuous reflectors within this interval over the site, which are expected to represent minor density boundaries.

R1 is a discontinuous irregular reflector and displays chaotic patterns. It is therefore interpreted as an erosional surface. The material between R1 and R2 is interpreted to be interbedded clays, silts and sands.

R2 underlies R1 and displays more simple parallel reflections. The material immediately below R2 is interpreted to be predominately represented by interbedded finer materials such as clays and silts.

The base of R2 is difficult to detect in all places due the presence of the sea floor multiple. Material below at these depths is generally expected to be well below dredge levels.

The SBP vessel trackplots are shown in Figures D2 with the interpreted seismic sections shown on Figure D3.

9.3 Side scan sonar preliminary results

The wide line spacing in the North Port area meant that mosaicking of the side scan sonar was not possible. The available interpreted side scan sonar results has identified a variable sea floor sonar character, including areas of sea grass and sand waves, with the results shown on the side scan sonar plan in Figure D4.

10.Anchorage (Appendix E)

10.1 **Bathymetry**

The bathymetric data has generally agreed well with the previous bathymetric survey data set and has identified sea bed levels ranging from -26m LAT and -11m LAT. The shallowest water areas are limited to the northern boundary and the deeper water levels located adjacent to the shipping channel.

The contoured bathymetric data has been provided on Figure E1.

10.2 Sub-bottom profiling

The SBP interpretation has identified three major reflectors in the Anchorage area. These are assigned Reflector R1, R2 and an interpreted rock reflector.

The material between the sea floor and R1 is interpreted as Recent deposits dominated by silts and sands. There are localised discontinuous reflectors within this interval over the site, which are expected to represent localised deposits of coarser materials or clay layers.

R1 is an irregular reflector which displays chaotic patterns with erosional features and is limited to the eastern extents of the Anchorage site. The dominant material between R1 and R2 is interpreted to be interbedded sands and silts.

R2 underlies R1 and displays more simple parallel reflections. The material immediately below R2 is interpreted to be predominately represented by interbedded fine materials such as clays and silts.

The interpreted rock reflector is continuously mapped across the Anchorage site. The rock reflector is variable in level and is very close to the sea floor at numerous locations on the northern and eastern extents. The penetration of seismic energy below this reflector is laterally variable and is related to degrees of weathering.

The SBP vessel trackplots are shown in Figure E2 with the interpreted seismic sections shown on Figure E3 with the interpreted rock levels contoured and presented on Figure E4.

10.3 Side scan sonar preliminary results

The side sonar has identified variable sea floor sonar character with the results shown on the side scan sonar mosaic in Figure E5. Sand waves dominate the sea floor o the north and south of the Anchorage with sea grass present to the east.

11. Multi-channel seismic reflection analysis and results (Appendix F)

A multi-channel seismic reflection (MCSR) survey has been completed in the Port Area and North Port Area along a series of 10 pre-defined transects. The MCSR survey was undertaken in the attempt to achieve similar level of detail and information as a seismic refraction survey which was the preferred method of investigation at the site, yet unable to be completed due to survey permit limitations.

The MCSR survey has been successful in mapping seismic reflectors to 120 milliseconds (two-way travel time) below the sea floor. The seismic data is generally of good quality but is variable in areas where water depths are very shallow and this presents some limitations in achieving good levels of investigation due to multiple signal paths between the sea floor and sea surface as well as sub-sea reflectors obscuring deeper reflectors of interest. Signal processing has been undertaken to seismic traces to limit this multiple effect and has been somewhat successful.

Signal processing included the following routines:

- Nominal marine geometry application
- Pre stack gain and band pass filter tests
- Preliminary Stack
- Velocity analysis performed at 125 m intervals (every 250th CDP @ 0.5 m).
- Final stack using picked velocities.
- Post stack processing:
- Band pass filter 150-300-1600-2000 Hz
- Post stack deconvolution
- FX domain running mix of 31 traces
- FX domain de-convolution
- Post stack AGC 40ms

The MCSR line locations are shown on the Location Plan in Figure F1. It should be noted that the sea floor levels presented on this plan are derived from data supplied by PoHDA and are used to show more extensive coverage in the North Port Area as only limited bathymetry was undertaken in this area as part of the survey. Field operations were undertaken at periods of high tide to achieve coverage as close as possible to the shoreline.

The MCSR records have been presented as interpreted seismic reflection sections on Figure F2.

An irregular reflector has been mapped on the seismic records and has been interpreted as a rock surface. This interpreted rock reflector is very weak in deeper areas where signal to noise ratio is low and detection difficult, some interpolation has been required. The rock reflector is variable in level and ranges from -93.4m LAT to -29.4m LAT.

The interpreted and reduced rock levels have been contoured and presented on Figure F3. This contour plan has been constructed using the MCSR data as well as using rock levels identified from the Boomer sub-bottom profiling survey for cross checks and to provide an extended rock surface model. Reliable detection of this rock reflector on the sub-bottom profiling records is limited to areas immediately around the existing Bluescope Steel and Long Island Point Wharves where rock is relatively shallow.

The levels of the interpreted rock reflector closely agree with the levels of rock encountered in three (3) geotechnical boreholes along MCSR Line 8 (Berth Line), from the 2009 AECOM series. An example of this seismic record with the projected boreholes is provided in Figure 3 (note the red band indicates rock level).

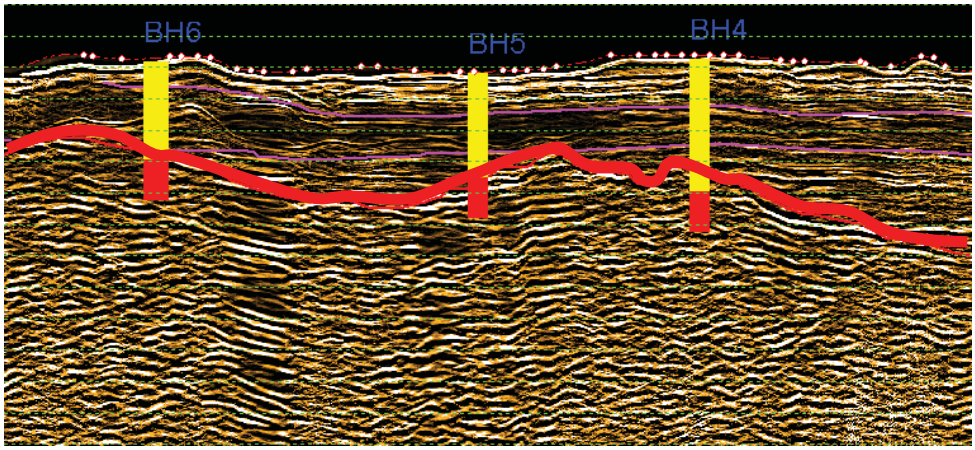

Figure 3 Example of the seismic record incorporating three AECOM (2009) boreholes (NTS)

Numerous reflectors have been interpreted overlying this rock reflector and are continuous for at least hundreds of metres. These reflectors are generally horizontal and represent velocity / density boundaries between unconsolidated materials.

The seismic velocity analysis undertaken on the MCSR data has enabled an appreciation of the sub-surface conditions to be achieved. The interpreted seismic velocities range from 1500m/s to 1900m/s which correlate with a wide range of geological materials such as very loose sands, silts and clays to dense gravels and extremely weathered rock. Seismic velocities along the lines are variable and in general show a gradational increase in seismic velocity with depth. The higher seismic velocity levels approaching 1900m/s generally correlate with the levels of the interpreted rock reflector. The seismic velocity analysis has been presented as cross sections on Figure F4.

Correlation and calibration with detailed geotechnical borehole data will allow refinement of this seismic model for foundation assessment and defining potential aquifer layers.

12.General comments and recommendations

The geophysics survey at the Port of Hastings has identified varying conditions at the proposed Port Site, Shipping Channels and Anchorage Area. The main features and recommendations for further investigation at these sites is summarised in the following sections:

12.1 Port Area

The near surface layer between the seafloor and R1 has been refined with the assistance of geotechnical borehole and CPT data and it is recommended that this information should be used to construct a 3D model of the mapped units over this site to assist design of the proposed port layout and to determine volumes of differing material types that are to be dredged or reclaimed.

We recommend undertaking further sub-bottom profiling in conjunction with a vibrocoring survey to further refine the geological model in the areas that are to be dredged as the line spacing is currently too broad to perform a detailed pre-dredge material and volume assessment.

We further recommend undertaking seismic refraction along the wharf and dolphin alignments to assess foundation conditions as well as to assess the settlement potential over the reclamation footprint, once these positions have been finalised.

We would also recommend undertaking a near-shore, high-resolution sub-bottom profiling survey to map thicknesses of very loose sediments and muds over the reclamation area to determine volumes of very loose material to be removed prior to reclamation works.

Sea grass or other biological zones interpreted on the side scan sonar records should be ground truthed with camera drops and assessed for environmental significance.

12.2 North Arm Channel

Areas where shallow rock has been identified; along the western side of the channel around Cribb Point and the southernmost end on the eastern side of the channel, should be tested further with seismic refraction techniques to fully address the impacts that this will have on dredging performance should the final channel level intersect rock.

The possible ship wreck identified just outside the channel toe line with the side scan sonar should be investigated further with a camera drop as this may be of historical significance and could impact channel design.

Sea grass or other biological zones interpreted on the side scan sonar records should be ground truthed with camera drops and assessed for environmental significance.

12.3 Western Channel

Aurecon and M&ES were advised that the initial -20m LAT channel design depth had been deepened to -24m LAT in the Western Channel and as such the Chirp sub-bottom profiling survey was limited in achieving depths of investigation due to the very dense seafloor materials. Rock shallower than -20m LAT is mapped at numerous locations within the Western Channel particularly in the area where a localised band of higher sea floor level crosses the channel. The sub-bottom profiling has indicated dense sea floor material, which include boulders overlying a variable rock surface which is at or very near the surface in many locations.

We recommend undertaking a sub-bottom profiling survey with a Boomer system over the areas shallower than -24m LAT that were initially undertaken with the Chirp system to reach the levels of investigation required to meet the revised channel depths as well as completing further infill lines and tie lines to map the levels of the irregular rock surface where required.

We further recommend that areas of rock shallower than -20m LAT should be tested further with seismic refraction techniques to fully address the impacts these materials will have on dredging performance. A multi-beam echo sounding survey should also be undertaken at these shallow locations where dredging is expected to allow sea bed levels to be mapped in more detail.

Targeted grab samples and camera drops should also be undertaken at the site to compliment the borehole data and to achieve a better understanding of the variability of material at the surface.

12.4 North Port Area

Sea grass or other biological zones interpreted on the side scan sonar records should be ground truthed with camera drops and assessed for environmental significance.

12.5 Anchorage Area

A very variable rock surface has been interpreted in this area and consideration should be given to designing an anchorage layout to avoid dredging in shallow rock areas.

Sea grass or other biological zones interpreted on the side scan sonar records should be ground truthed with camera drops and assessed for environmental significance.

13. Limitations

This report has been prepared in accordance with the brief, where provided. The contents of the report are for the sole use of the client (Port of Hastings Development Authority) and no responsibility or liability will be accepted to any third party. Data or opinions contained within this report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data provided by PoHDA and collected by others, data retrieved from a geophysics survey and collected at specific locations and by using suitable investigation techniques. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the client's Brief and this report does not purport to completely describe all the site characteristics and properties.

Subsurface conditions relevant to construction or dredge works should be assessed by contractors who can make their own interpretation of the data provided. They should perform any additional tests as necessary for their own purposes. It is strongly recommended that any plans and specifications prepared by others and relating to the content of this report, or any amendments to the original plans and specifications, are reviewed by Aurecon to verify that the intent of our recommendations is properly reflected in the design. During construction we request the opportunity to review our interpretations if the exposed site conditions are significantly different from those inferred in this report.

A specialist dredging contractor should be engaged to confirm the type of dredge machine required and to thoroughly assess all dredging issues with project.

Subsurface conditions can change over time. This should be borne in mind, particularly if this report is used after a protracted delay.

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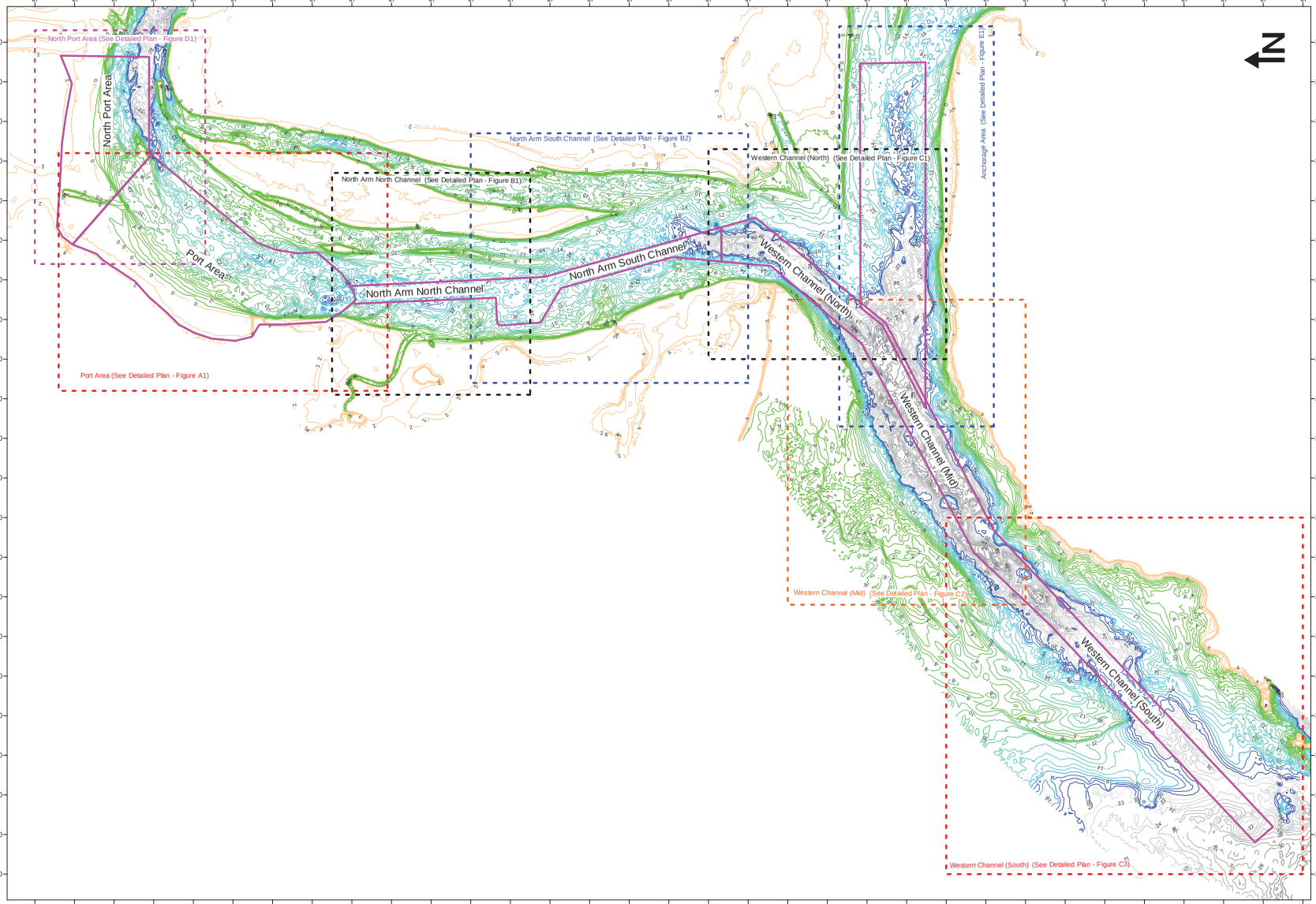
Appendices



LEGEND

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

aurecon

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS

MASTER LOCATION PLAN

SCALE 1:50,000

Survey Date: JAN-FEB 14 | Project Ref: 424

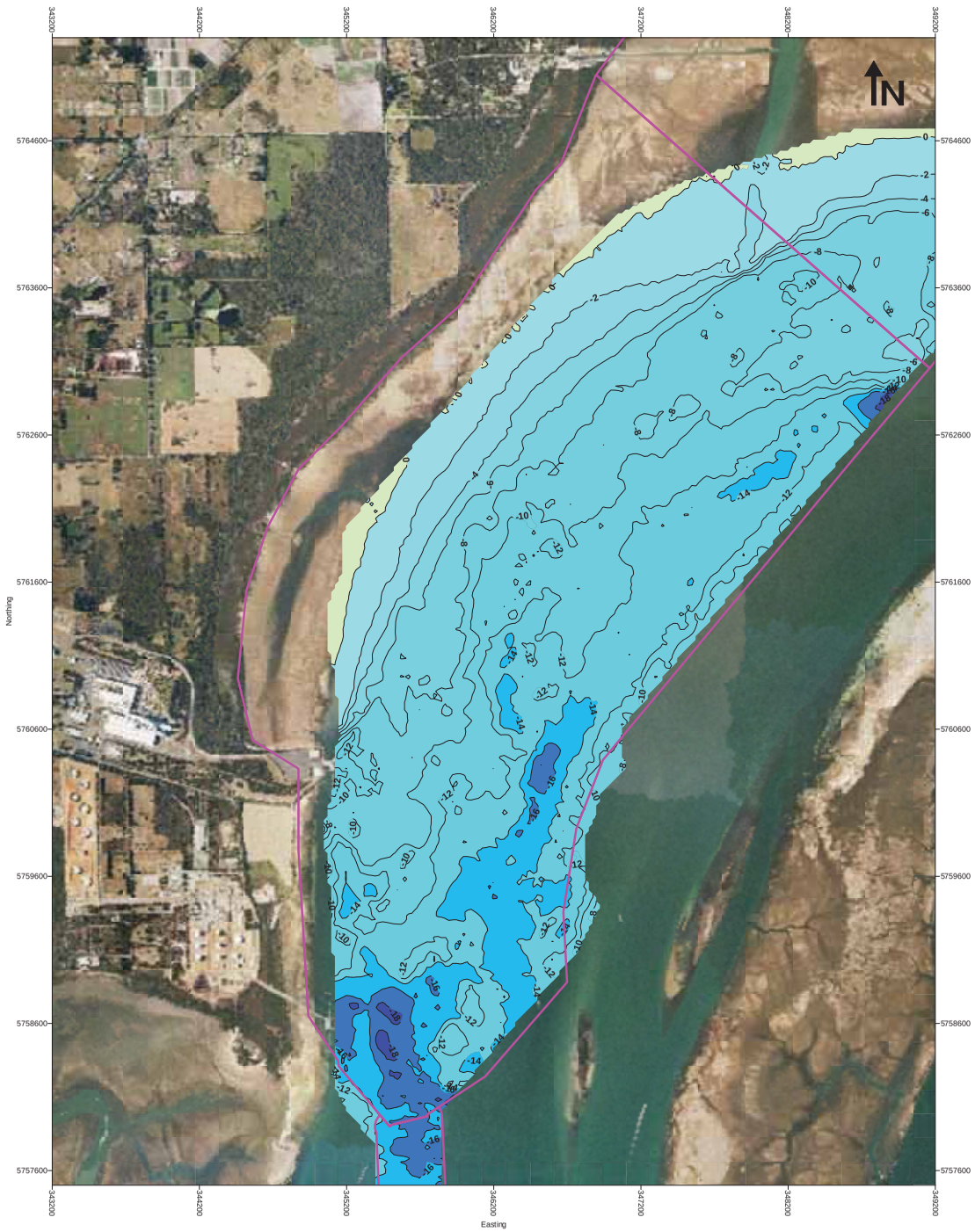
Issue No.	Date	Description	Surv.	Interp	Drawn	Appr.
1	14/04/14	MLP	dpk		dpk	
2	11/05/14	MLP	dpk		dpk	
3	10/06/14	MLP	dpk		dpk	

Client Drawing No.

Figure No. 1

Sheet No.

Appendix A
Port Area



LEGEND

Limits of Investigation

Reduced Level Metres LAT

2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

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LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SEAFLOOR LEVELS CONTOUR PLAN

SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	Prelim Bathy	pb	dpk	dpk	
2	09/06/14	Bathy	pb	dpk	dpk	
4	05/10/14	Bathy	pb	dpk	dpk	pl

Client Drawing No | Figure No. A1 | Sheet No.

LEGEND

Line PA-09 = Start of SBP Line PA-09 (0.0m)

Historical Borehole Location

R,S or D10 Worley Parsons 2013-2014 Borehole Location

CPTS 10 Worley Parsons 2013-2014 CPT Test Location

Limits of Investigation

NOTES

Line label indicates start of line

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

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LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SUB-BOTTOM PROFILING SURVEY
LONGITUDINAL VESSEL TRACKPLOTS
AND BOREHOLE LOCATIONS

SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	SBP TPs	dpk	dpk	dpk	
2	09/06/14	SBP TPs	dpk	dpk	dpk	
4	09/10/14	SBP TPs	dpk	dpk	dpk	ar

Client Drawing No | Figure No. A2 | Sheet No.

LEGEND

Line PA-09 = Start of SBP Line PA-09 (0.0m)

Historical Borehole Location

R,S or D10 Worley Parsons 2013-2014 Borehole Location

CPTS 10 Worley Parsons 2013-2014 CPT Test Location

Limits of Investigation

NOTES

Line label indicates start of line

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

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LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SUB-BOTTOM PROFILING SURVEY
TIE LINE VESSEL TRACKPLOTS
AND BOREHOLE LOCATIONS

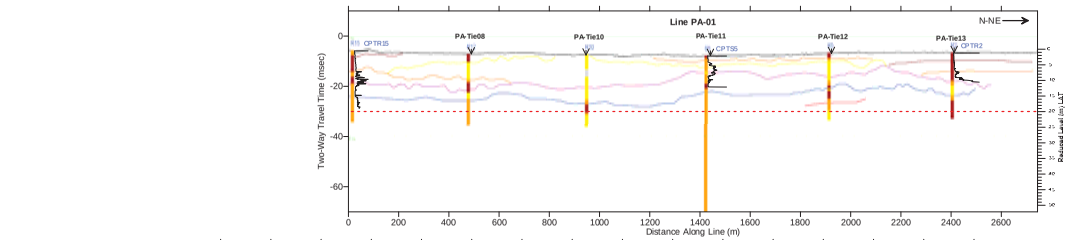
SCALE 1:15,000 (A1 sheet)

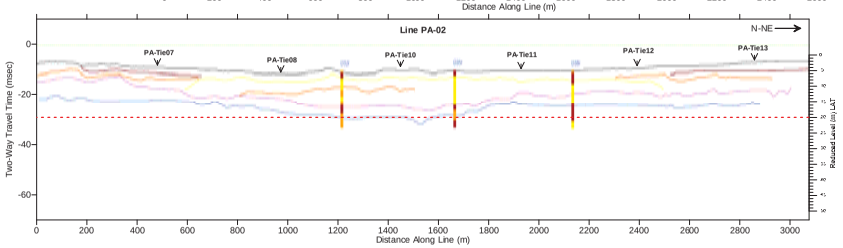
0 250 500 750 1000

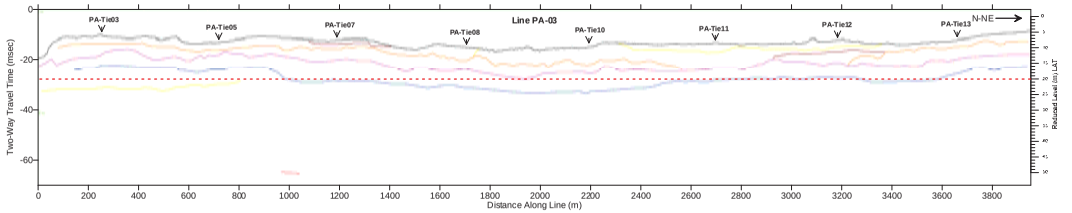
Survey Date: JAN-FEB 14 | Project Ref: 424

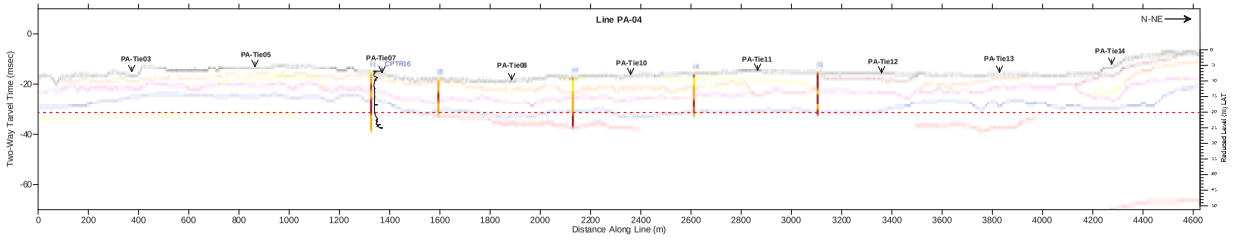
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr.
1	03/04/14	SBP TPs	dpk	dpk	dpk	
2	10/06/14	SBP TPs	dpk	dpk	dpk	
4	29/10/14	SBP TPs	dpk	dpk	dpk	gr

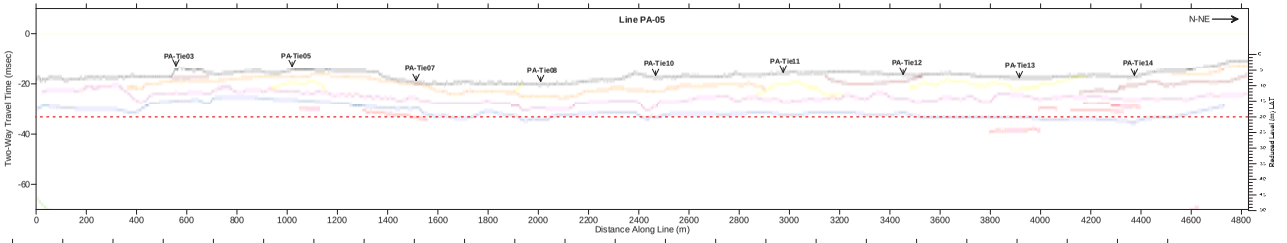
Client Drawing No. | Figure No. A3 | Sheet No.

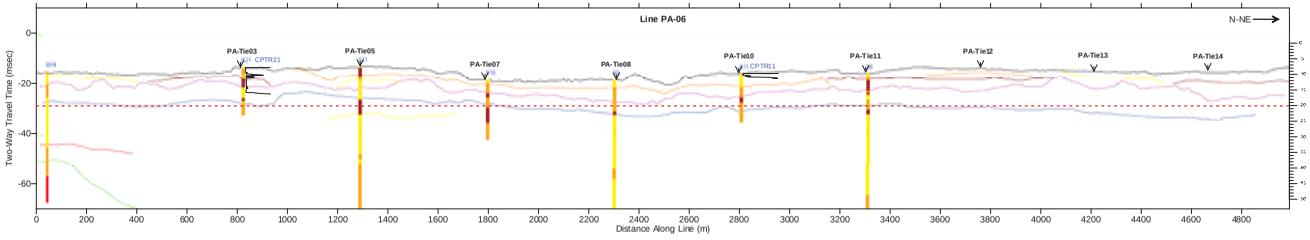












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION
Horizontal Datum: MGA/GDA94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER
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LOCATION MAP

CLIENT DETAILS
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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

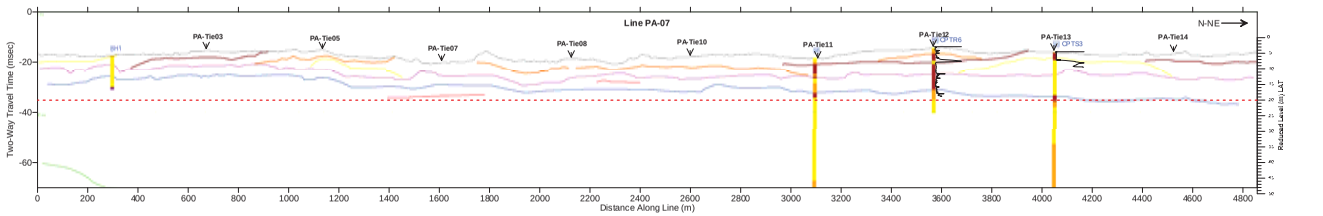
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES PA-01 TO PA-06

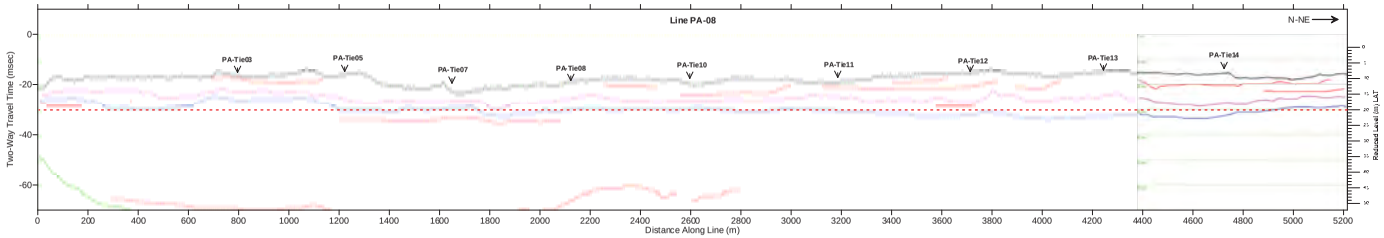
SCALE H1:10,000 V1:1,000 (A1 sheet)

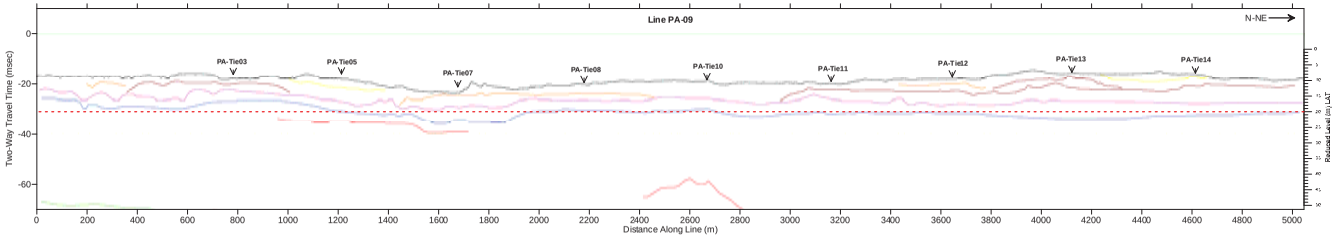
Survey Date JAN-FEB 14 | Project Ref 424

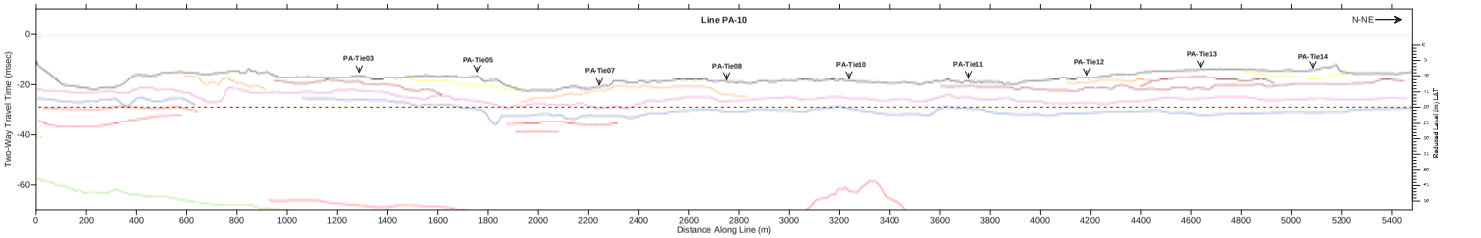
Issue No.	Date	Descripter	Surv	Interp	Drawn	Appr
1	02/04/14	RSP ISS	dyk	pfdpk	dyk	
2	23/04/14	RSP ISS	dyk	pfdpk	dyk	
4	09/10/14	RSP ISS	dyk	pfdpk	dyk	gr

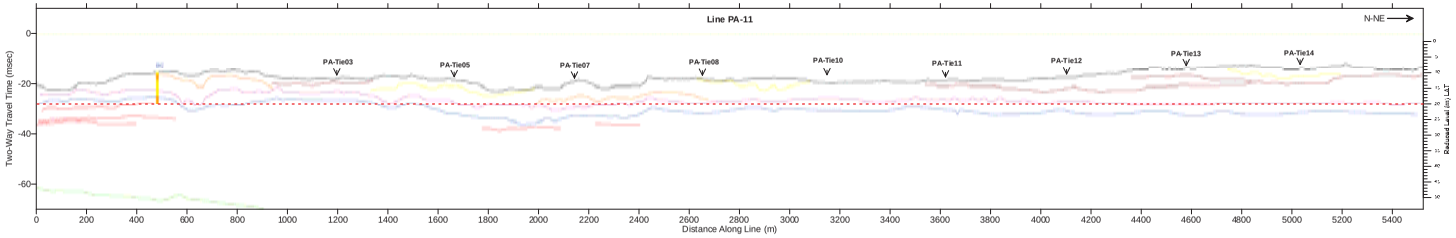
Client Drawing No | Figure No. | A4 | Sheet No.

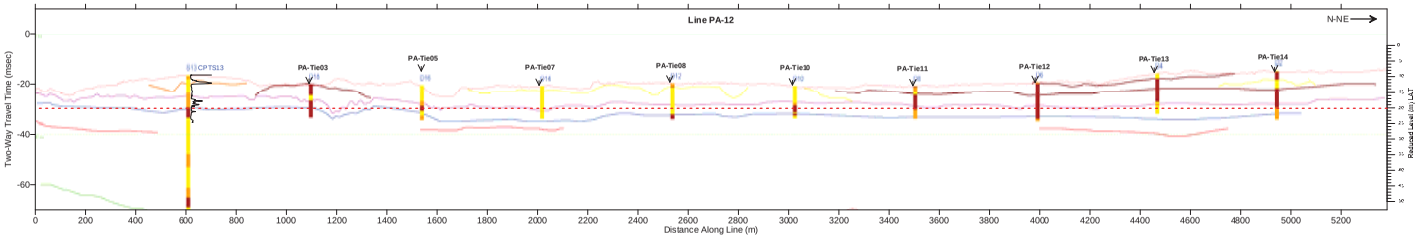












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION
Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER
This plan should be read in conjunction with the accompanying report

LOCATIONMAP

CLIENT DETAILS
AURECON AUSTRALASIA PTY LTD

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marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

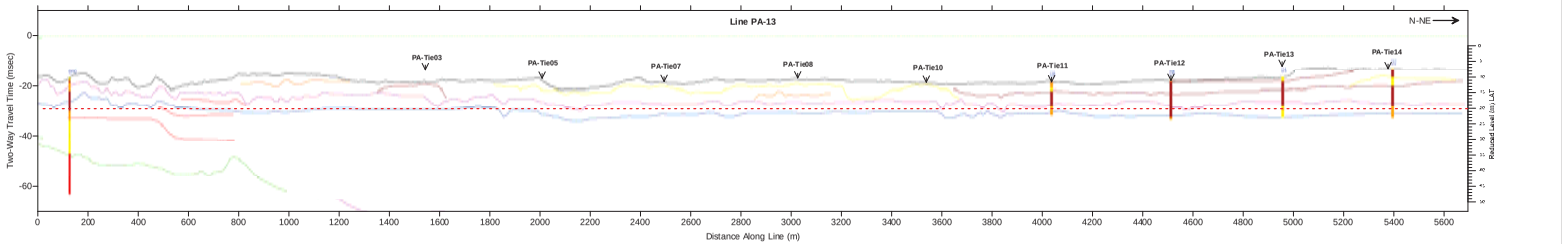
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMICSECTIONS
LINES PA-07 TO PA-12

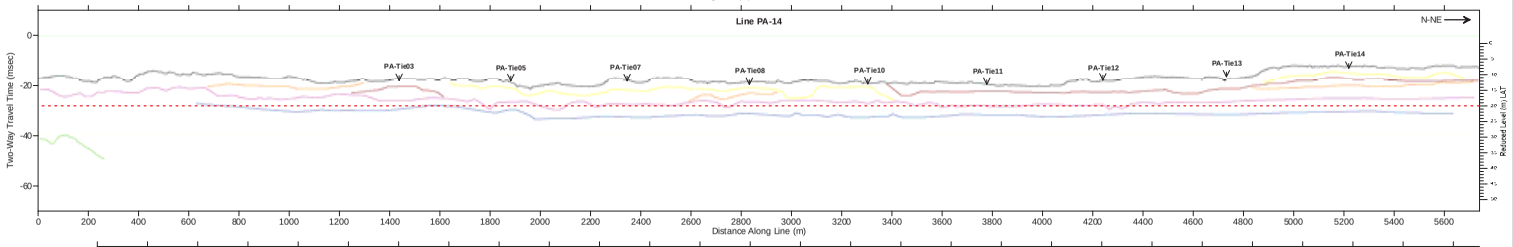
SCALE H1:10,000 V1:1,000 (A1 sheet)

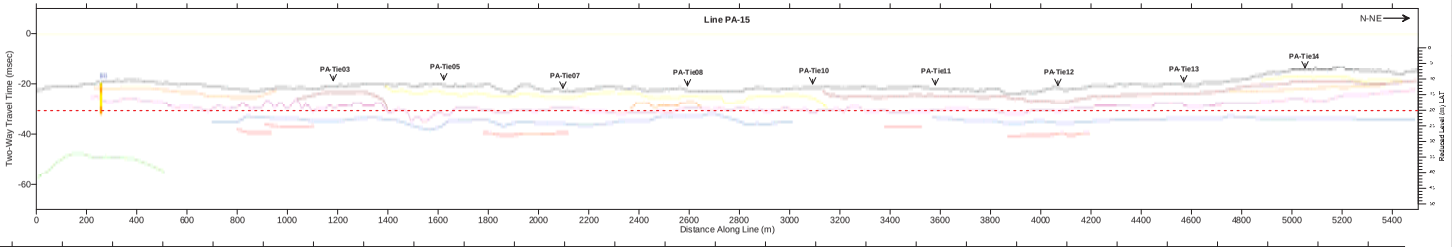
Survey Date JAN-FEB 14 | Project Ref 424

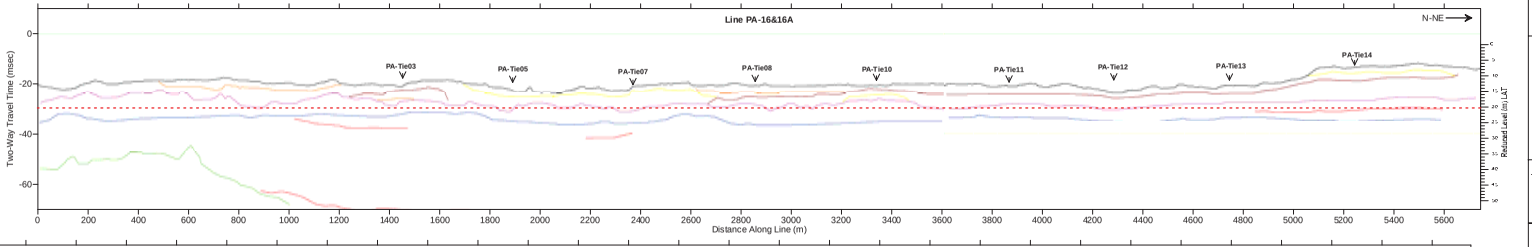
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	SBP I&S	dpk	pf/dpk	dpk	
2	10/06/14	SBP I&S	dpk	pf/dpk	dpk	
4	09/10/14	SBP I&S	dpk	pf/dpk	dpk	gr

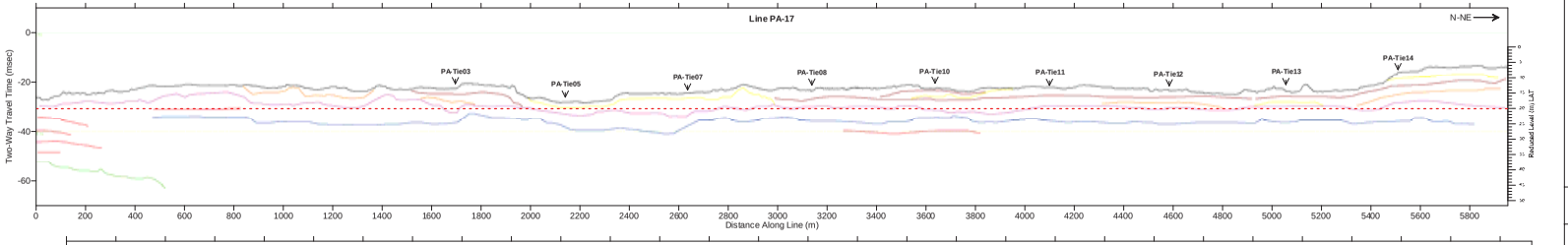
Client Drawing No. | Figure No. A5 | Sheet No.

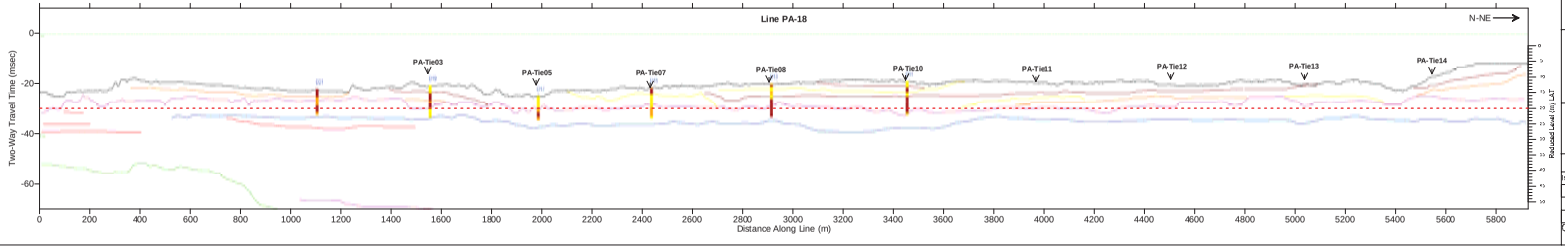












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

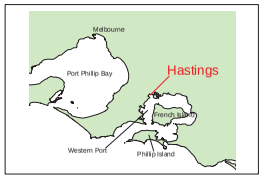
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

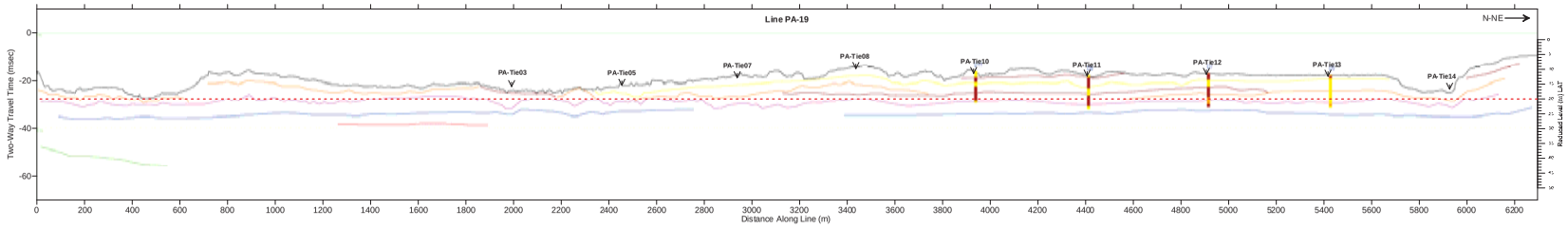
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES PA-13 TO PA-18

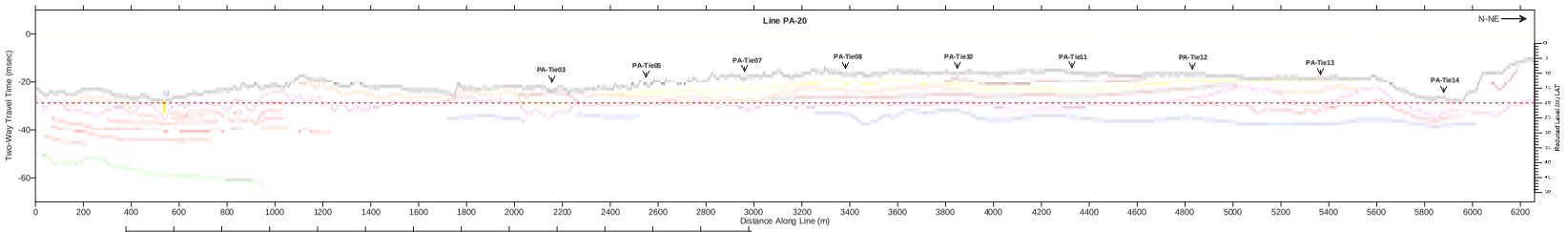
SCALE H1:10,000 V1:1,000 (A1 sheet)

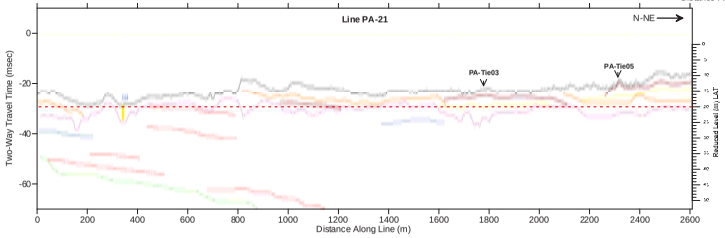
Survey Date: JAN-FEB 14 | Project Ref: 424

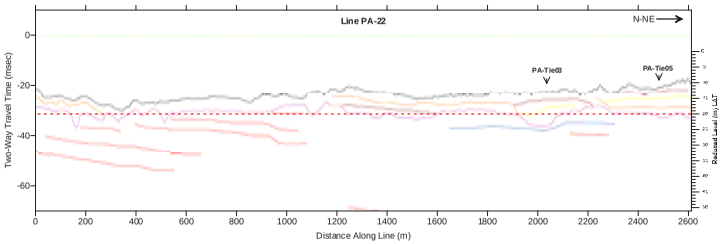
Issue No.	Date	Descriptor	Surv.	Interp.	Drawn	Appr.
1	6/06/14	RPP ISS	dpk	pfdpk	dpk	
2	11/06/14	RPP ISS	dpk	pfdpk	dpk	
4	05/10/14	RPP ISS	dpk	pfdpk	dpk	pr

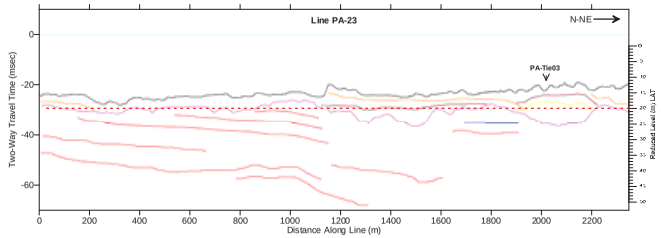
Client Drawing No | Figure No. A6 | Sheet No.

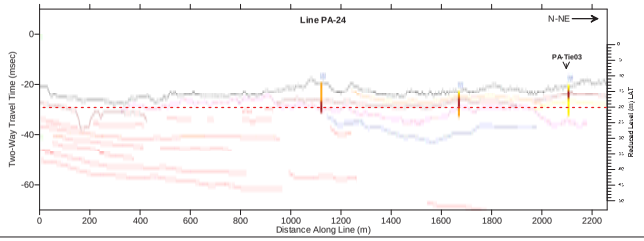












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

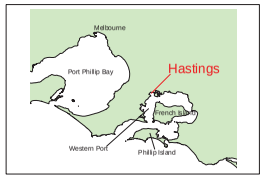
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

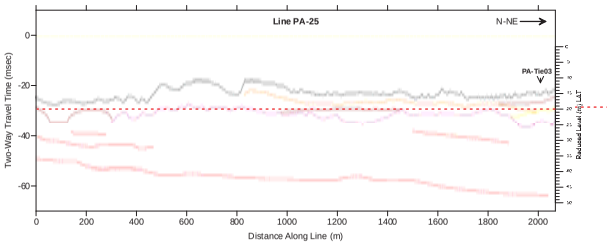
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES PA-19 TO PA-24

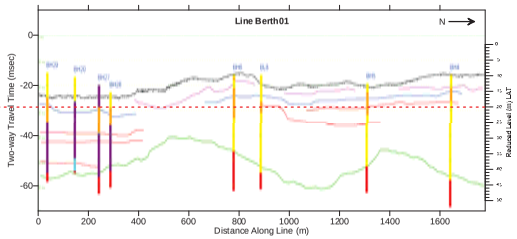
SCALE H1:10,000 V1:500 (A1 sheet)

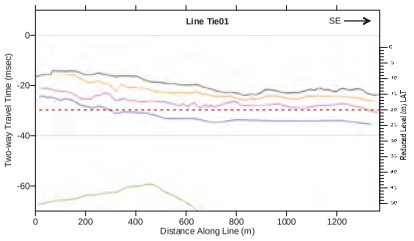
Survey Date JAN-FEB 14 | Project Ref 424

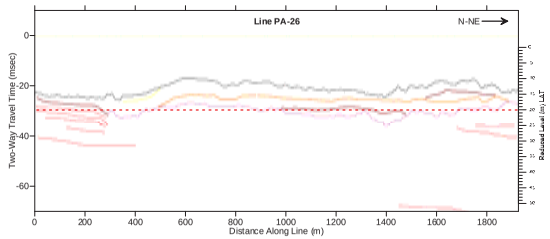
Issue No.	Date	Descriptor	Surv.	Interp.	Drawn	Appr.
1	07/04/14	RPP ISS	dpk	pfdpk	dpk	
2	10/06/14	RPP ISS	dpk	pfdpk	dpk	
4	05/10/14	RPP ISS	dpk	pfdpk	dpk	gr

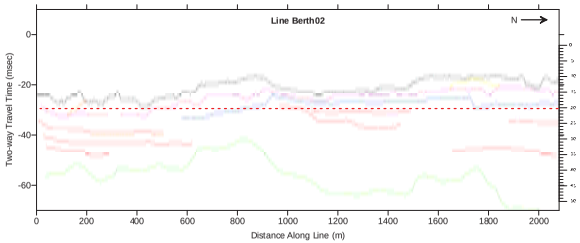
Client Drawing No | Figure No. A7 | Sheet No.

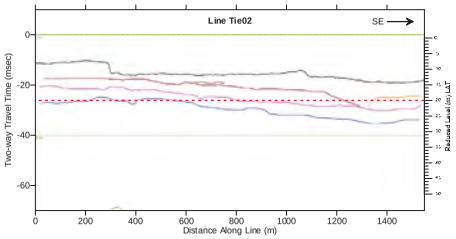


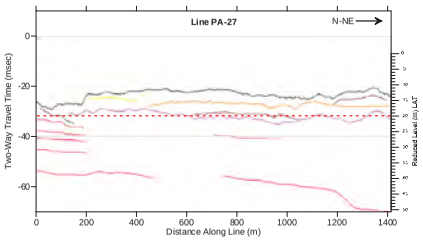


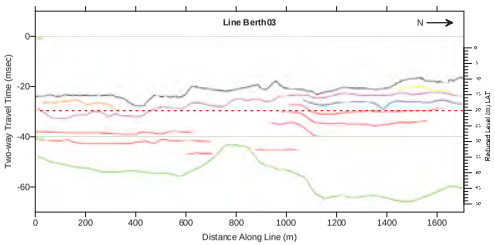


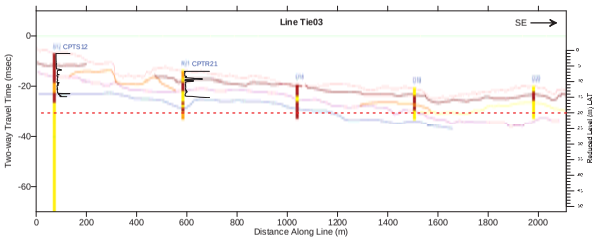


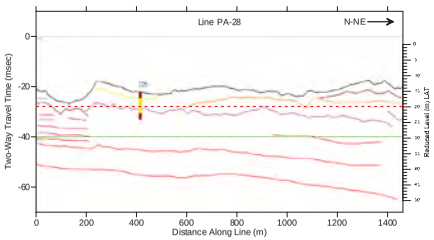


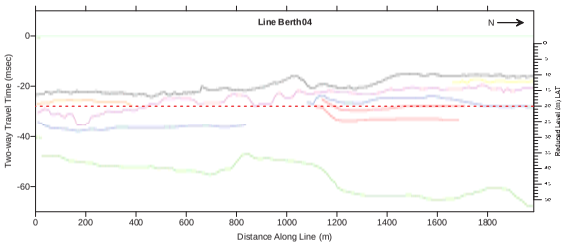


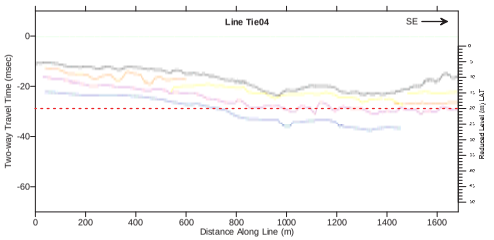


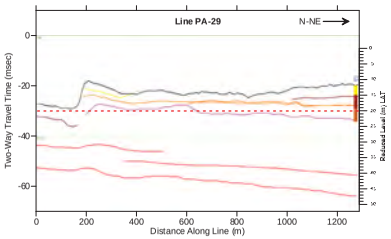


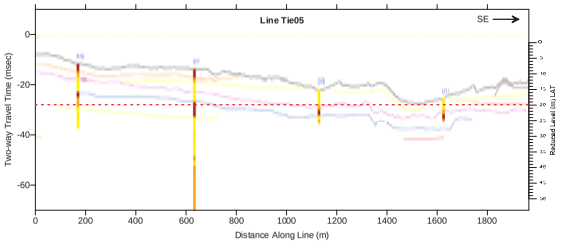












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

aurecon

marine & earth sciences

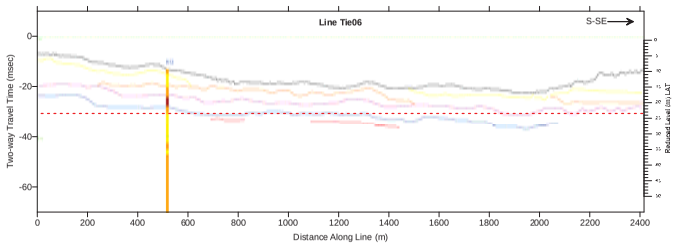
PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES PA-25 TO PA-29, BERTH 01 TO 04
AND TIE LINES 01 TO 05

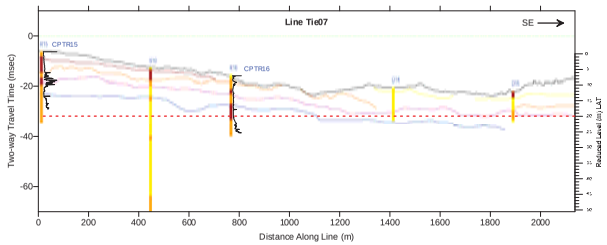
SCALE H1:10,000 V1:500 (A1 sheet)

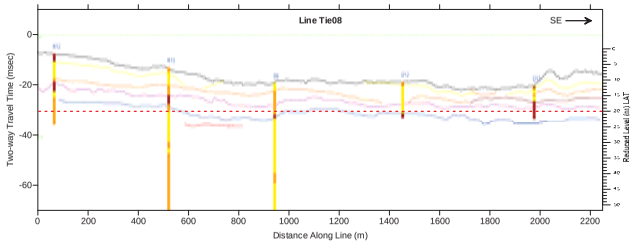
Survey Date: JAN-FEB 14 | Project Ref: 424

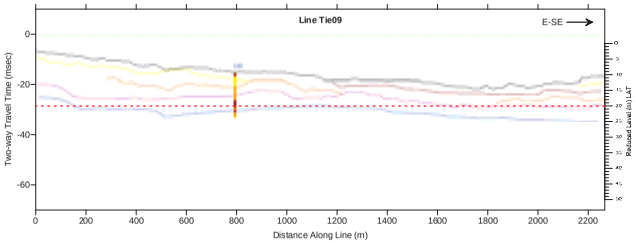
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	BSP ISS	dpk	pfdpk	dpk	
2	10/09/14	BSP ISS	dpk	pfdpk	dpk	
4	05/10/14	BSP ISS	dpk	pfdpk	dpk	gi

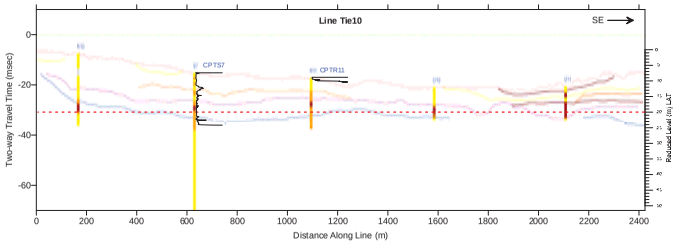
Client Drawing No | Figure No. A8 | Sheet No.

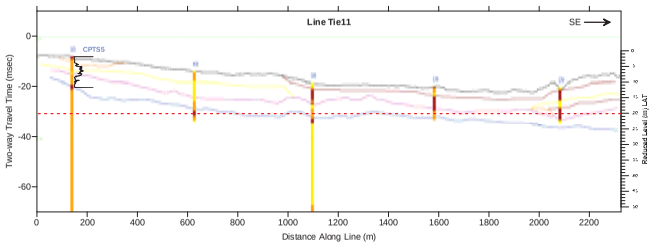


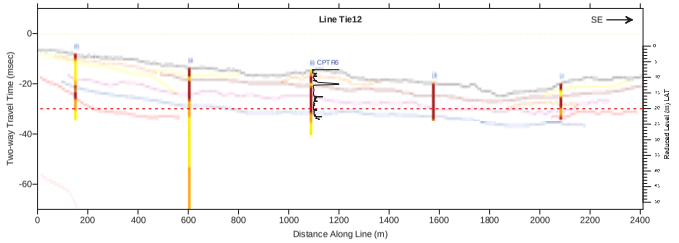


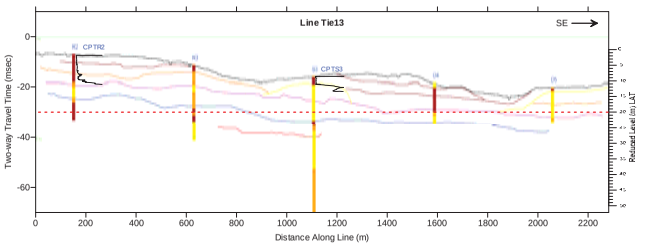


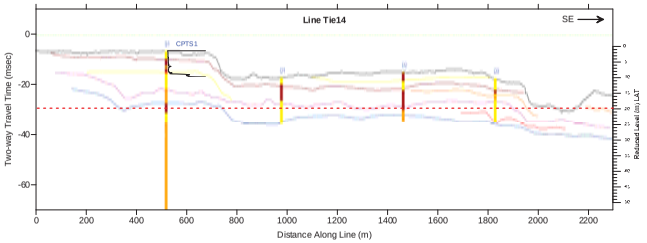












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Pa-Tie03 — Tie Line Intersection Point
- S10 — Approximate Borehole Position
- Proposed Dredge Level
- CPT Test Location and Data Graph

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
TIE LINES 06 TO 14

SCALE H1:10,000 V1:500 (A1 sheet)

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	SBP ISS	dpk	pfdpk	dpk	
2	11/08/14	SBP ISS	dpk	pfdpk	dpk	
4	05/10/14	SBP ISS	dpk	pfdpk	dpk	pj

Client Drawing No | Figure No. A9 | Sheet No.

LEGEND

Limits of Investigation

Reduced Level Metres LAT

-5
-7
-9
-11
-13
-15
-17
-19
-21
-23
-25

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

aurecon

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SUB-BOTTOM PROFILING SURVEY
REFLECTOR R1 REDUCED LEVELS CONTOUR PLAN

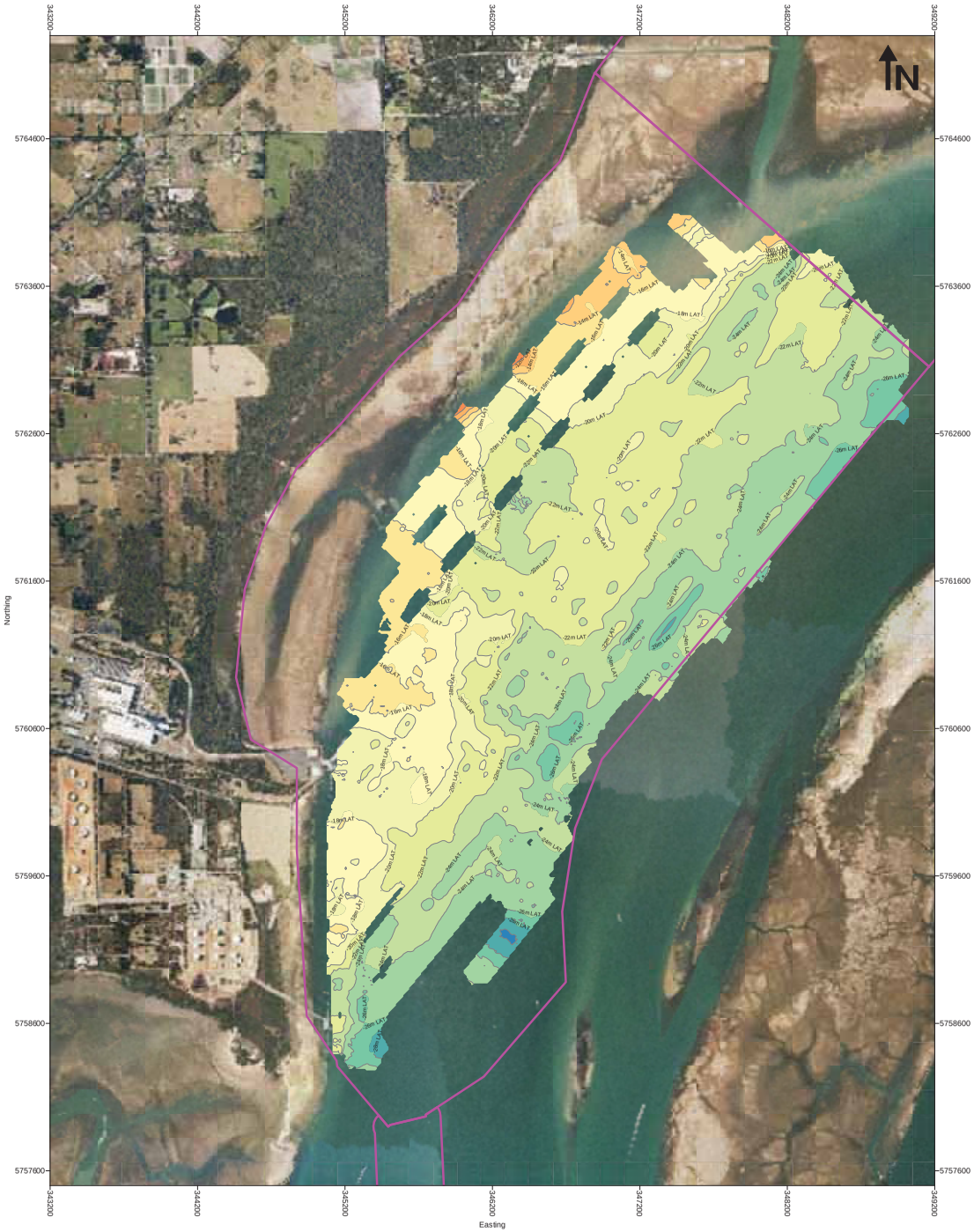
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No	Date	Description	Surv.	Interp.	Drawn	Appd
1	03/04/14	R2 cont	tpk	dpk	dpk	
2	10/09/14	R2 cont	tpk	dpk	dpk	
4	03/10/14	R2 cont	tpk	dpk	dpk	gr

Client Drawing No | Figure No. A10 | Sheet No.



LEGEND

Limits of Investigation

Reduced Level Metres LAT

-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32

NOTES

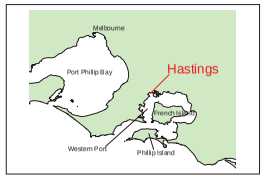
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SUB-BOTTOM PROFILING SURVEY
REFLECTOR R2 REDUCED LEVELS CONTOUR PLAN

SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

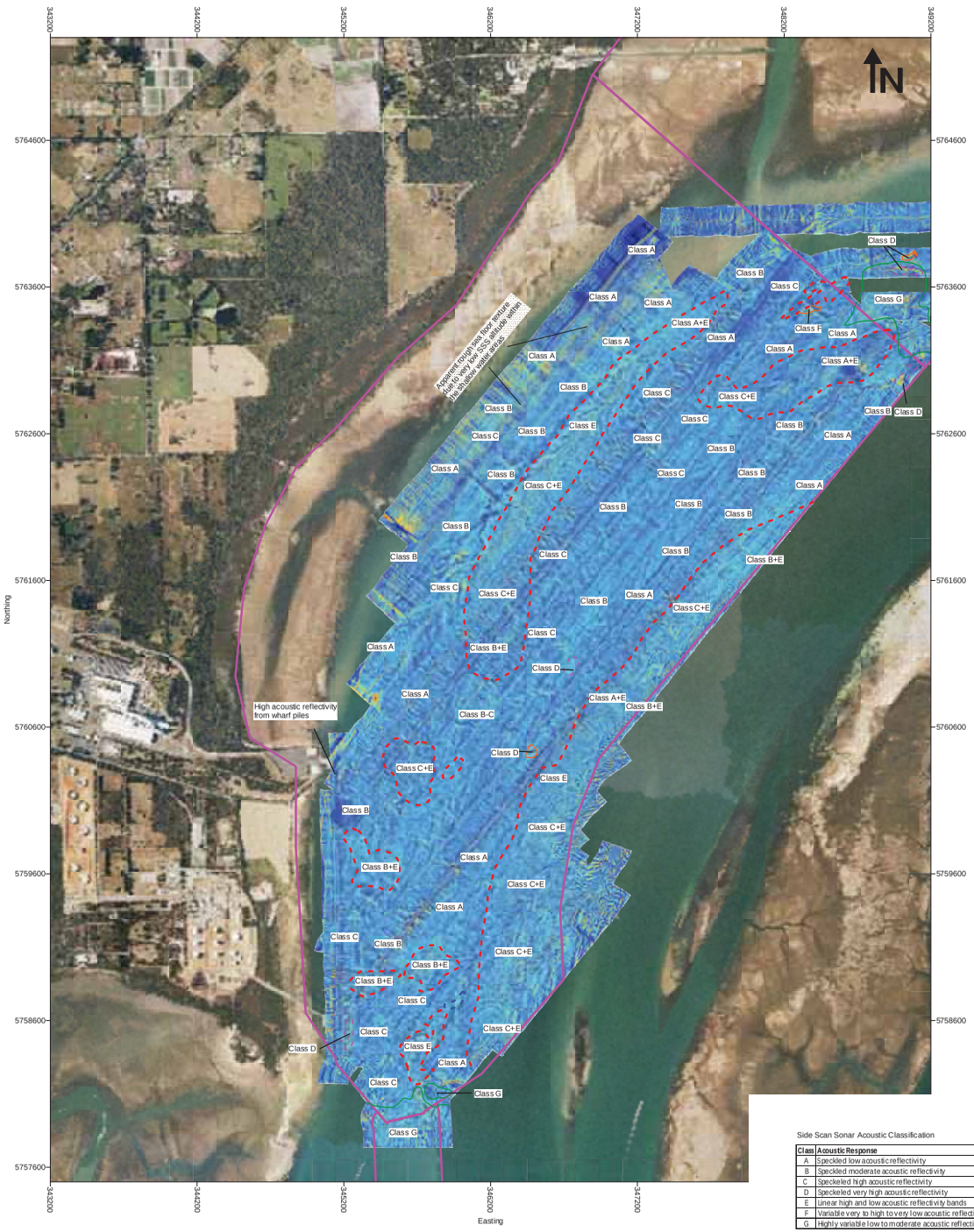
Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No	Date	Description	Surv.	Interp.	Drawn	Appd
1	02/04/14	R2 cont	dpk	dpk	dpk	
2	10/05/14	R2 cont	dpk	dpk	dpk	
4	29/10/14	R2 cont	dpk	dpk	dpk	pl

Client Drawing No

Figure No. A11

Sheet No.



Side Scan Sonar Acoustic Classification

Class	Acoustic Response	Interpretative Comments
A	Speckled low acoustic reflectivity	Clay, Silty Clay and Sandy Clay
B	Speckled moderate acoustic reflectivity	Clayey Silt, Clayey Sand and Sandy Silt
C	Speckeled high acoustic reflectivity	Silty Sand and Sand
D	Speckeled very high acoustic reflectivity	Coarse Sands and Gravels
E	Linear high and low acoustic reflectivity bands	Sand Waves
F	Variable very to high to very low acoustic reflectivity with shadows	Outcropping Rock or Gravels, Cobbles and Boulders on seabed. Shadow effects from relief features
G	Highly variable low to moderate acoustic reflectivity clumps with shadows	Possible sea grass or other biological growth

LEGEND

Sand Wave Zone
Coarse Sands / Gravel Zone
Sea Grass Zone

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SIDE SCAN SONAR SURVEY
MOSAIC AND SEAFLOOR MAPPING PLAN

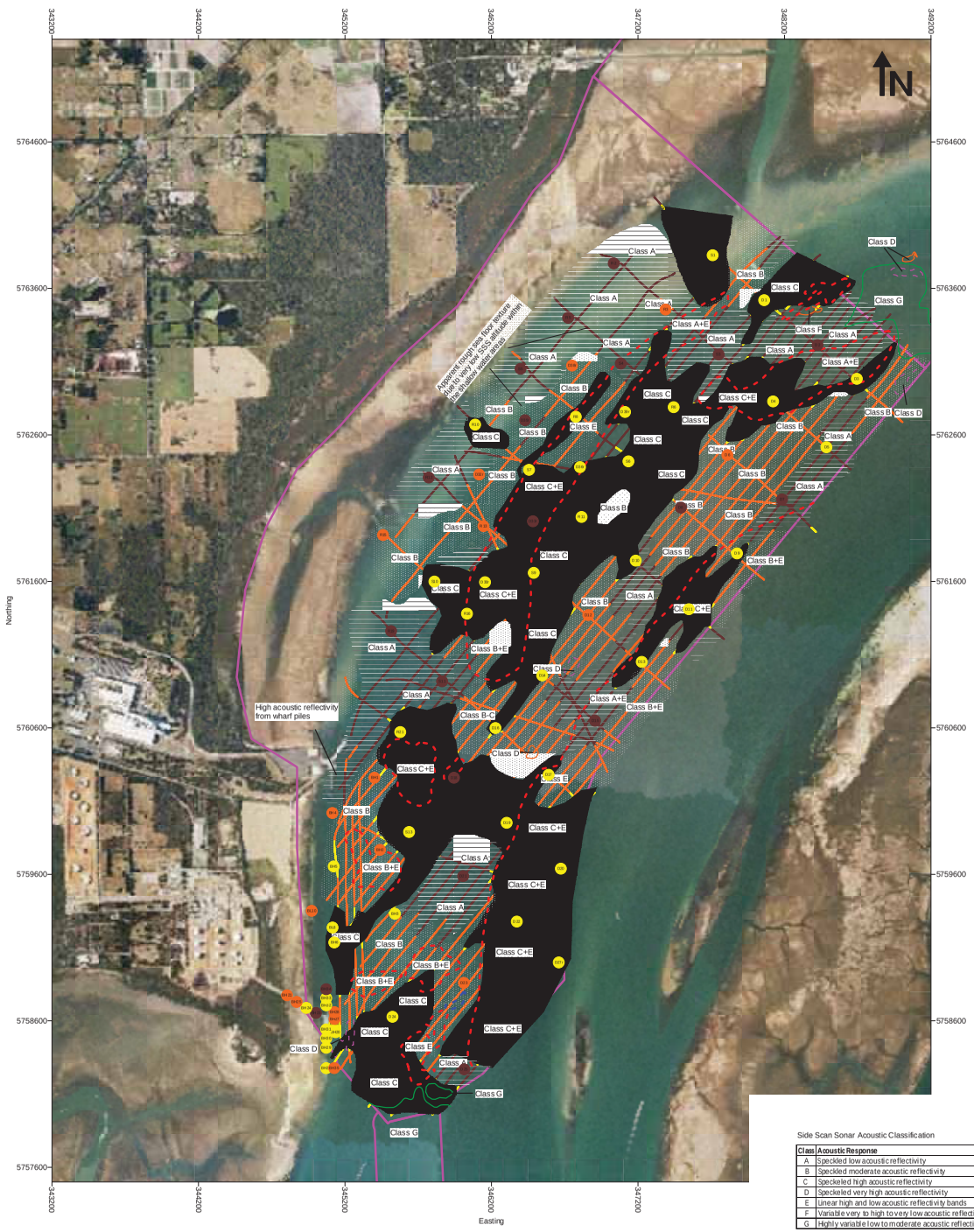
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No	Date	Description	Surv	Interp	Drawn	Appd
1	07/04/14	SSS SCP	dpk	hk	dpk	
2	09/08/14	SSS SCP	dpk	hk	dpk	
4	16/10/14	SSS SCP	dpk	dpk	dpk	gl

Client Drawing No. | Figure No. A12 | Sheet No.



Side Scan Sonar Acoustic Classification

Class	Acoustic Response	Interpretative Comments
A	Speckled low acoustic reflectivity	Clay, Silty Clay and Sandy Clay
B	Speckled moderate acoustic reflectivity	Clayey Silt, Clayey Sand and Sandy Silt
C	Speckeled high acoustic reflectivity	Silty Sand and Sand
D	Speckeled very high acoustic reflectivity	Coarse Sands and Gravels
E	Linear high and low acoustic reflectivity bands	Sand Waves
F	Variable very to high to very low acoustic reflectivity with shadows	Outcropping Rock or Gravels, Cobbles and Boulders on seabed. Shadow effects from relief features
G	Highly variable low to moderate acoustic reflectivity clumps with shadows	Possible sea grass or other biological growth

LEGEND

Side Scan Sonar Interpretation and Sea Floor Mapping
- Sand Wave Zone
- Coarse Sands / Gravel Zone
- Sea Grass Zone
- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand

Sub-Bottom Profiling Interpreted Material at Surface Extents
- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand

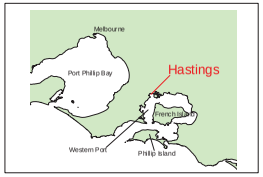
Material at Surface Logged in Geotechnical Boreholes
- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand

NOTES

GEODETIC INFORMATION
Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER
This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS
AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
PORT AREA

SIDE SCAN SONAR SURVEY
SEAFLOOR MAPPING PLAN AND CORRELATION WITH SUB-BOTTOM PROFILING AND BOREHOLE DATA

SCALE 1:15,000 (A1 sheet)

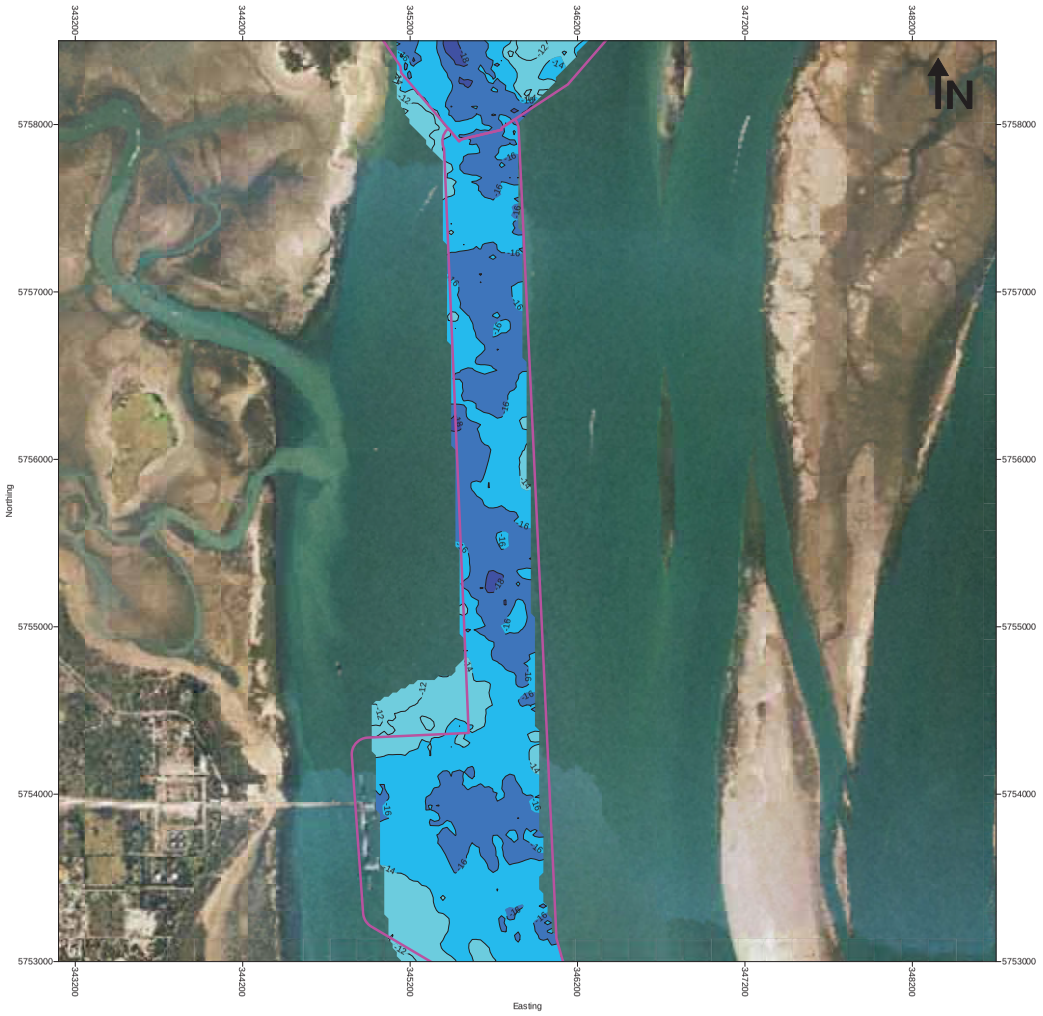
0 250 500 750 1000

Survey Date JAN-FEB 14 | Project Ref 424

Issue No.	Date:	Descripter	Surv.	Interp.	Drawn	Appr.
1	28/09/14	SSS SCP	dpk	dpk	dpk	
2	10/09/14	RRS SCP	dpk	dpk	dpk	gs

Client Drawing No. | Figure No. A13 | Sheet No.

Appendix B
North Arm Channel



LEGEND

Limits of Investigation

Reduced Level Metres LAT

2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36

NOTES

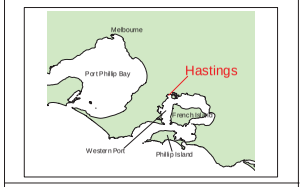
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

SEAFLOOR LEVELS CONTOUR PLAN

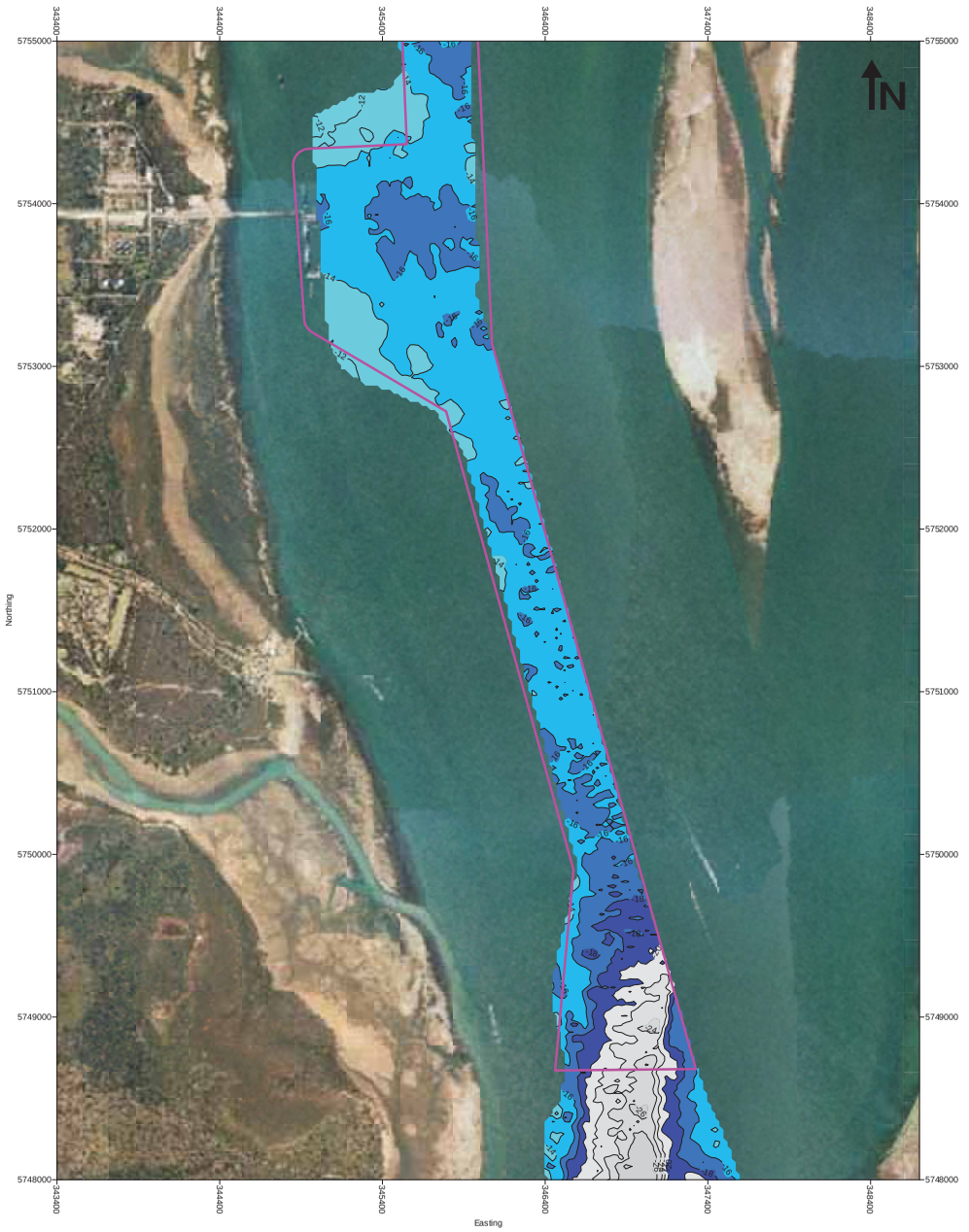
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	Bathy	pb		dbk	
2	05/05/14	Bathy	pb		dbk	
4	30/10/14	Bathy	pb		dbk	ar

Client Drawing No | Figure No. B1 | Sheet No.



LEGEND

Limits of Investigation

Reduced Level Metres LAT

2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

SEAFLOOR LEVELS CONTOUR PLAN

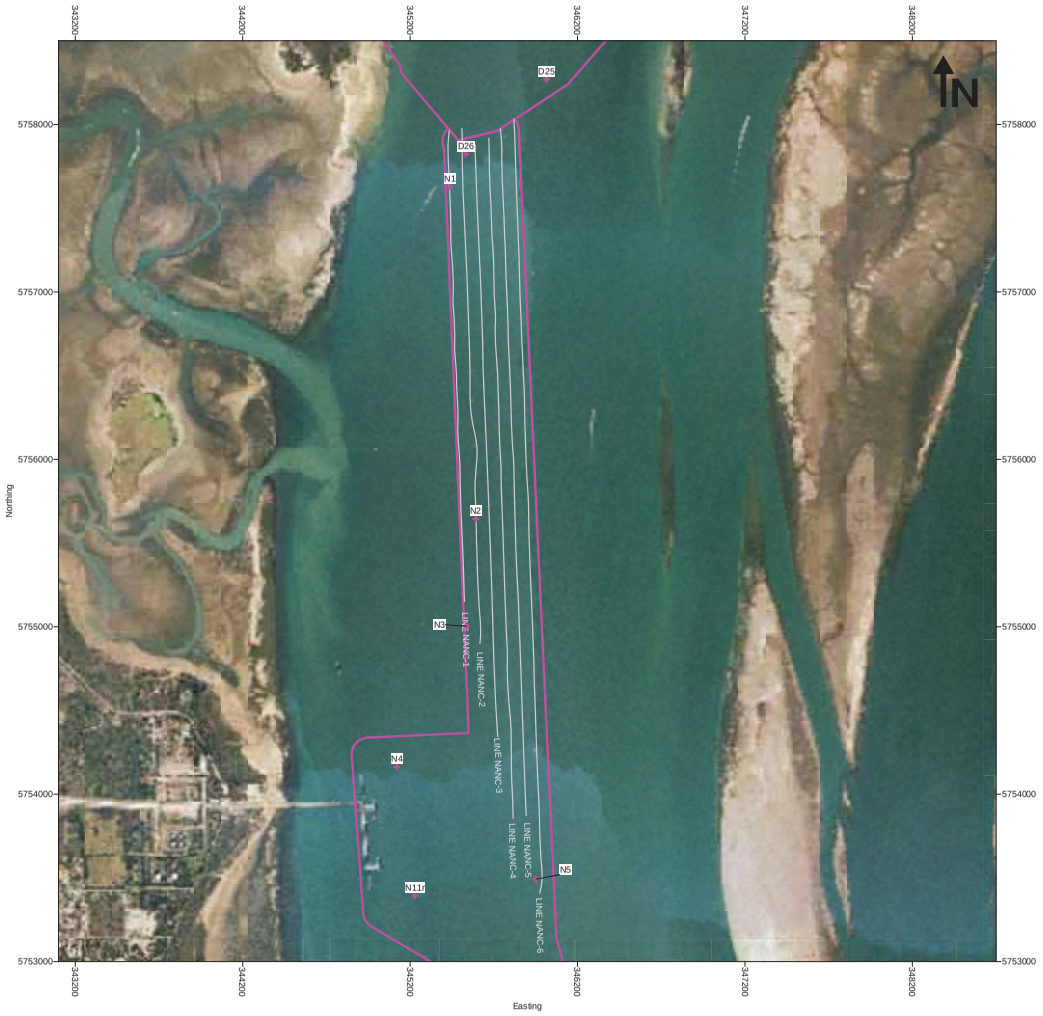
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	Bathy	pb		dpk	
2	05/06/14	Bathy	pb		dpk	
4	16/10/14	Bathy	pb		dpk	sr

Client Drawing No | Figure No. B2 | Sheet No.



LEGEND

Line NANC-1 = Start of SBP Line NANC-1 (0.0m)

BH128 Historical Borehole Location

N2 Worley Parsons 2013-2014 Borehole Location

NOTES

Line label indicates start of line

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

SUB-BOTTOM PROFILING SURVEY
VESSEL TRACKPLOT PLAN

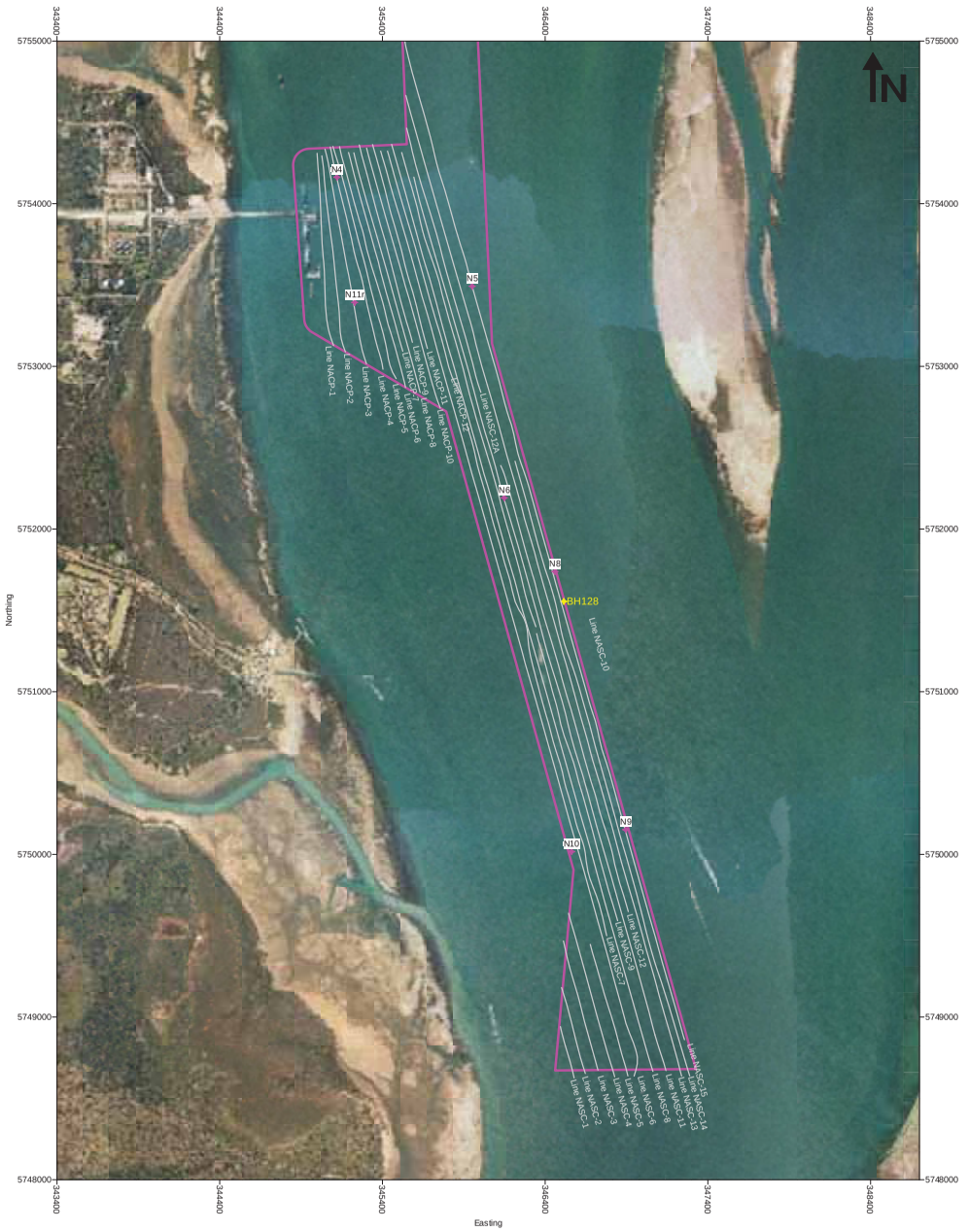
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	SBP TPs	dpk	dpk	dpk	
2	06/05/14	SBP TPs	dpk	dpk	dpk	
4	10/10/14	SBP TPs	dpk	dpk	dpk	pi

Client Drawing No | Figure No. B3 | Sheet No.



LEGEND

Line NASC-1 = Start of SBP Line NASC-1 (0.0m)

BH128 Historical Borehole Location

N2 Worley Parsons 2013-2014 Borehole Location

NOTES

Line label indicates start of line

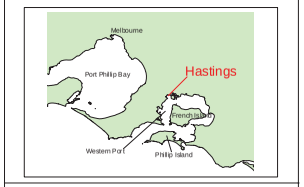
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

SUB-BOTTOM PROFILING SURVEY
VESSEL TRACKPLOTS

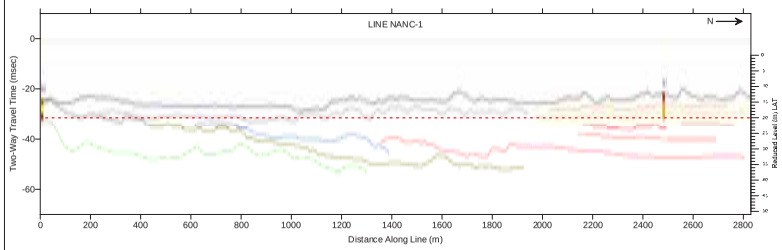
SCALE 1:15,000 (A1 sheet)

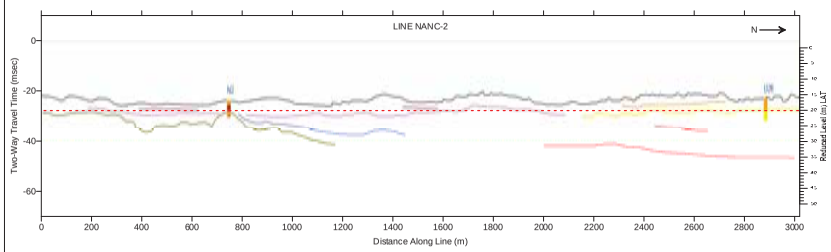
0 250 500 750 1000

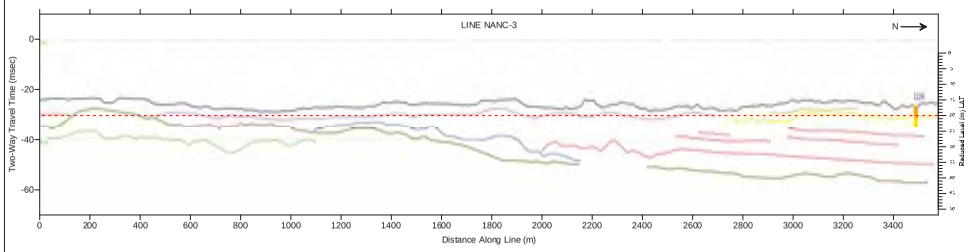
Survey Date: JAN-FEB 14 | Project Ref: 424

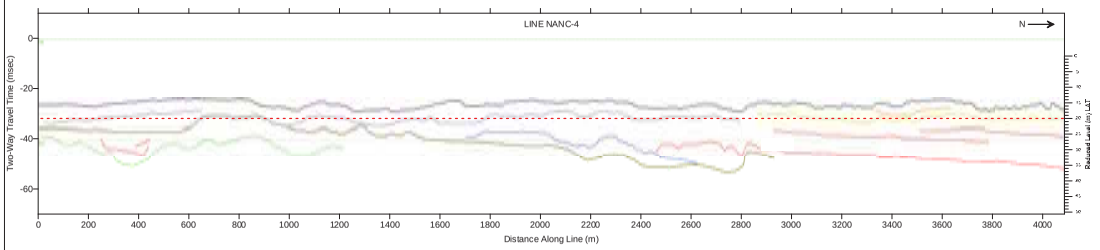
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	SBP TPs	dpk	dpk	dpk	
2	05/06/14	SBP TPs	dpk	dpk	dpk	
4	19/10/14	SBP TPs	dpk	dpk	dpk	gr

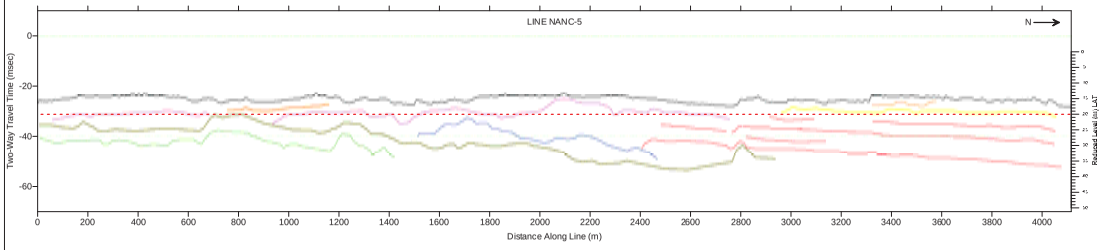
Client Drawing No | Figure No. B4 | Sheet No.











LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Reflector R3
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Proposed Dredge Level
- S10 Approximate Borehole Position

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

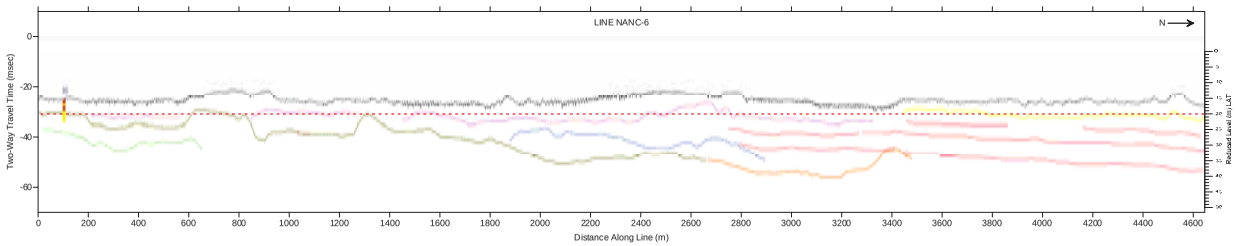
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES NANC-1 TO NANC-5

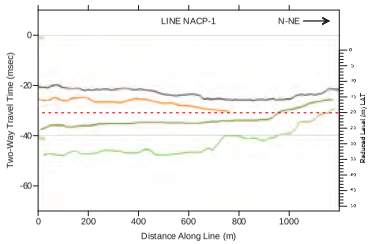
SCALE H1:10,000 V1:1,000 (A1 sheet)

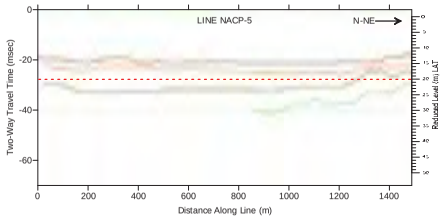
Survey Date: JAN-FEB 14 | Project Ref: 424

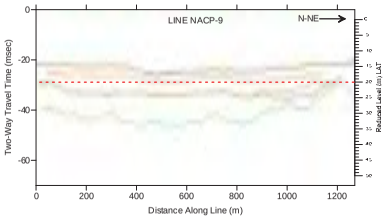
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	6/04/14	SDP ISS	dpk	pl/dpk	dpk	
2	10/09/14	SDP ISS	dpk	pl/dpk	dpk	
4	10/10/14	SDP ISS	dpk	pl/dpk	dpk	gi

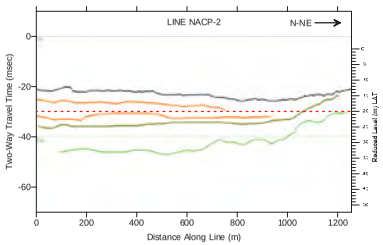
Client Drawing No | Figure No. B5 | Sheet No.

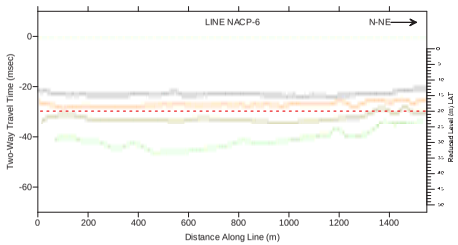


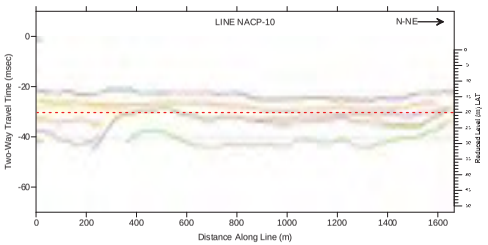


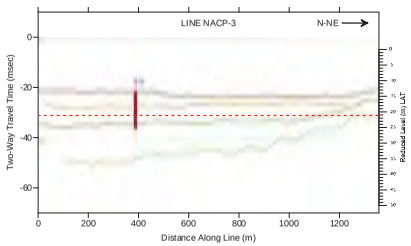


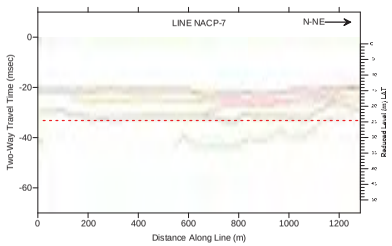


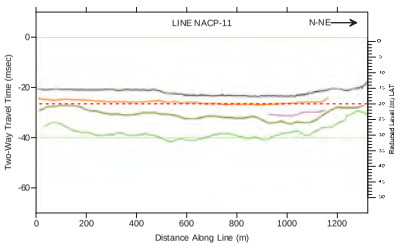


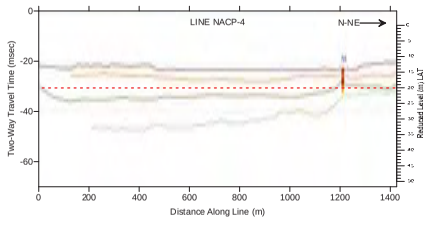


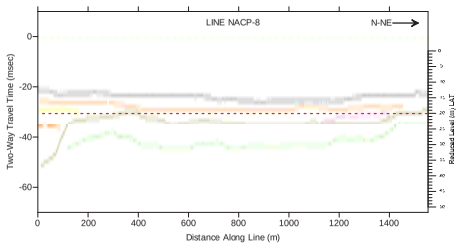


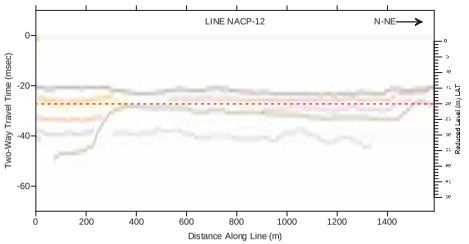












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Reflector R3
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Proposed Dredge Level
- S10 Approximate Borehole Position

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATIONMAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

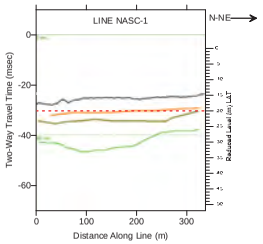
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES NANC-6 AND NACP-1 TO NACP-12

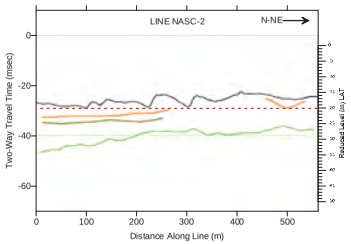
SCALE H1:10,000 V1:1,000 (A1 sheet)

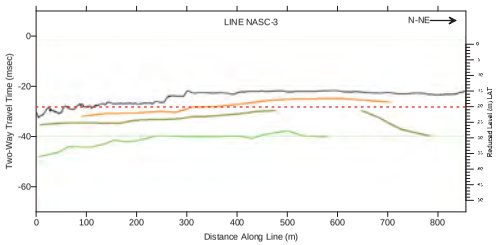
Survey Date: JAN-FEB 14 | Project Ref: 424

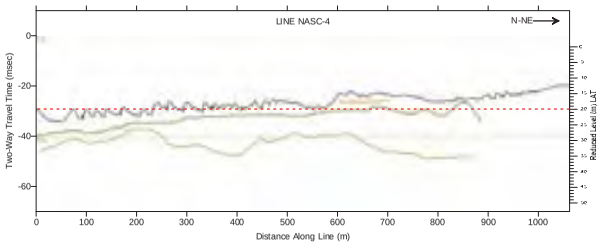
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr.
1	03/04/14	BBP ISS	dpk	pWpk	dpk	
2	10/09/14	BBP ISS	dpk	pWpk	dpk	
4	10/10/14	BBP ISS	dpk	pWpk	dpk	pr

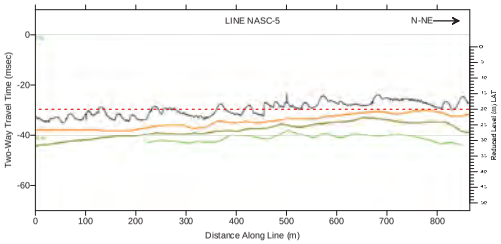
Client Drawing No. | Figure No. B6 | Sheet No.











LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Reflector R3
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Proposed Dredge Level
- S10 Approximate Borehole Position

Borehole Log Colour Code

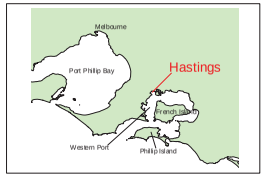
- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION
Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER
This plan should be read in conjunction with the accompanying report

LOCATIONMAP



CLIENT DETAILS
AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

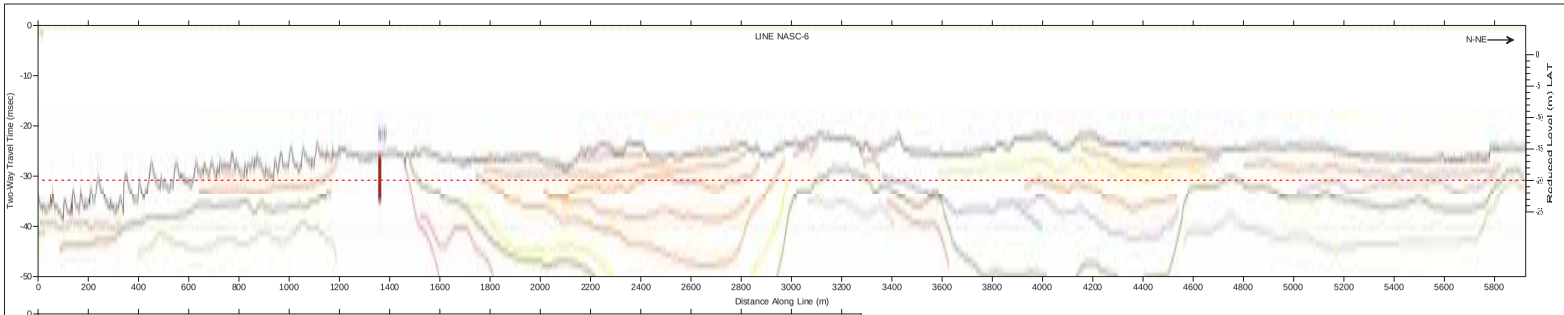
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES NASC-1 TO NASC-5

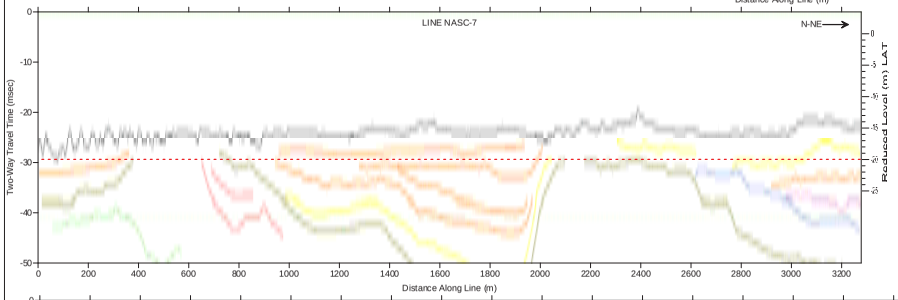
SCALE H1:5,000 V1:500 (A1 sheet)

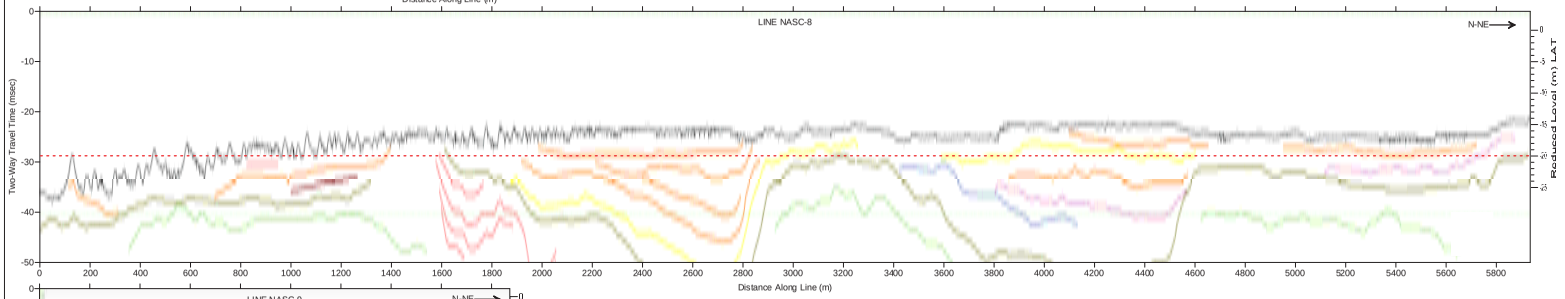
Survey Date: JAN-FEB 14 | Project Ref: 424

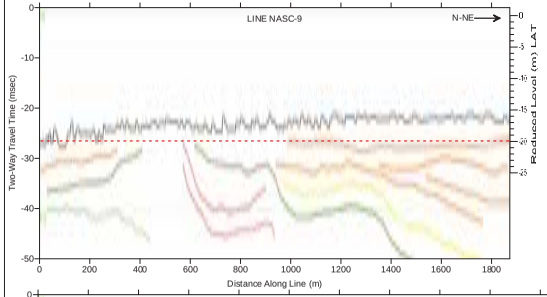
Issue No.	Date	Description	Surv	Interp.	Drawn	Appr
1	05/04/14	SDP ISS	dpk	pHpk	dpk	
2	10/06/14	RDP ISS	dpk	pHpk	dpk	
4	15/10/14	SDP ISS	dpk	pHpk	dpk	pi

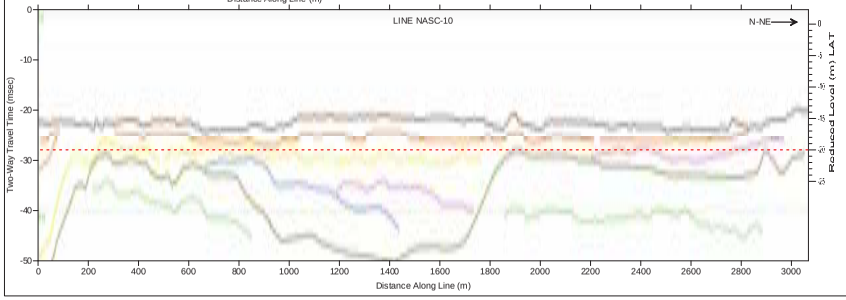
Client Drawing No.
Figure No. B7
Sheet No.











LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Reflector R3
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Proposed Dredge Level
- S10 Approximate Borehole Position

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

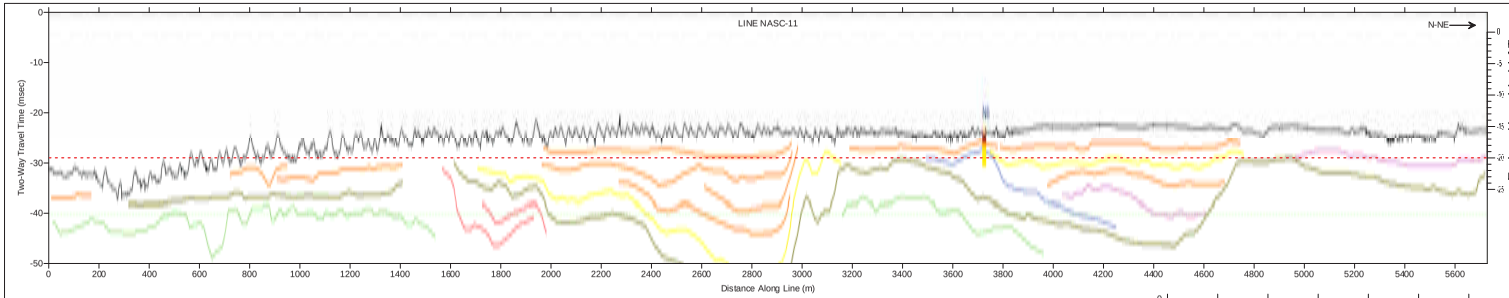
SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES NASC-6 TO NASC-9

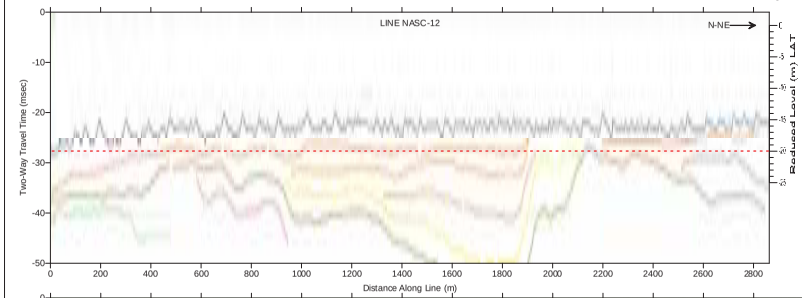
SCALE H1:10,000 V1:500 (A1 sheet)

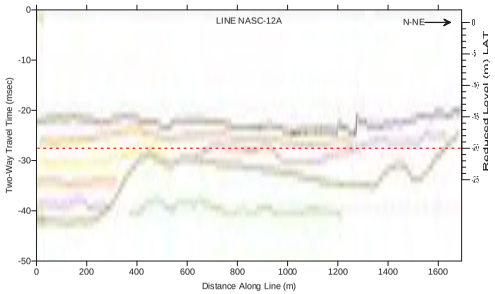
Survey Date: JAN-FEB 14 | Project Ref: 424

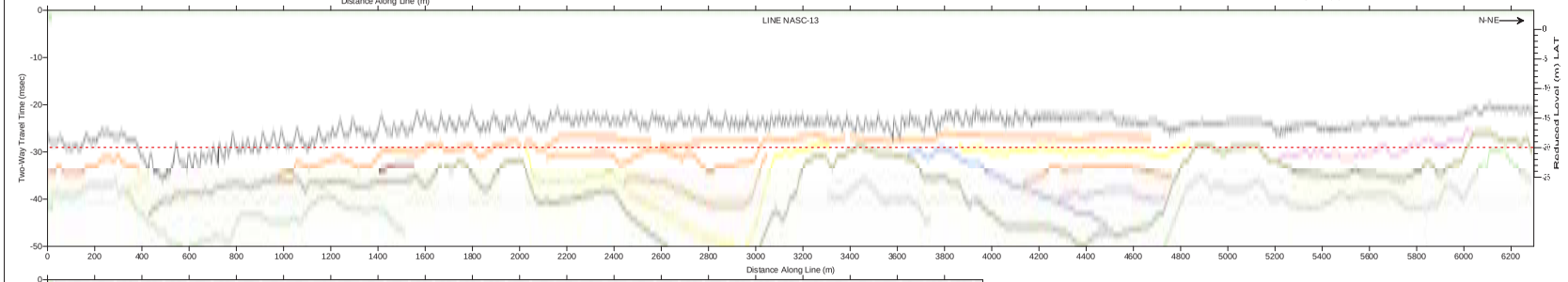
Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	05/04/14	RSP ISS	dpk	pfdpk	dpk	
2	10/06/14	RSP ISS	dpk	pfdpk	dpk	
4	16/10/14	RSP ISS	dpk	pfdpk	dpk	pf

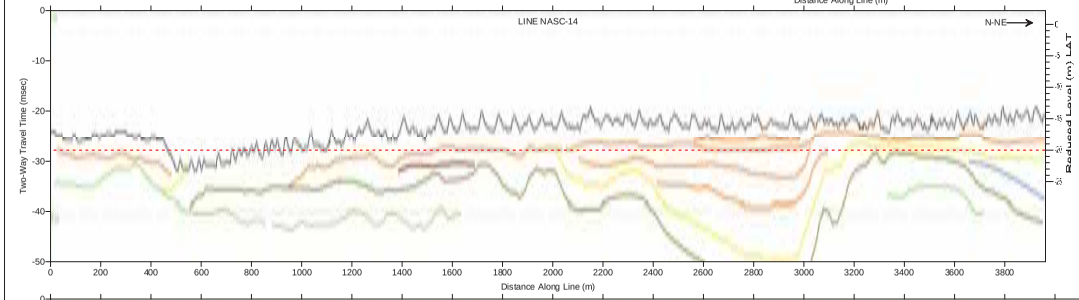
Client Drawing No | Figure No. B8 | Sheet No.

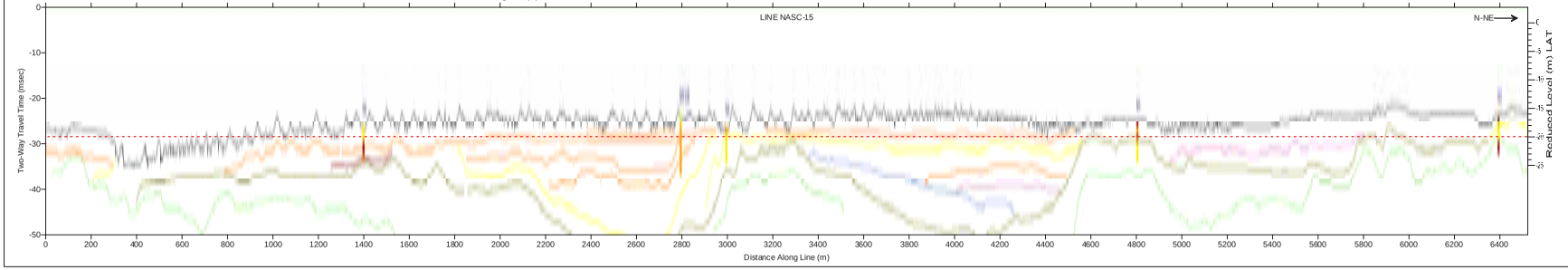












LEGEND

- Sea Floor Profile
- Silty Sand & Sand
- Clayey Silt, Clayey Sand & Sandy Silt
- Silty Clay, Sandy Clay & Clay
- Reflector R1
- Reflector R2
- Reflector R3
- Internal Discontinuous Reflector
- Interpreted Rock Reflector
- Proposed Dredge Level
- S10 Approximate Borehole Position

Borehole Log Colour Code

- Clay, Silty Clay and Sandy Clay
- Clayey Silt, Clayey Sand and Sandy Silt
- Silty Sand and Sand
- Gravelly Material
- High Amplitude Reflector Possible Indurated Layer
- Rock

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

SUB-BOTTOM PROFILING SURVEY (BOOMER)
INTERPRETED SEISMIC SECTIONS
LINES NASC-10 TO NASC-15

SCALE H1:10,000 V1:500 (A1 sheet)

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv	Interp	Drawn	Appr
1	05/04/14	SBP I&S	dpk	pl/dpk	dpk	
2	10/09/14	SBP I&S	dpk	pl/dpk	dpk	
4	10/10/14	SBP I&S	dpk	pl/dpk	dpk	ej

Client Drawing No | Figure No. B9 | Sheet No.

LEGEND

Limits of Investigation

Reduced Level Metres LAT

-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36
-38
-40
-42
-44
-46

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

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LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

SUB-BOTTOM PROFILING SURVEY
INTERPRETED ROCK LEVELS CONTOUR PLAN

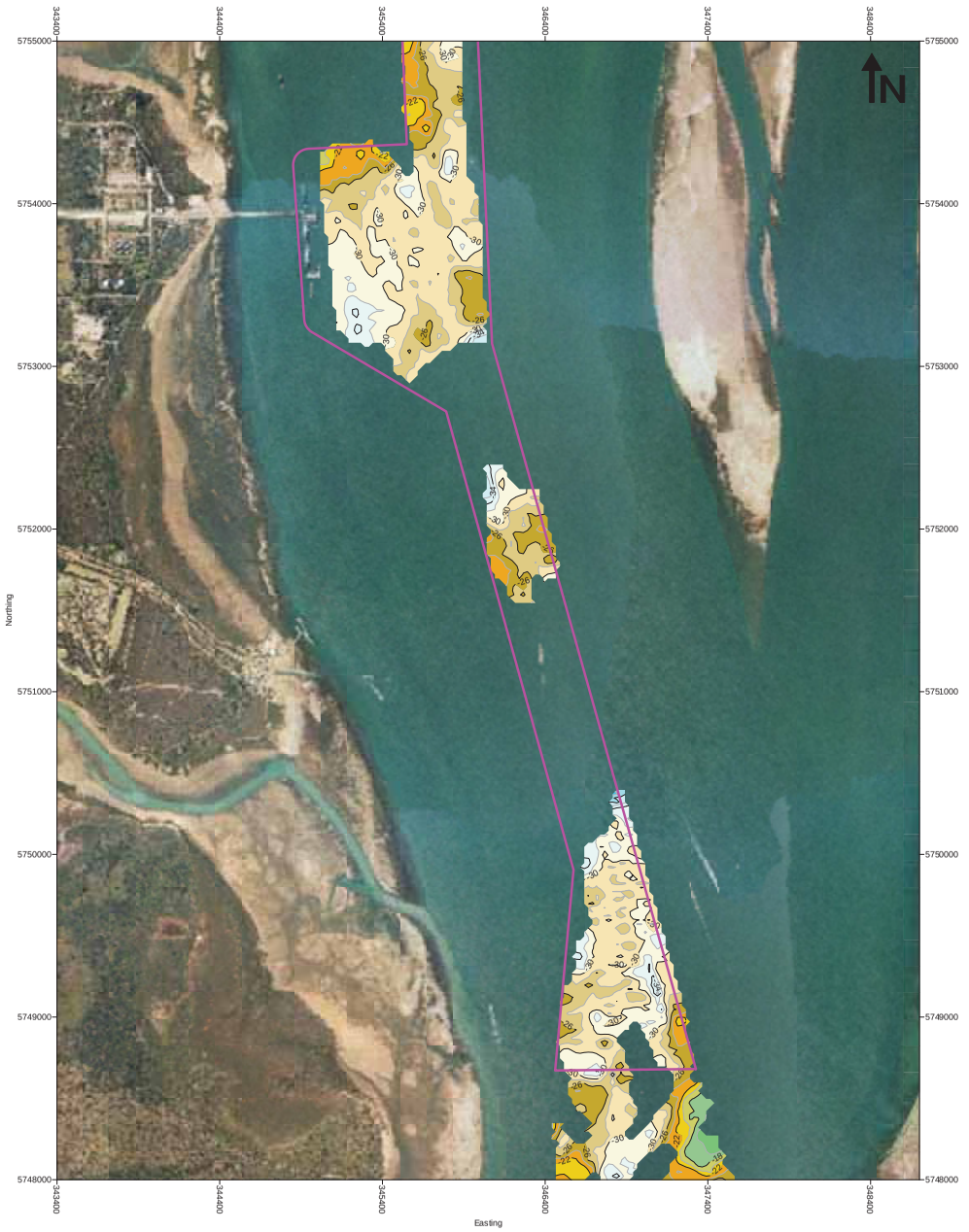
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	24/04/14	Rock RLs	dpk	dpk	dpk	
2	10/06/14	Rock RLs	dpk	dpk	dpk	
4	10/10/14	Rock RLs	dpk	dpk	dpk	ar

Client Drawing No | Figure No. B10 | Sheet No.



LEGEND

Limits of Investigation

Reduced Level Metres LAT

-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36
-38
-40
-42
-44
-46

NOTES

GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP

CLIENT DETAILS

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PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

SUB-BOTTOM PROFILING SURVEY
INTERPRETED ROCK LEVELS CONTOUR PLAN

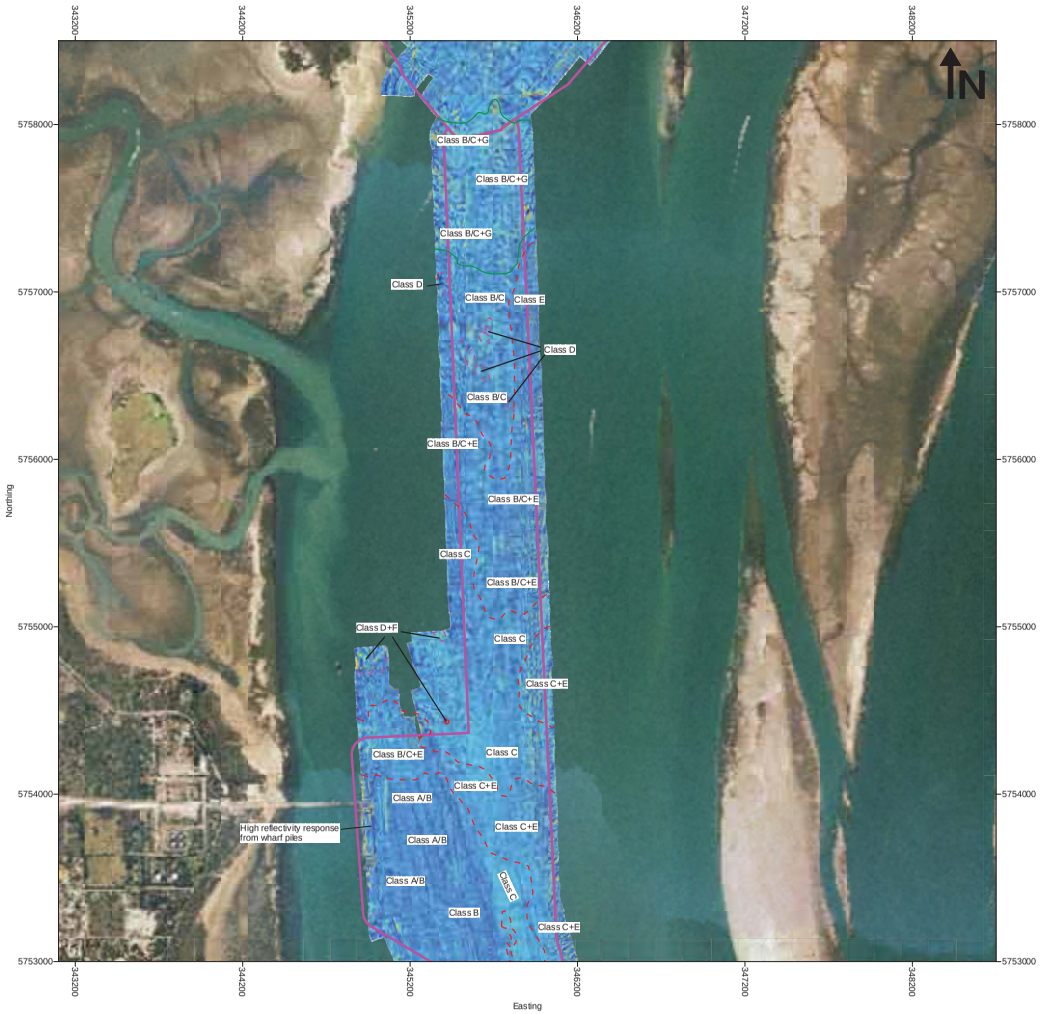
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	24/04/14	Rock RLs	dpk	dpk	dpk	
2	10/06/14	Rock RLs	dpk	dpk	dpk	
4	10/10/14	Rock RLs	dpk	dpk	dpk	gt

Client Drawing No | Figure No. B11 | Sheet No.



Side Scan Sonar Acoustic Classification

Class	Acoustic Response	Interpretative Comments
A	Speckled low acoustic reflectivity	Clay, Silty Clay and Sandy Clay
B	Speckled moderate acoustic reflectivity	Clayey Silt, Clayey Sand and Sandy Silt
C	Speckeled high acoustic reflectivity	Silty Sand and Sand
D	Speckeled very high acoustic reflectivity	Coarse Sands and Gravels
E	Linear high and low acoustic reflectivity bands	Sand Waves
F	Variable very to high to very low acoustic reflectivity with shadows	Outcropping Rock or Gravels, Cobbles and Boulders on seabed. Shadow effects from relief features
G	Highly variable low to moderate acoustic reflectivity clumps with shadows	Possible sea grass or other biological growth

LEGEND

- Sand Wave Zone
- Zone Boundary
- Sea Grass Zone

NOTES

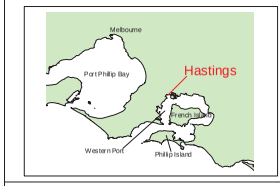
GEODETIC INFORMATION

Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER

This plan should be read in conjunction with the accompanying report

LOCATION MAP



CLIENT DETAILS

AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM NORTH CHANNEL

SIDE SCAN SONAR SURVEY
MOSAIC AND SEAFLOOR MAPPING PLAN

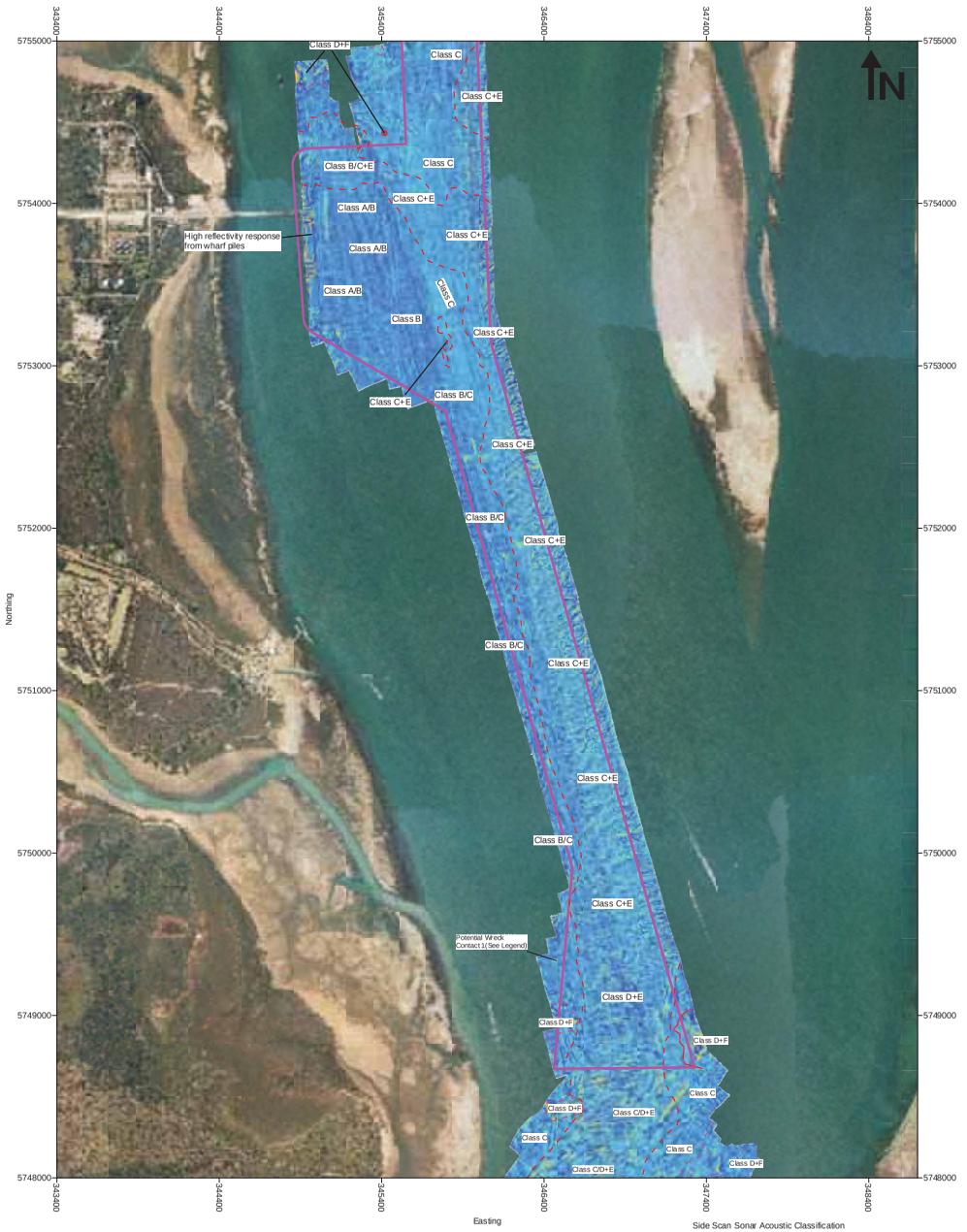
SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	SSS SCP	dpk	hk	dpk	
2	08/08/14	SSS SCP	dpk	hk	dpk	
4	10/10/14	SSS SCP	dpk	hk	dpk	sr

Client Drawing No | Figure No. B12 | Sheet No.



Side Scan Sonar Acoustic Classification

Class	Acoustic Response	Interpretative Comments
A	Speckled low acoustic reflectivity	Clay, Silty Clay and Sandy Clay
B	Speckled moderate acoustic reflectivity	Clayey Silt, Clayey Sand and Sandy Silt
C	Speckeled high acoustic reflectivity	Silty Sand and Sand
D	Speckeled very high acoustic reflectivity	Coarse Sands and Gravels
E	Linear high and low acoustic reflectivity bands	Sand Waves
F	Variable very to high to very low acoustic reflectivity with shadows	Outcropping Rock or Gravels, Cobbles and Boulders on seabed. Shadow effects from relief features
G	Highly variable low to moderate acoustic reflectivity clumps with shadows	Possible sea grass or other biological growth

LEGEND

Sand Wave Zone
Zone Boundary
Sea Grass Zone

Contact1
● Sonar Time at Target: 1/16/2014 9:12:53 PM
● Click Position
-38.39105957793 145.2422181178 (WGS84)
(X) 346489.01 (Y) 5749332.02 (Projected Coordinates)
● Map Projection: UTM84-55S
● Range to target: 57.62 Meters
● Fish Height: 11.23 Meters
● Heading: -1.000 Degrees
Dimensions and attributes
● Target Width: 17.38 Meters
● Target Length: 36.49 Meters
● Description: Potential Wreck

NOTES

GEODETIC INFORMATION
Horizontal Datum: MGA/GDA 94 Zone 55
Vertical Datum: metres LAT

DISCLAIMER
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LOCATION MAP

CLIENT DETAILS
AURECON AUSTRALASIA PTY LTD

marine & earth sciences

PORT OF HASTINGS DEVELOPMENT PROJECT
MARINE GEOPHYSICAL AND HYDROGRAPHIC SURVEYS
NORTH ARM SOUTH CHANNEL

SIDE SCAN SONAR SURVEY
MOSAIC AND SEAFLOOR MAPPING PLAN

SCALE 1:15,000 (A1 sheet)

0 250 500 750 1000

Survey Date: JAN-FEB 14 | Project Ref: 424

Issue No.	Date	Description	Surv.	Interp.	Drawn	Appr
1	02/04/14	SSS SCP	dpk	bk	dpk	
2	09/09/14	SSS SCP	dpk	bk	dpk	
4	10/10/14	SSS SCP	dpk	bj	dpk	sr

Client Drawing No | Figure No. B13 | Sheet No.