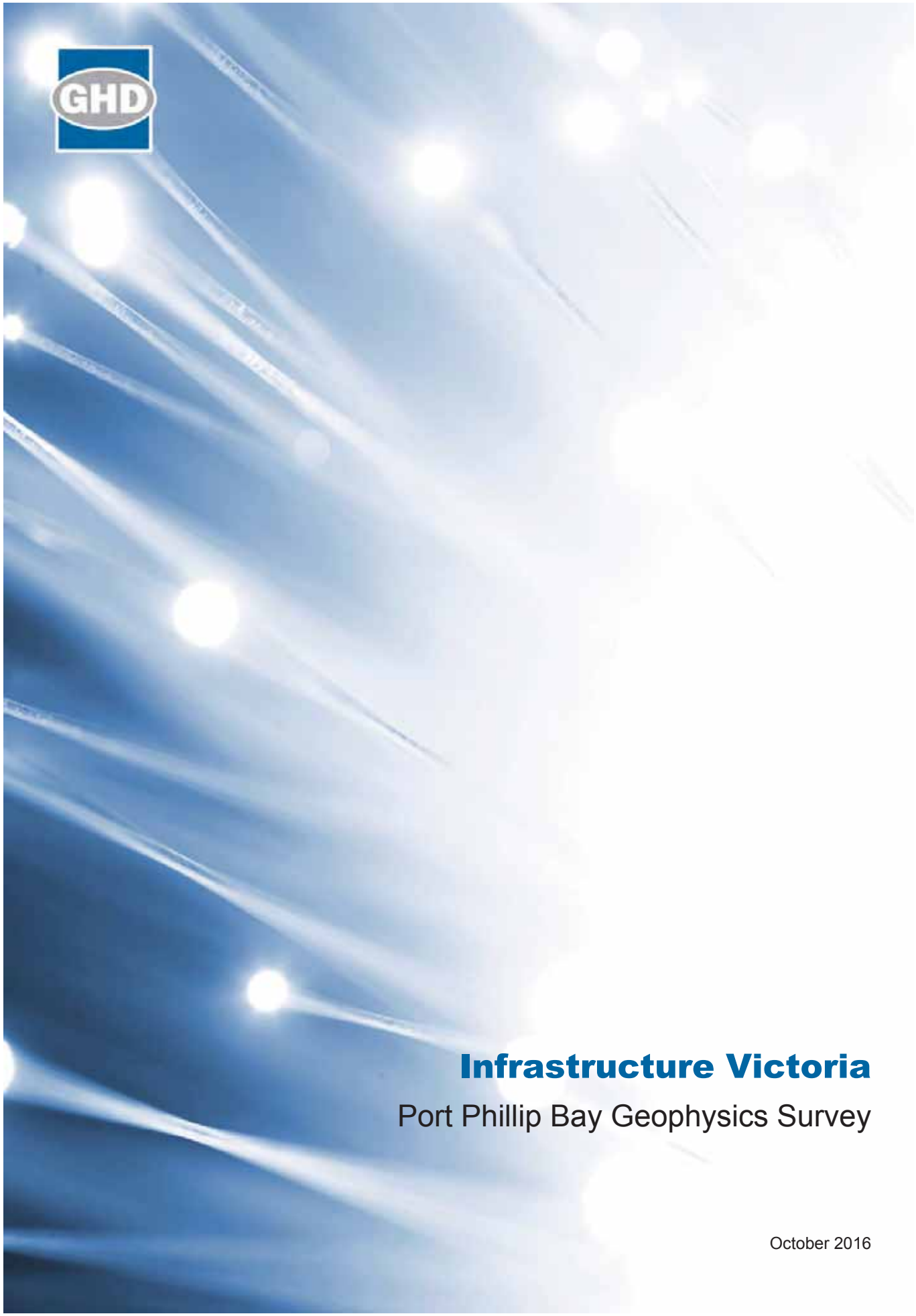

Infrastructure Victoria

Port Phillip Bay Geophysics Survey

October 2016

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Appendices

1. Introduction

1.1 General Project Background

GHD working with Marine and Earth Sciences (MES) has been commissioned by Infrastructure Victoria (IV) to undertake a geophysical investigation of the north-western shoreline of Port Phillip Bay close to the Western Treatment Plant between Point Cook and Point Lillias (the Investigation) as per the project brief (Draft Dated on 10/08/2016).

Geophysical survey was undertaken to help define the potential extent of Basalt rock within the survey area (site). Specifically, to define the lateral and vertical extent of Basalt rock within the area. It is understood that only limited data regarding to the potential extent of rock in that area is available at the moment. It is recognised, that the presence of the Basalt flow may be an impediment to future port development in the area.

The investigation has employed Subbottom Profiling (SBP), Marine Magnetics (MM) and Side Scan Sonar (SSS) geophysical survey to map the Basalt extents and also provide an initial assessment of sediments that may reside above any rock to further inform the evaluation of options for Victoria's second container port study.

GHD have pertinent local knowledge and relevant geophysical survey experience, and have been involved in a number of projects within the area of interest recently. These projects comprise similar geological settings and have employed the same range of geophysical investigation techniques. Some of the recent GHD investigations undertaken in this area for which results were included or referred to in this study were:

- Wilson Spit Rock Study geophysical investigation which was located slightly west from the proposed area of interest at the SW corner of the existing Wilson Spit Channel;
- Barwon River crossing geophysical and geotechnical investigation undertaken in 2007 which comprised of a seismic refraction survey across Barwon River close to Barwon Heads, and
- Ballan Road onshore seismic reflection survey to detect basement rock features near Werribee.

This report contains the summary of:

- the results of the SBP, MM and SSS survey undertaken in the study area,
- an extract of our recent Wilson Spit Rock study geophysical investigation results (that was undertaken for the Victorian Regional Channels Authority) in (Appendix A – Figures) and (related) URS BH logs (Appendix B)
- findings by Holdgate 2016 that were contained in a Draft Geotechnical Investigation report that was referenced as part of our study.

1.2 Scope of works

GHD understand that IV is investigating suitable sites for Victoria's second container port. This is inclusive of the 'Bay West' site, which covers the above study area (Figure 1).

The exact location of the port and navigational infrastructure within the study area have not yet been determined. It is however understood that the port development will potentially involve dredging of access channels, swinging basins and berth pockets as well as areas of reclamation and piled quay structures, whose feasibility could be impacted by the presence of rock. These activities would also be expected to form a significant proportion of any overall project costs.

This work (investigation) is aimed at identifying the key risks posed by historic Basalt flows, to help identify an optimum solution for the future port location in order to minimise the potential future project capital costs involved with any such port development in this area. Knowledge of the location and presumed extents of the rock horizon within the anticipated development zone is a primary objective of this study.

Specifically, IV aims to gain more information concerning following information in the order of significance:

1. The likely extent, depth and thickness of basalt or other hard rock ***shallower than 20m below Chart Datum*** across the study area;
2. The nature of seabed sediments overlying rock, ideally to estimate the proportion of sand, silt and clay.
3. The dredgability of materials identified
4. The suitability of materials identified for use in reclamation
5. The suitability of materials for foundation of reclamation (i.e. to have reclamation created on top of the material in situ)

The survey area was covered by longitudinal (parallel) and tie lines (perpendicular) to the shoreline with a limited maximum agreed coverage of 137 linear kilometres using following geophysical investigation techniques:

- Subbottom Profiling (SBP);
- Marine Magnetics (MM) and
- Side Scan Sonar (SSS);

Previous investigations undertaken in the area have also been included in the overall analysis of the results of this geophysical survey. The recent studies for VRCA are most relevant in this respect.

1.3 Geophysical Survey Area and Data Acquisition

Two types of survey lines were used to investigate the seabed and sub-seabed conditions during the IV Bay West Geophysical Investigation. Those were:

1. longitudinal survey lines (LL) and
2. perpendicular - tie lines (TL).

These surveys traversed a number of predefined alignments within the limits of the designated survey area, as shown in Figure 1.

The agreed scope of works included surveying the main survey area using parallel LL lines at approximately 2 km centre spacing together with three tie lines (TL) which were positioned based on the findings of an initial screening analysis of the Subbottom Profiling image response.

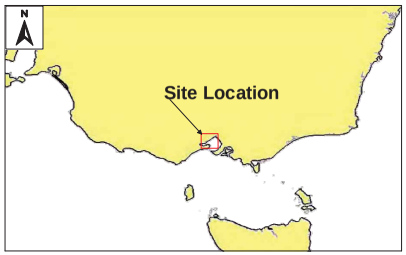
The survey line positions for each of these survey spreads are shown in Figure 1 and summarised on the tabulated presentation in Table 1.

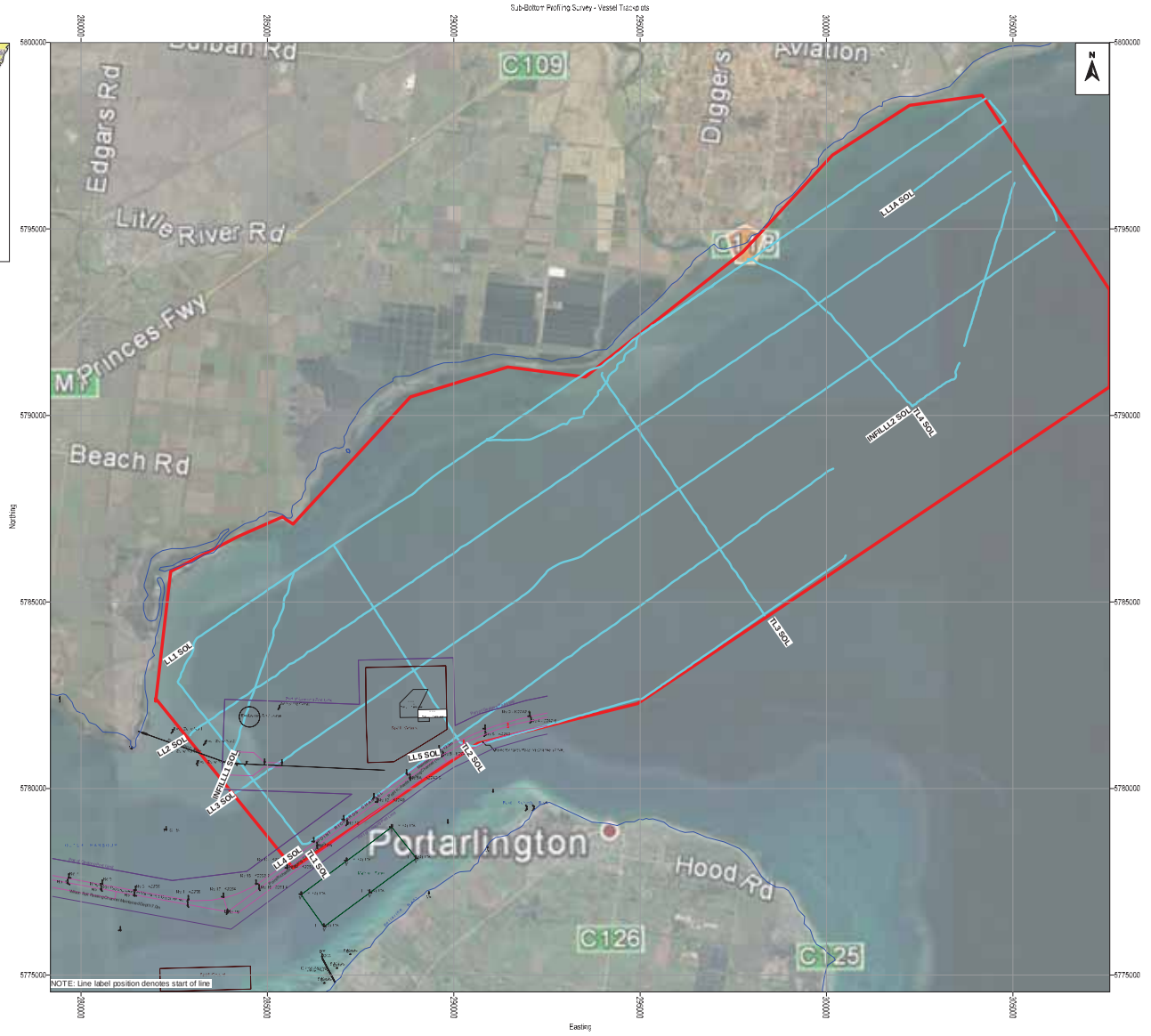
The fieldwork investigation for the agreed scope has been undertaken between 24th and 26th August 2016. No standby time has been applied due to inclement weather conditions during the survey. A total of approximately 147 km of survey lines have been acquired during the investigation

Some details on the SBP line coordinates and lengths are presented in Table 1 below.

Table 1 Geophysics Survey line coordinates. Total length ~147000 m

Line Name	Start Easting	Start Northing	End Easting	End Northing	Distance (km)
LL1	283013.80	5783907.21	304200.47	5798432.66	25.69
LL1A	302359.51	5796032.53	304793.33	5797871.59	3.05
LL2	282951.40	5781444.74	305011.74	5796500.09	26.71
LL3	284386.73	5780042.07	306072.64	5794910.39	26.29
LL4	285946.86	5778514.71	300112.91	5788520.44	17.34
LL5	290533.67	5781164.21	300456.14	5786213.83	11.13
TL1	285978.07	5778452.37	282608.17	5782816.24	5.51
TL2	290190.44	5781226.55	286789.34	5786463.19	6.24
TL3	298365.56	5784561.79	293872.36	5791138.76	7.97
TL4	302297.11	5790234.82	297959.92	5794193.47	5.87
INFILL1	284105.90	5780977.18	285634.84	5785715.10	4.98
INFILL2	302297.11	5790265.99	305042.95	5796157.21	6.50
TOTAL (km)					147.29





LEGEND:

- Bay West Main Project Area
- Wilson Spit study (GHD 2016)
- Bay West SBP, SSS and MM Survey (GHD 2016)

Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria

Bay West Project

Offshore Geophysical Investigation

SBP, MM and SSS Survey

scale 1:60,000 date 16/09/2016

Scale: 1:60000 @ A1

0 2000 4000 6000

m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

Job No. 31/34451

file ref G:/31/34451/Tech/Geophysics/Report/Figures/

Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Sub-Bottom Profiling Vessel Trackplots

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N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure 1

2. Reliance

This Report is confidential and:

- Has been prepared by GHD for Infrastructure Victoria (IV - the Client);
- May only be used and relied on by the Client;
- Must not be copied to, used by, or relied on by any person other than the Client; and
- May only be used for the purpose of assisting the understanding of the subsurface profile along the proposed alignment (and must not be used for any other purpose).

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To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and this Report are expressly excluded.

The services undertaken by GHD in connection with preparing this Report were limited to those specified in section 1.2.

The reader is reminded that Geophysical surveys have limitations and ambiguities associated with signal to noise ratio, data processing and interpretation methods in determining likely subsurface geotechnical conditions. Sections 3 and 8 of this report outline some of the specifics and limitations associated with geophysical survey methods and interpretation approaches.

The opinions, conclusions and any recommendations in this Report are based on information obtained from, and testing undertaken at or in connection with, specific sample lines / points at site. Site conditions at other parts of the site may be different from the site conditions found at the specific sample lines / points

Site conditions (including the presence of any hazardous substances and/or site contamination) may change after the date of this Report. GHD expressly disclaims responsibility:

- arising from, or in connection with, any change to the site conditions; and
- to update this Report if the site conditions change.

3. Geophysical Survey Methodology

3.1 Offshore Positioning and Levelling

The start and end points of the survey lines as well as survey extents were based on MGA/GDA 94 Zone 55 South coordinates. This data was imported into the Chesapeake survey software package which was interfaced to a Hemisphere R131 differential GPS using wide area differential corrections transmitted from the AMSA network. Accuracy of horizontal positioning is +/- 0.5 metres. The Chesapeake survey software package was interfaced with positioning system and sensors and provides pre-survey design, on line navigation control, data logging of full raw data set and screen real time quality control. Seafloor levels were acquired by the on board echo sounder in electronic format and were used to reduce the seismic data to LAT datum.

3.2 Sub-bottom Profiling and Bathymetric Survey Principles

Sub-bottom profiling systems identify and measure various sediment layers that exist below the sediment/water interface. These acoustic systems use a technique that is similar to simple echo sounders. A sound source emits a signal vertically downwards into the water and a receiver monitors the return signal that has been reflected off the material beneath the pond. Some of the acoustic signal will penetrate the bottom and be reflected when it encounters a boundary between two layers that have different acoustical properties (acoustic impedance). The system uses this reflected energy to provide information on sediment layers beneath the sediment-water interface.

Acoustic impedance is related to the density of the material and the rate at which sound travels through the material. When there is a change in acoustic impedance, such as the water-sediment interface, part of the transmitted sound is reflected. However, some of the sound energy penetrates through the boundary and into the sediments. This energy is reflected when it encounters boundaries between deeper sediment layers having different acoustic impedance. The system uses the energy reflected by these layers to create a profile of the sub-bottom sediments.

3.2.1 Advantages

Sub-bottom profiling systems can be useful for characterizing benthic conditions, since they provide information on sub-surface sediment structure. No other acoustic techniques provide this type of information, and only physical sampling via cores or in-situ photography via sediment profile imaging will allow for characterization of subsurface structures. Sub-bottom profiling systems may penetrate as deep as 35 meters into unconsolidated sediments beneath the sea floor, which is much deeper than most cores and Sediment Profile Imaging (SPI). The reflection surveying method offers more subsurface coverage than refraction methods and faster recording. Therefore, they are usually more cost effective than the refraction method.

3.2.2 Limitations

An increase in output power gives better penetration into the sub-bottom layers. Sometimes however, if the seafloor is very hard or shallow, the increase in power will cause more signal to

be reflected back off the water / sediments interface. The signal might then be reflected off the water surface, leading to multiple reflections and "noise" in the data.

Signal frequency also has an effect on system performance. Higher frequency systems (2 to 20 kHz) will produce high definition data of the upper sediment layers. These higher frequency signals have shorter wavelengths, and they are able to discriminate between layers that are closely spaced. Lower frequency systems will give greater penetration but at a lower resolution.

Longer sound pulse length transmits more energy and yields deeper penetration. However, a long pulse length may decrease the ability to discriminate between adjacent reflectors, thus decreasing the system resolution.

Similarly, the penetration depth depends on the hardness of the overlying layers and the presence of gas deposits, such as methane. Sub-bottom systems are limited by a narrow swath width, so continuous sub bottom coverage is time-consuming and expensive to obtain. As with other single-beam acoustic methods, the footprint is relatively small and dependent on depth.

Whether reflection methods will work better than refraction methods will depend on:

- The strength of the seismic source (pinger /boomer / sparker);
- The bedrock depth (shallower bedrock is more easily mappable);
- The presence of gas-filled lenses inside the sediment layers close to the water / sediments interface (which may absorb the source energy and mask bottom reflections, particularly in deeper bedrock areas);
- Water layer reverberations (hard sub bottom reflections dominate);
- Weathering on the bedrock surface (may weaken the bedrock reflector); and
- Steep dips on bedrock (loss of reflection signal may occur on steep sided canyons in the bedrock surface).

3.2.3 Main SBP Equipment technical specification

GHD and Marine and Earth Sciences used an Applied Acoustics high power boomer system in the survey. The boomer has selectable energy levels from 50 to 350 Joules and high resolution and penetration rate. 250 Joules energy level was used in the survey.

For operational redundancy GHD have also provided the C-Boom and C- Phone boomer system.

Some technical specifications of the main GHD and MES main SBP system are presented in table below.

Table 2 Specifications of the Applied Acoustics CSP-P High Power boomer Sub Bottom Profiling system.

Parameter	Specification
Sediment penetration	up to 100 m
Vertical resolution	up to 25 cm
Primary frequency	1760 Hz
Primary TX power / source level	>215 dB//µPa re 1 m
Ping rate	up to 6 Hz

3.3 Side scan sonar

Sidescan sonars use two sensors to ensonify a swath of seafloor each side of a towed torpedo-shaped 'fish'. These transducers produce a thin fan shaped beam that is concentrated on the seabed in a line that runs from below the fish, perpendicularly out to the maximum range on each side. The forward motion of the device allows the beams to cover a wide swath of the seabed.

The two transducers simultaneously emit a sonic pulse at a particular frequency. As the transmitted pulse interacts with the seafloor at angles off normal, most of the energy is reflected away from the transducer. The small amount of this backscattered energy that is received, is amplified and recorded by a digital acquisition system. This recording occurs over an extended period allowing for returns to be obtained out to the selected maximum ground range. The line of data obtained after each pulse, is considered a function of time. Using the speed of sound in water the distance from the fish for each position along this line can be predicted. Signal levels are digitally sampled and as the transducers move forward subsequent lines of data are built up to form an acoustic image of the area.

This image is a record of the instantaneous intensity of the backscatter and is affected by the following factors in decreasing order of importance:

- Sonar frequency (higher frequencies give higher resolution but attenuate more quickly with range than lower frequencies).
- The geometric relationship between the transducer and the target object (slope).
- Physical characteristics of the surface (texture)
- Nature of the surface (composition, density)

Side scan sonar survey was undertaken using a C-Max CM2 digital Side Scan Sonar system.

3.3.1 System specifications

Specifications for the CM2 Side Scan Sonar system used in the survey are presented in Table 3 below.

Table 3 Specifications of the CM2 digital Side Scan Sonar System

Parameter	Specification
Ranges	100 m, 150 m 200 m, 300 m, 400 m, 500 m at 100kHz 25 m, 50 m, 75 m, 100 m, 150 m at 325 kHz 12.5 m, 25 m, 37.5 m at 780 kHz
Acoustic pulse rates, pings per second (at range)	780kHz: 24.7(12.5m); 13.5(25m); 18.0(37.5m) 325kHz: 13.5(25m); 13.0(50m); 9.1(75m); 7.0(100m); 4.8(150m) 100kHz: 6.9(100m); 3.6(200m); 2.4(300m); 1.83(400m); 1.46(500m)
Lateral resolution	39mm at 780kHz and 25m range at 325kHz, 78mm at 325kHz (not 25m range), 156mm at 100kHz
Array length and beamwidths (2-way 3dB points)	0.37m at 325kHz & 100kHz; 0.21m at 780kHz 0.45º horizontal at 325kHz 1.0º horizontal at 100kHz 0.32º horizontal at 780kHz

3.4 Marine magnetics

A Marine Magnetometer (MM) survey was aimed at detecting the extents and limits of the basalt flow effectively which will additionally enhance the interpretation of the sub-bottom profiling and SSS data set in these areas. The MM survey was carried out concurrently with the SBP and the SSS survey.

GHD / M&ES team used the SeaSpy high sensitivity marine magnetometer with integrated depth, altimeter and heading sensor to complete this scope of the geophysical investigation.

The SeaSPY magnetometer can be towed independently or integrated with the C-Max Sidescan Sonar. The SeaSpy magnetometer was towed at 8 m offset distance from the C-Max SSS sensor on a tow cable.

Specifications for the SeaSpy magnetometer are presented in Table 4 below.

Table 4 Specifications of SeaSpy Magnetometer system used in the survey

Parameter	Specification
Resolution	0.001 nT
Operating range	18,000 – 120,000 nT
Sensitivity	0.02 nT @10 Hz
Accuracy	<0.1 nT

4. Field Acquisition Procedures

4.1 Sub-Bottom Profiling (Seismic Reflection)

An Applied Acoustics boomer system was used to acquire sub-bottom profiling data for mapping geological layers across the site. The technique involved towing a seismic source (boomer) and seismic receivers (hydrophone streamer) 20 m behind the survey vessel travelling at slow speeds (Figure 2).

The boomer seismic source was operated at an energy level of 250 joules and a firing rate of 3 pps. Return signals were received via the 12 element hydrophone array streamer interfaced to a 24 bit analogue to digital converter which in turn was interfaced to a 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.

Figure 2 SBP Survey setup - boomer towed during the survey

The boomer and hydrophone streamer were towed 20 m behind the vessel with a separation of 3 m with the vessel speed maintained between 2.5 and 3.5 knots. Layback and offset corrections, band pass filtering, time variable gains and stacking to optimise the appearance of the seismic record were performed during the survey and these procedures were included in the post processing stage. Prestart equipment checks included a tap test on the hydrophones array and checking response on the digital oscilloscope.

4.2 Side Scan Sonar

A high resolution digital CMax CM2 was used to collect sonar data. The side scan sonar towfish was towed through the water by a stainless steel tow cable connected to a 24 volt winch which was secured to the back deck of the survey vessel (Figure 3).

The steel tow cable was run through a cable counter connected to a davit and interfaced to the acquisition computer with the cable out distance. appended digitally to the sonar file header to allow layback corrections to be applied for each of the systems separately.

Figure 3 Back deck vessel setup during the survey

The towfish was towed at various altitudes from the sea floor due to the variable seabed topography levels (target altitude of 10% of water depth was generally maintained) and was operated at a frequency of 325 kHz with a beam range of 50 m.

The towfish was interfaced with Chesapeake SonrWiz 6 software which provided real time mosaic and digitally records the data to hard drive along with time stamps and navigation data in accordance with the accepted industry practice. Positioning of the towfish was referenced to the DGPS antenna. Prestart equipment checks included a rub test on the transducer face and assessing response on the digital display prior to deploying.

4.3 Magnetometer Survey

A Marine Magnetics SeaSpy magnetometer was used to measure the magnetic flux density using an Overhauser sensor over the investigation area. The magnetometer was interfaced through the side scan sonar tow cable and was towed 8 m behind the side scan sonar towfish. The magnetometer was set to sample at 1 Hz and was interfaced to the acquisition computer which receives the magnetic and position data and was recorded to the internal hard drive (Figure 4).

Positioning of the towfish was referenced to the DGPS antenna. Prestart equipment checks included internal system check on start-up and deploying the towfish off the stern of the vessel and initiating sampling to assess data quality and stability.

Figure 4 Computer System Setup on board vessel

4.5 Survey Vessel and safety and environmental procedures

The offshore survey operations were carried out from M&ES commercial survey vessel (Figure 5).

Figure 5 Survey Vessel

The vessel used in the survey holds all relevant certificates of survey commercially. All the certificates and tickets were kept on board. GHD principal geophysicist Zivko Terzic has performed the safety and technical audit prior the survey to assure the GHD technical (QA/QC), safety and environmental procedures prescribed for the survey were followed. The survey crew were equipped with the binoculars for the MM observation. The prescribed procedures from the project approved EMP were strictly followed.

Daily pre-start meetings were performed to ensure the safety and data quality were not compromised. The staff on the vessel was wearing the PFD and other safety equipment at all times. Regular two-way radio communication with the Port master and the onshore survey personnel were maintained.

5. Processing and Interpretation Procedures

5.1 Seafloor Level Mapping

Areas of the site with seafloor levels lower than -10m LAT have been mapped using the sub-bottom profiling records which involved digitising the seafloor reflector and reducing this measurement with the Corio Bay observed tide data supplied by the Victorian Regional Channel Authority. Although the reduced seafloor levels calculated with this method agree well with overlapping existing hydrographic datasets, the use of this data is primarily for developing the geological model and for general site assessment and should not be used for navigation. The seafloor level contour plan has been generated by the reduced sub-bottom profiling data alone as the LIDAR data was not available at the time of reporting and it should be noted that the line spacing is very broad and interpolation has been used to present the general seafloor level trends across the large site. The reduced seafloor levels are presented on Figure A1 – Appendix A.

5.2 Processing of Sub-Bottom Profiling Data

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 refraction data acquired during the Wilson Spit Rock study project. 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 survey lines. The sub-bottom profiling vessel trackplots are shown on Figure A2 – Appendix A.

5.3 Side Scan Sonar

The side scan sonar data has been processed by digitising the seafloor, applying layback and offset corrections as well as beam angle corrections. Coverage of the survey area is limited to the swath width (50 to 100m) either side of each survey line. The sonar data has been used to map the seafloor character and features along each of the discreet survey lines.

The sonar data has been presented as a mosaic along with interpretation of seafloor features and differing sonar character zones on Figure A8 - Appendix A.

5.4 Magnetometer

The magnetometer data has been cleaned to remove data outliers points associated with survey turns as well as some noisy data where the magnetometer towfish struck the seafloor near Wedge Point in very shallow water. The magnetometer data has been corrected for layback and offset from the DGPS reference of the survey vessel and presented as a magnetic intensity plot on Figure A9 - Appendix A.

6. Bay West Geophysics Investigation Results

6.1 Seafloor Level Mapping

The reduced seafloor levels range from -0.5m LAT within the nearshore area at Wedge Point to -15.4m LAT further offshore. Some features observed on the contour plan include a ridge extending out into the bay adjacent to the existing wharf at Wilson Point as well as some irregularity of the seafloor gradient along the coastline. Minor higher relief areas extending out into the bay are observed at Wedge Point and at the far north-east of the site.

6.2 Sub-Bottom Profiling

Figure A5 – Appendix A contains the track plots of the analysed SBP records.

Figure A6 and Figure A7 in Appendix A contain the SBP data survey results. Based on the specific seismic signature (specific seismic signal amplitude /frequency characteristics) the analysis of the SBP records have identified five main seismic stratigraphical units. These units are summarised below:

- **Unit 1** – This unit extends from the seafloor and is predominantly represented by a series of horizontal to sub-horizontal reflectors beneath the seafloor and is continuous over the site except where outcropping rock is present. The material within this unit is expected to be represented by recently deposited fine sands and silts. Mapping this unit has been difficult at places due to the seafloor multiple obscuring this reflector on SBP TL4 and SBP LL1a.
- **Unit 2** – This unit lies between Unit 1 and Unit 3 or 4 and is represented a transparent seismic character on the records which is typical of fine silts and clayey deposits. Very weak horizontal to sub-horizontal internal reflectors are observed as well as some complex reflectors representing infilled palaeochannels. Some localised coarser material are interpreted on the records and lie at the top of this Unit and may be associated with coarse sands and gravel deposits. These are located between CH20,000m-CH21,300m on SBP LL1, between CH11,800m-CH15,000m on SBP LL2, between CH19,000m-CH20,000m on SBP LL3 and between CH400m-CH1,100m on SBP TL4 (Figure A6 and A7 in Appendix A).
- **Unit 3** – This discontinuous unit underlies Unit 2 and is placed above Unit 4 where present and is represented by a coarser seismic character which is typical of silty and sandy material and has weak internal horizontal to sub-horizontal reflectors.
- **Unit 4** – This basal unit is not mapped continuously across the site with the top of this unit is represented by a strong reflector and is irregular in profile and detectable up to 80m below the seafloor. This unit appears to be subjected to folding from CH14,000m to CH20,0000 on all the SBP LL profiles.
- **Basalt Unit** - This unit is not mapped continuously and is represented by a reflector that displays diffractions which is typical of a rock reflector. This basalt layer ranges in level from -3m LAT to -29m LAT. The basalt unit is extensive between Kirk Point and Point

Wilson and extends beyond the Point Richards Channel. The basalt unit profile interpreted on the nearshore line SBP LL1 shows a semi continuous irregular rock profile and is not present between CH20,000m-CH21,500m, between CH21,800m-CH22,400m and between CH23,400m-25,200m. On SBP LL2 the rock is limited from the start of this line to CH4,800m and between CH9,500m-CH11,500m. On SBP LL3 and SBP LL4 the basalt unit is limited only to the south-western extents of these lines. The presence of two localised basalt outcrops are observed on SBP LL1a.

Figure A3 presents results of the SBP survey with the top of rock level contour map presented with Figure A4 showing the soil thickness contour map with the thickness of sediments overlaying the interpreted bedrock layer.

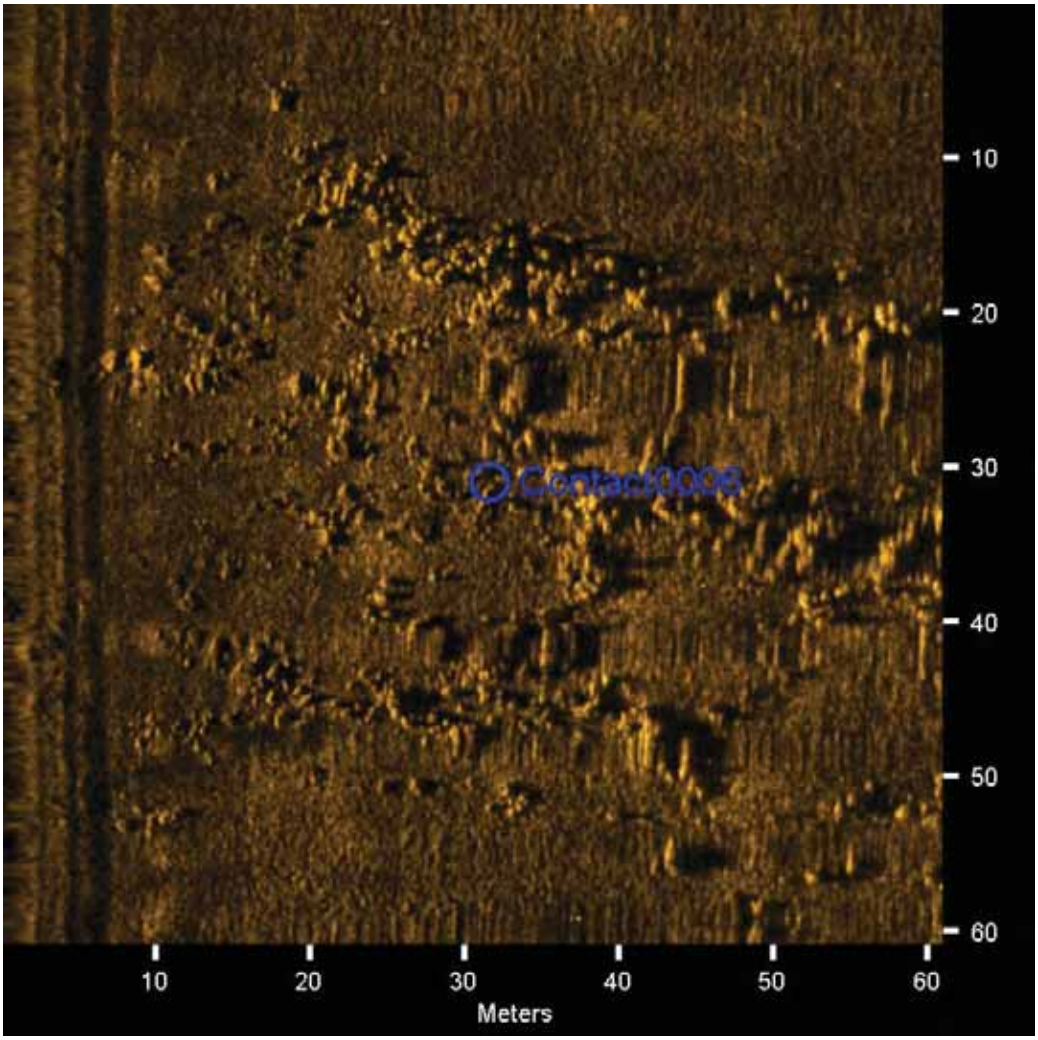
6.3 Side Scan Sonar

The side scan sonar survey has identified a variable seafloor sonar character with the mosaic presented on Figure A8 – Appendix A along with the interpreted zones of differing sonar character. The summary of the sonar interpretation is presented in Table 5 below:

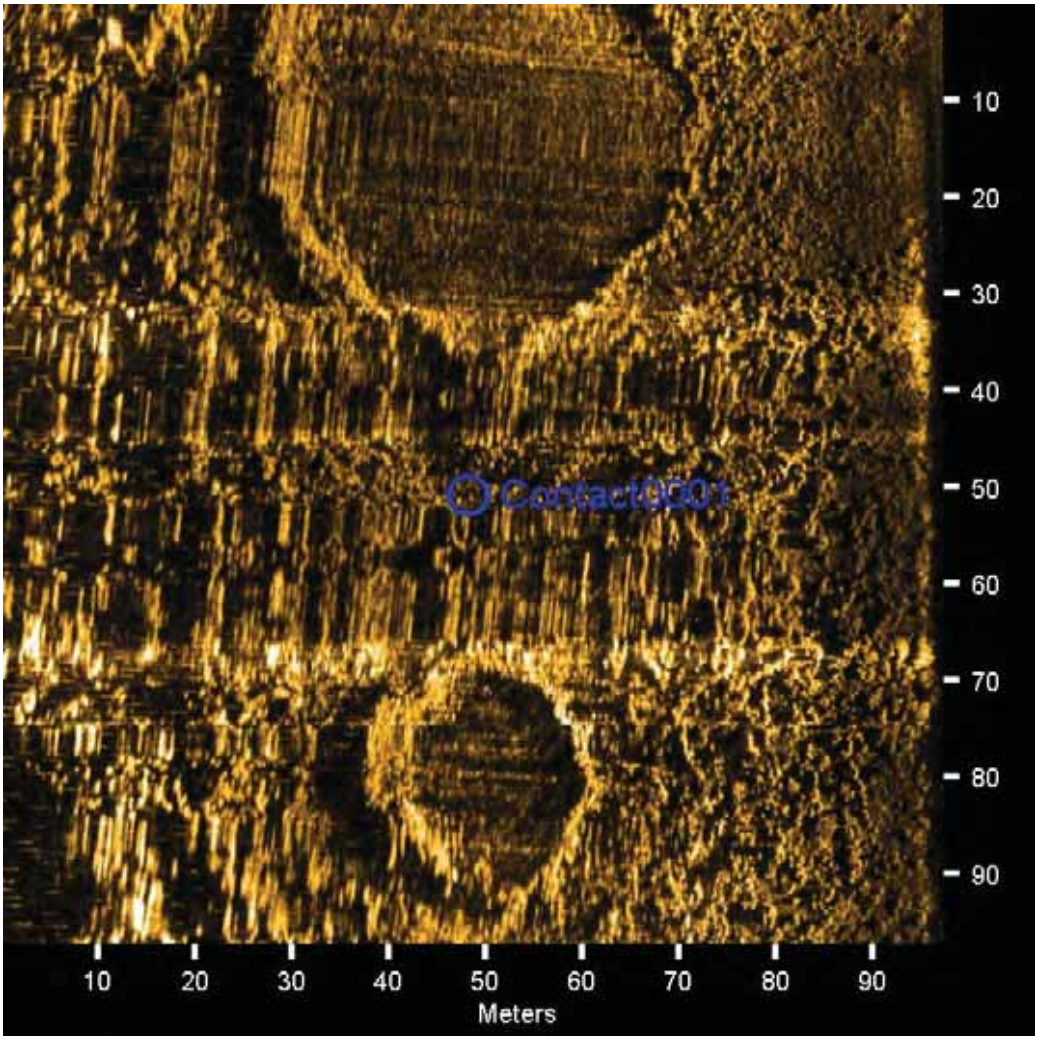
Table 5 Summary of Side Scan Sonar Interpretation

Sonar Response	Seafloor Material Interpretation	Interpretative Comments
Low Reflectivity / Fine Speckled Appearance	Silts and Fine Sands	This material is the predominantly identified within the nearshore area to approximately the 9m LAT contour interval
Low Reflectivity / Very Fine Speckled Appearance	Silts and Clays	This material is the identified within the offshore area where seafloor levels are deeper than -9m LAT
High Reflectivity / Coarse Speckled Appearance	Gravels and Cobbles and Low Relief Rock	This signature material is mapped extensively between Kirk Point and Point Wilson and extends approximately 4km offshore. Localised zones of this signature are also mapped within the nearshore area between reference chainage 8,200m-8,800m and at Werribee River.
Very High Reflectivity and Shadow Effects	Outcropping Rock / High Relief Features	This signal response character is mapped extensively between Kirk Point and Point Wilson and extends approximately 4km offshore. A localised zone is also mapped within the nearshore area between reference chainage 7,800m-9,000m and at reference chainage 26,000m.
Irregular Shaped Moderate Reflectivity Features with Diffuse Branching Boundaries	Seafloor Vegetation	The extents of the significant seafloor vegetation are confined to the southern parts of the survey area in areas of no rock outcrop

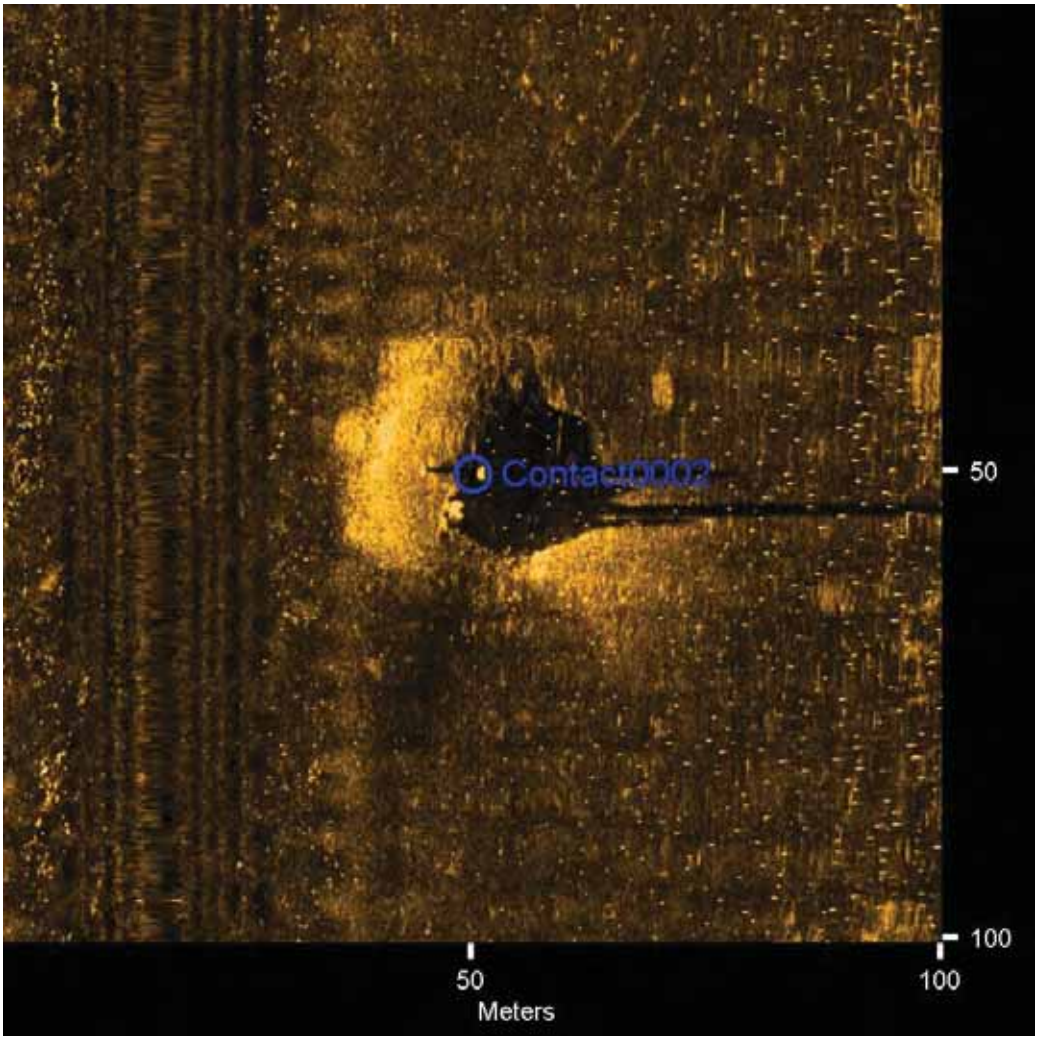
Numerous localised features (contacts) have been identified on the sonar records and these are summarised in in Table 5, with the locations of these contacts shown in Figure A8 – Appendix A.



Contact0006	Dimensions and attributes
• Sonar Time at Target: 8/25/2016 9:28:34 PM • Click Position -38.0868259100 144.5284417123 (WGS84) (X) 283243.66 (Y) 5781666.53 (Projected Coordinates) • Map Projection: UTM84-55S • Acoustic Source File: C:\SonarWiz-projects\WestMelbPort\SSS\Line-0042.xtf • Ping Number: 6690	• Avoidance Area: • Classification1: • Description: Outcropping Rock



Contact0001	Dimensions and attributes
• Sonar Time at Target: 8/23/2016 2:45:36 AM • Click Position -38.0594309404 144.5406662940 (WGS84) (X) 284235.39 (Y) 5784735.25 (Projected Coordinates) • Map Projection: UTM84-55S • Acoustic Source File: C:\SonarWiz-projects\WestMelbPort\SSS\Line-0016.xtf • Ping Number: 83260	• Avoidance Area: • Classification1: • Description: Circular features on outcropping rock: Possible Maars Structure



Contact0002	Dimensions and attributes
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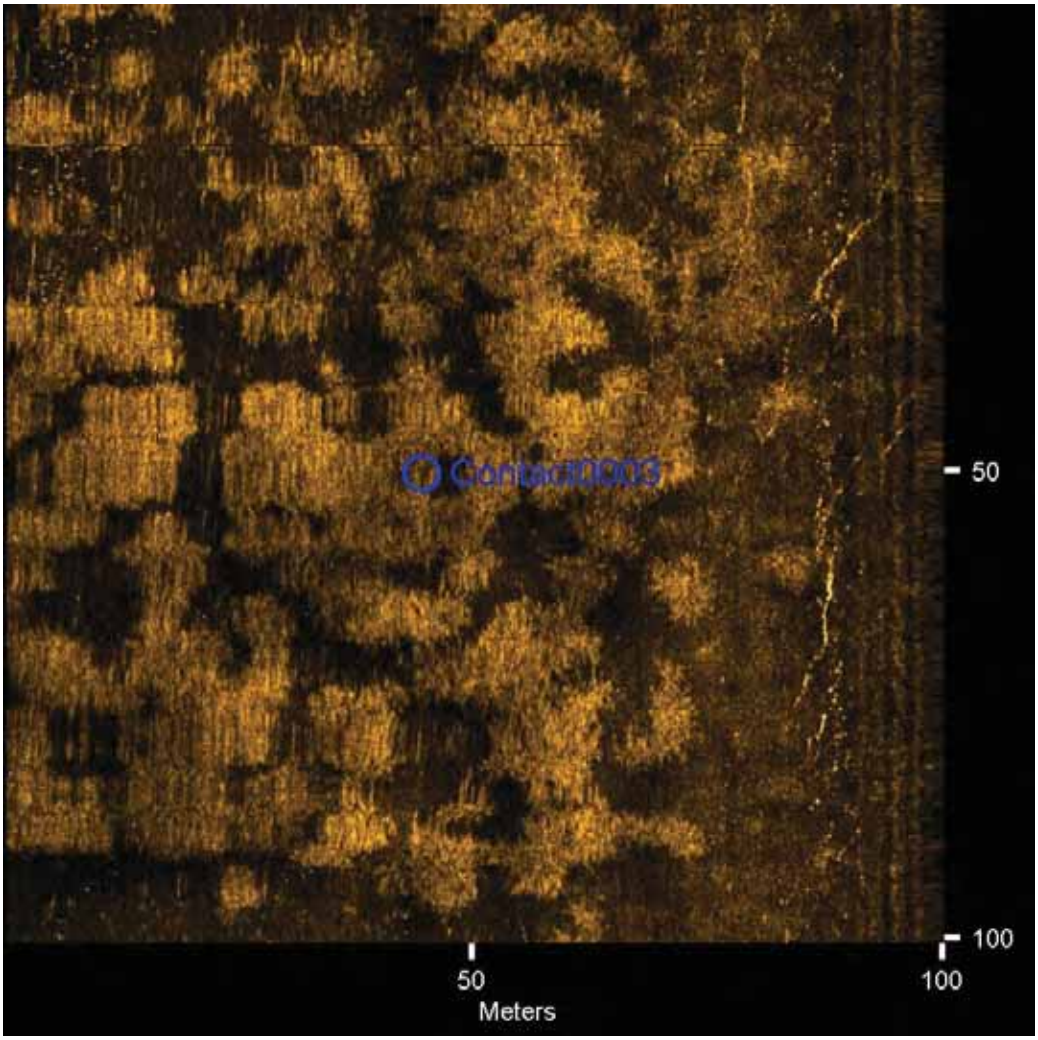

Contact0003	Dimensions and attributes
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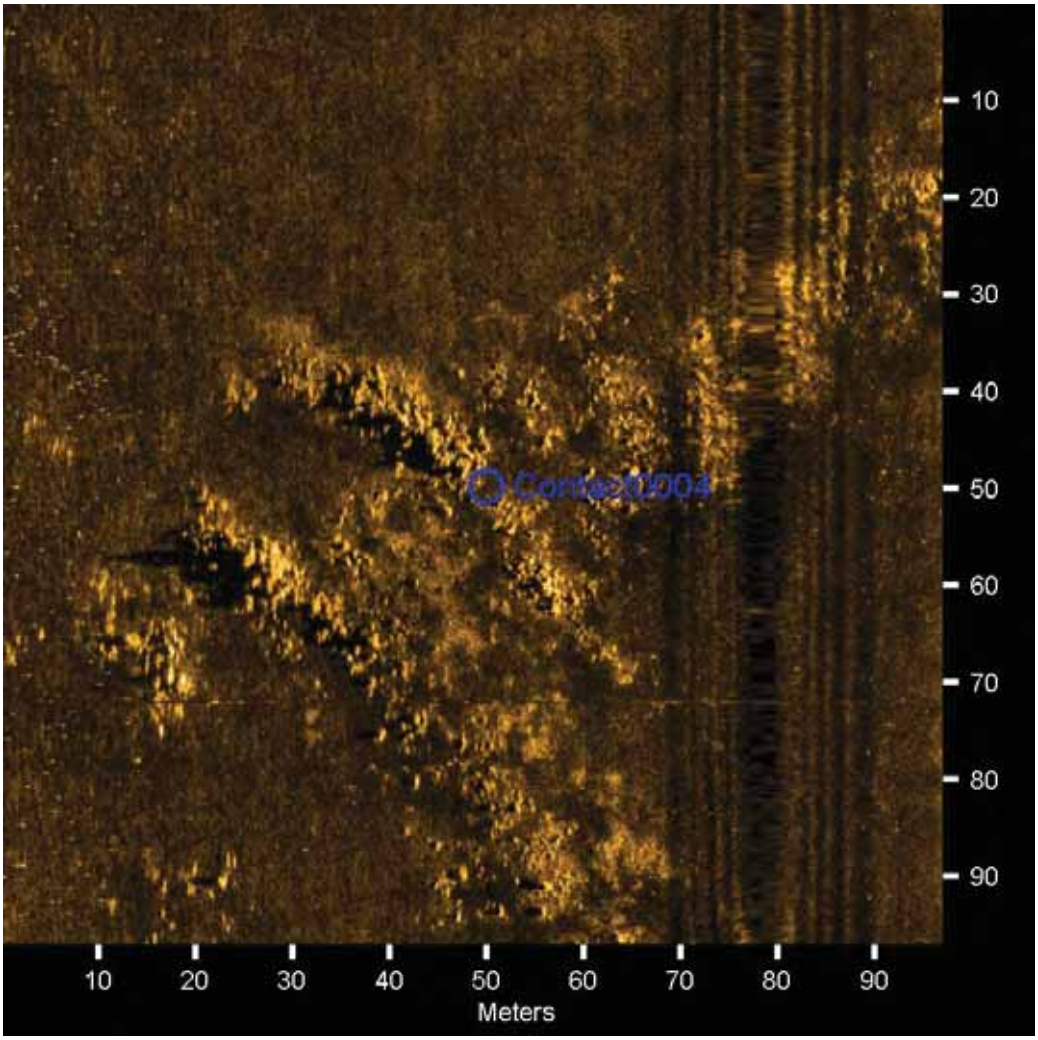

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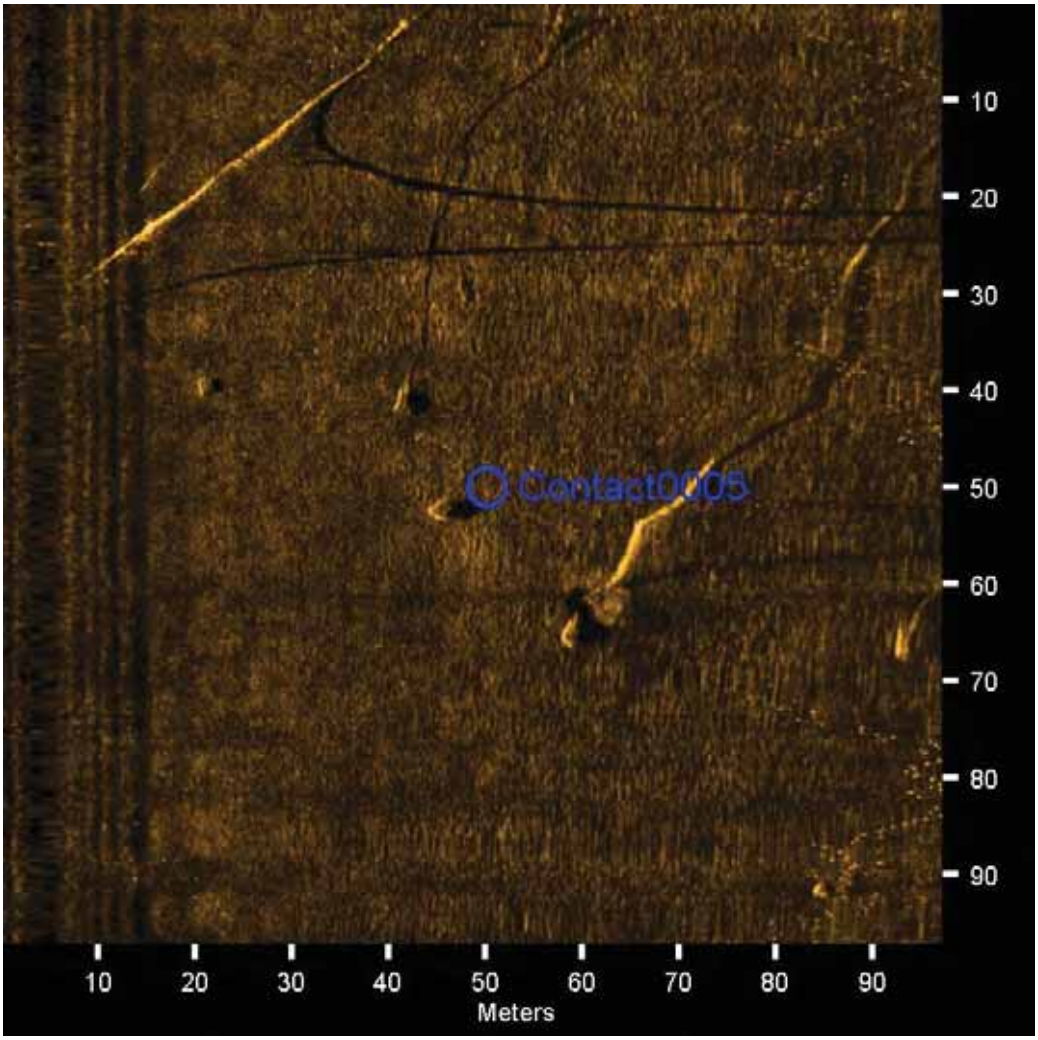

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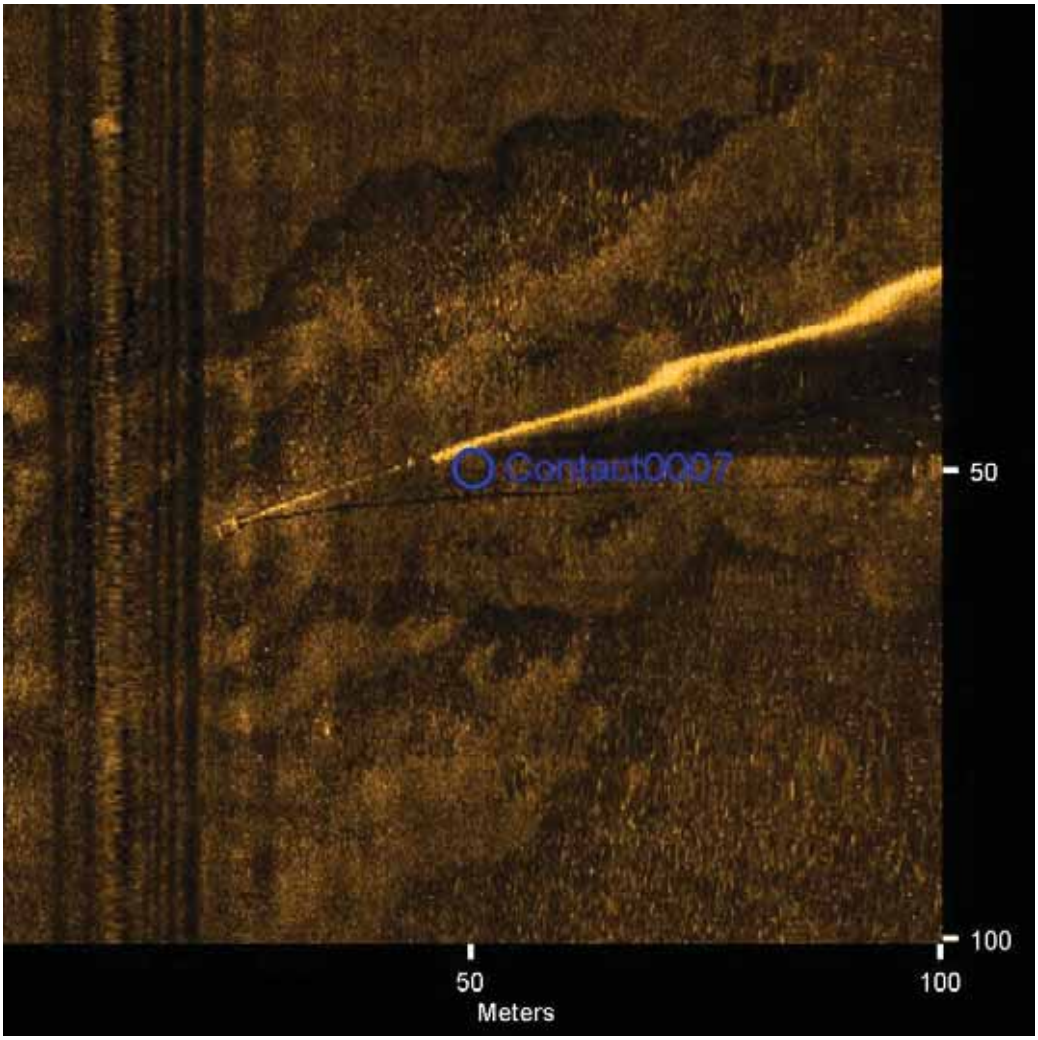

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6.4 Marine Magnetometer Survey Results

The magnetic intensity plot displays a highly variable signature between Kirk Point and Point Wilson and extends to the southern limits of the survey area at Point Wilson Channel. This rapidly changing magnetic signature is typical of geological material such as volcanic rock (basalt) which distorts the earth's natural magnetic field.

The intensity of the nearshore untidy magnetic signal signature is variable and is partly related to the changing depth of basalt below seafloor and to a degree, weathering of this unit. Localised high magnetic intensity zones are detected along the nearshore Mag LL1 profile between reference chainage 7,500m-8,800m, 9,500m-11,500m, 18,000m-19,000m and 19,800m-20,000m and 25,500m-26,800m (see Figure A9 – Appendix A). Some of these high intensity zones correlate well with localised magnetic anomalies detected on the Mag LL2 profile 2,000m offshore and could indicate a continuation of this magnetically susceptible unit.

The magnetometer intensity plot within the offshore area east of Kirk Point is generally smooth and shows no significant intensity variation anomalies which could be related to shallow basalt. Some magnetic intensity variability is noted on Mag TL4 profile with the signature somewhat different to that of the nearshore zones and could be related to potential gravel deposits.

Some anomalies have been identified on the records which coincide with existing navigation beacons / buoys as well as jetty and wharf structures.

The magnetic field data has been presented on Figure A9 with the combined marine and airborne magnetometer data presented on Figure A10 to provide an appreciation of regional geological conditions.

6.5 3D geological Model

Integration of geophysical and other geoscientific data in a 3D environment for a holistic multidisciplinary interpretation has been undertaken for this project using Leapfrog software. Leapfrog software has a comprehensive capability with regards to the data integration and interpretation.

The existing geotechnical and geological data have been digitised for input into the geological model. Information such as existing bathymetry, proposed dredge depths of channels, borehole locations, collar elevation of boreholes and depths of material types and any interpretation of geological units were also incorporated in the model.

Geophysical data from Wilson Spit Rock study have also been entered into the model. Using the imported information, a geological interpretation of the data was completed by interpolating surfaces between differing geological units and/or material types. These surfaces were adjusted based upon anticipated geological processes and geophysical data with selection between the SBP, borehole information and MM data. The surfaces created within the model can be exported into a CAD format suitable for design.

The 3D model allows for a rapid assessment of data gaps and allows easy planning of any further investigation. The 3D model can also be used in volumetric analysis and estimation of the material to be dredged.

Extract summary borehole information from the historical geotechnical investigations in the area (GHD 1993 and URS 2014) are summarised in Table 7 Appendix B of this report.

7. Summary of the results and recommendations

The marine geophysical surveys have successfully mapped seafloor and sub-seabed conditions across the site and have met the projects objectives.

7.1 Summary of results

The results of the Bay West Geophysical Investigation can be summarised as follows:

- The sub-bottom profiling survey has identified a variable bedrock profile which is interpreted as a basalt unit (Figure A6 – Appendix A). The SBP survey found outcropping or very close to the seafloor rock over significant part of the south western and northern edge of the survey area (towards Wilson point) and with results of the SBP and MM survey closely correlate with the side scan sonar records where outcropping rock is detected.
- The basalt rock profile is not detected continuously over the survey area and the interpreted rock contour levels presented on Figure A3 show the extents to which it is detected within the appointed ~ -20 m LAT level on the lines covered as part of this broad reconnaissance survey. Apart from the extensively mapped basalt areas between Kirk Point and Wilson Point there are two locations which basalt extend into the bay and these are located offshore Little River and at the far north-eastern parts of the investigation area offshore from the Williams Laverton RAAF Base.
- Based on the findings of the Wilson Spit Rock study seismic refraction investigation, competent rock is encountered at the SW corner of the Wilson Spit survey area with slightly weathered basalt observed within and above the -15 m CD. Based on the SBP signal signature, similar strength basalt can be expected at the far SW corner of the Bay West main survey area.
- Figure A3 - Appendix A presents results of the SBP survey with the top of rock level contour map and Figure A4 - Appendix A showing the soil thickness contour map with the thickness of sediments overlaying the interpreted basalt bedrock layer.
- Based on the in-depth analysis of the SBP profiles acquired in the survey it appears that besides the shallow basalt zones indicated in Figure A3, rock is not present within the -20 m LAT elsewhere across the survey area.
- A discontinuous rock reflector has been interpreted on SBP LL1a (Figure A6) with the location of this closely coinciding with the outcropping basalt identified on the side scan sonar records (see Section 6.2). The rock reflector along this line is very weak which is related to a poor density and seismic velocity contrast between layers and is not easily detected and could be caused by the extremely weathered rock profile.
- The penetration of seismic energy below this basalt rock reflector (see above bullet point) also tends to support the hypothesis with regards the extremely weathered nature of the basalt at this location as Unit 4 – resembling deeper more competent rock reflector is detected below this basalt rock layer. In general, a rock profile will reflect most seismic energy from a boomer system and provide limited penetration beyond the competent rock

layer. Based on the analysis of this reflector in Figure A6 – Appendix A it is not possible to determine the thickness of the basalt layer with sufficient level of certainty.

- The magnetic intensity plot (Figure A9 – Appendix A) shows variability over the site with the highly variable levels signature of the magnetic field coincides very well with outcropping volcanic rock that has been identified on the side scan sonar records, historical information related to the basalt presence in the area (GHD 2016; URS 2014, GHD 1993; Holdgate 2016) and shallow or outcropping rock interpreted on the sub-bottom profiling records. The Mag TL4 profile which extends out from Werribee River has identified some subtle magnetic anomalies and correlate with areas of interpreted gravel deposits on the sub-bottom profiling records. Figure A10 contains regional airborne magnetic map with overlayed marine magnetics data acquired in this survey for comparison purposes.
- The folding and deformation of the interpreted Unit 4 could be related to a granite intrusive identified on the regional airborne magnetic intensity plot (strong high anomaly in the centre area – Figure A10 – Appendix A) with the nature of this material unknown and unlikely to be of any impact given its depth is predominantly greater than approximately -30m LAT. From the GHD Ballan Rd – onshore reflection survey near Werribee it is known that the basalt dominates shallow depths with much deeper basement rock in this area - at depths around 300 m or deeper.
- Figure A11 shows the top of rock SBP based Map based on Bay West and Wilson Spit rock study geophysical survey combined with the integrated Interpretation map produced by Holdgate which indicates the depth to rock from various sources within wider project area. A good level of correlation can be noted between those two marine geophysical surveys and the map based on the integrated interpretation by Dr Holdgate.
- Figure A12 presents a composite map containing the marine magnetics results from Bay West and Wilson Spit geophysical investigations superimposed over the integrated interpretive map (Holdgate – 2016). Clear correlation of these two survey results can be noted based on the Wilson Spit and Bay West geophysical investigations as compared with the inferred rock extent showed on the integrated interpretation map by Holdgate.

7.2 Recommendations

Based on the existing level of knowledge regarding the subbottom material in the wider project area and the information gathered from various sources, following recommendations can be drawn:

- It is recommended to undertake infill geophysical survey lines to better define the offshore extents of the basalt unit as the nature of the edges of these can be very irregular and localised to narrow corridors. This infill survey is especially recommended in the nearshore zones east and west from the Werribee river
- It is also recommended to undertake additional geotechnical vibrocore or borehole drilling and invasive investigation to distinguish the detailed nature of the sediments and the basalt rock encountered in the survey

8. Limitations Associated with Geophysics Survey Interpretations

8.1 Shallow Seismic Reflection Survey Limitations

The offshore / inshore seismic reflection surveys in shallow water (less then 10 m) multiple “intrabed” reflections can cause interpretation problems and limitations ion depth of the interpretation. Gas filled sediments in the shallow subsurface organic sediments (below water / sediments interface) can cause deterioration in reflected ways signal amplitudes consequently causing problems in layer interface definition and data interpretation.

In some cases when insufficient seismic impedance contrast between the sediment layers prevents observable reflections interpretation can be hindered. These problems of seismic reflection signal responses can also be associated with massive homogeneous sediment rock layers present in the subsurface.

The average seismic velocity assigned for time conversion to depth is 1600 meters per second. This velocity was assigned after analysis of the shallow refraction data. Some reduction on the averaged seismic velocity of the sediment layer was conservatively used in the interpretation. 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.

Resolution of the SBP system used is estimated at +/- 25 cm.

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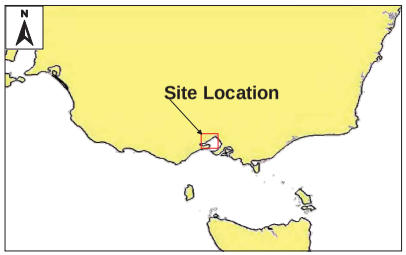
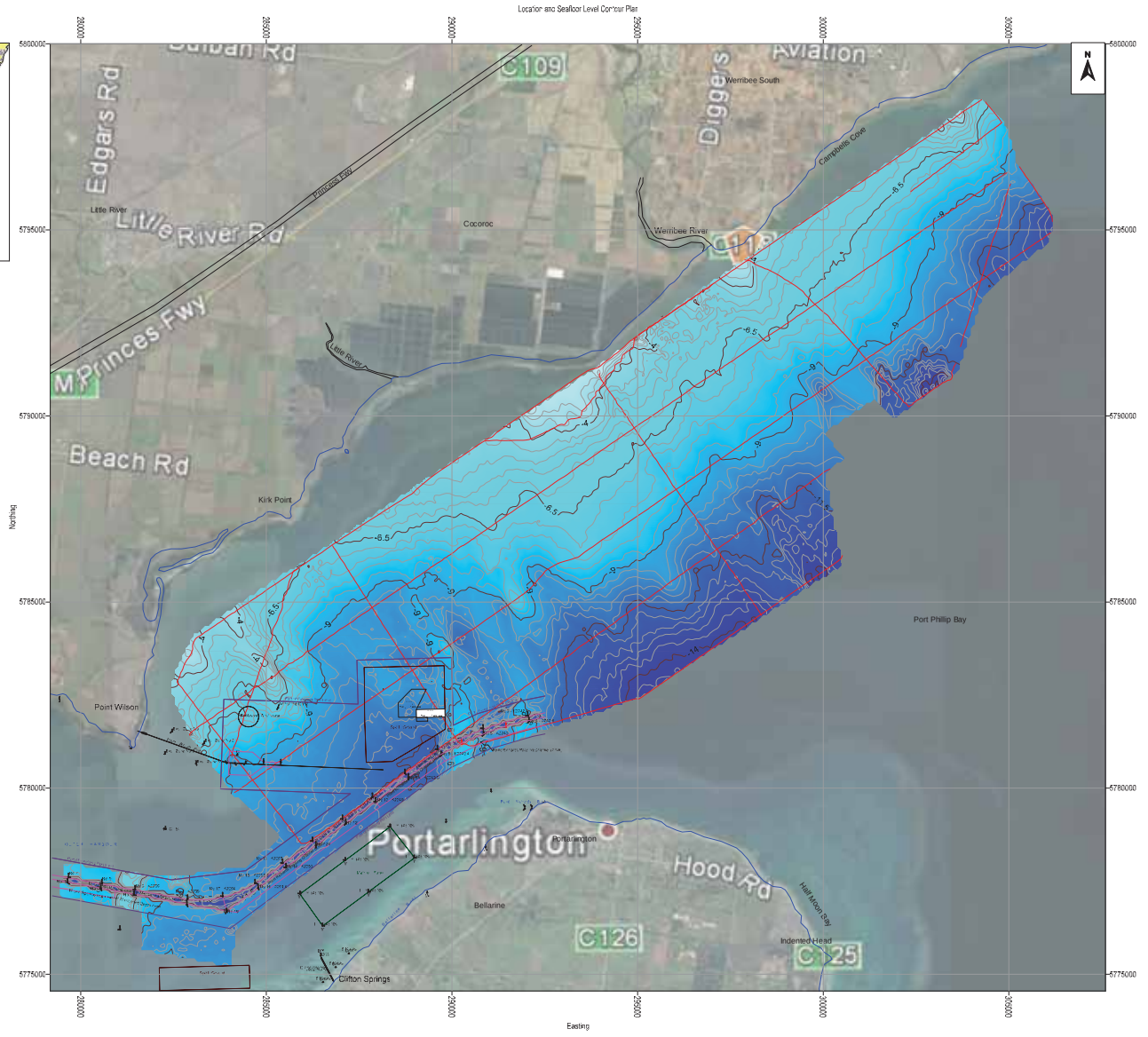
Appendices

Appendix A - (Figures)

Content:





LEGEND:

Wilson Spit study (GHD 2016)

Bay West SBP, SSS and MM Survey (GHD 2016)

Bathymetry (mCD)

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Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria

Bay West Project

Offshore Geophysical Investigation

SBP, MM and SSS Survey

scale 1:60,000 date 16/09/2016

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Projection: Transverse Mercator
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Job No. 31/34451

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Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Location and Seafloor Level Contour Plan

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

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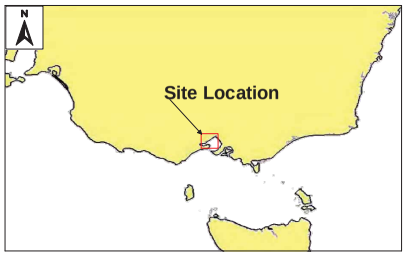
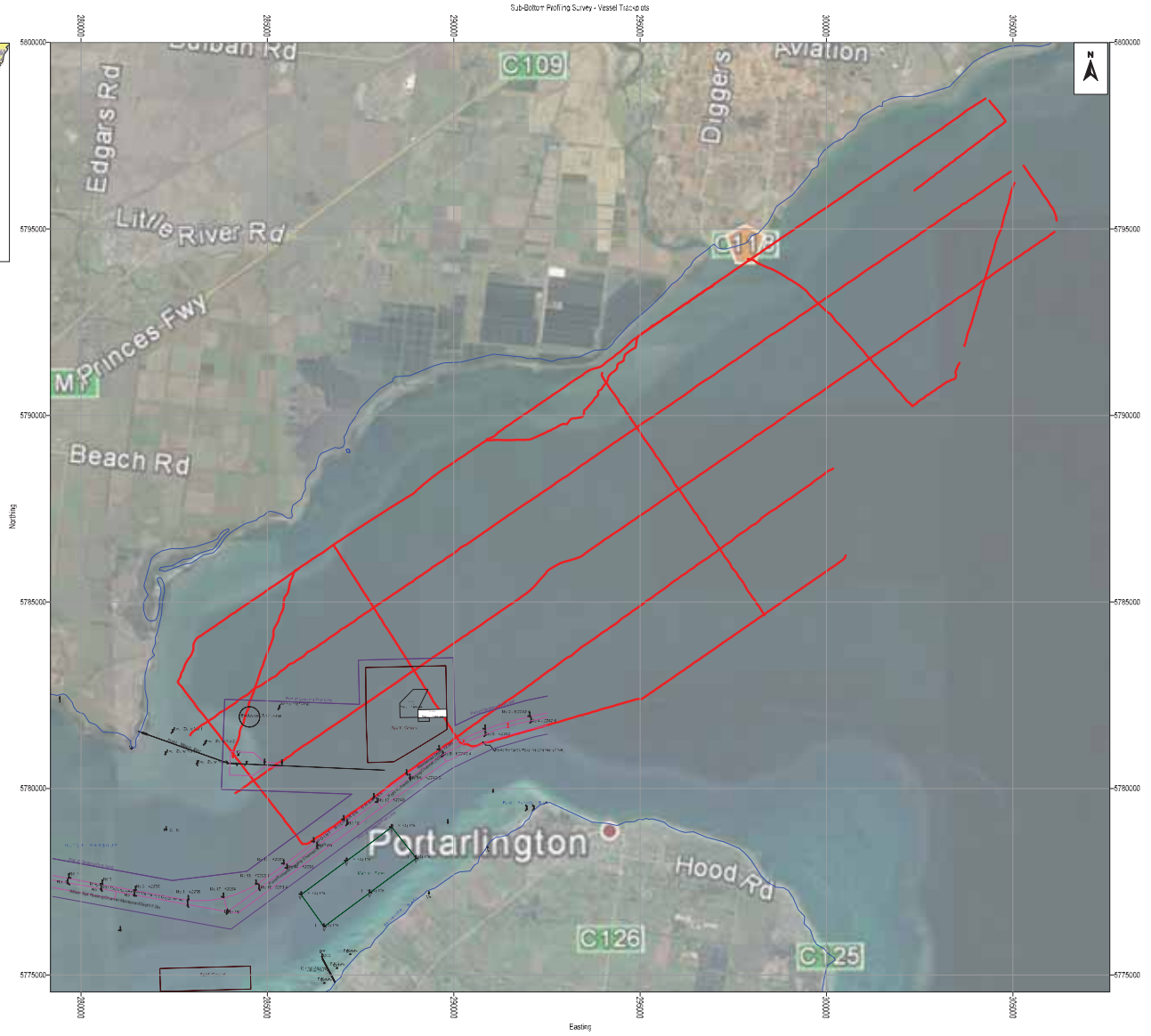
Figure A1





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GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria
Bay West Project
Offshore Geophysical Investigation
SBP, MM and SSS Survey
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Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Sub-Bottom Profiling Vessel Trackplots

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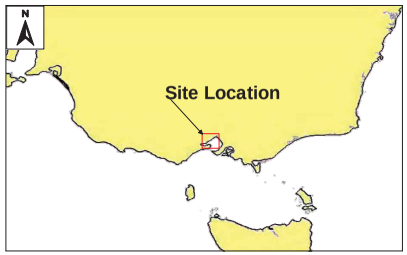
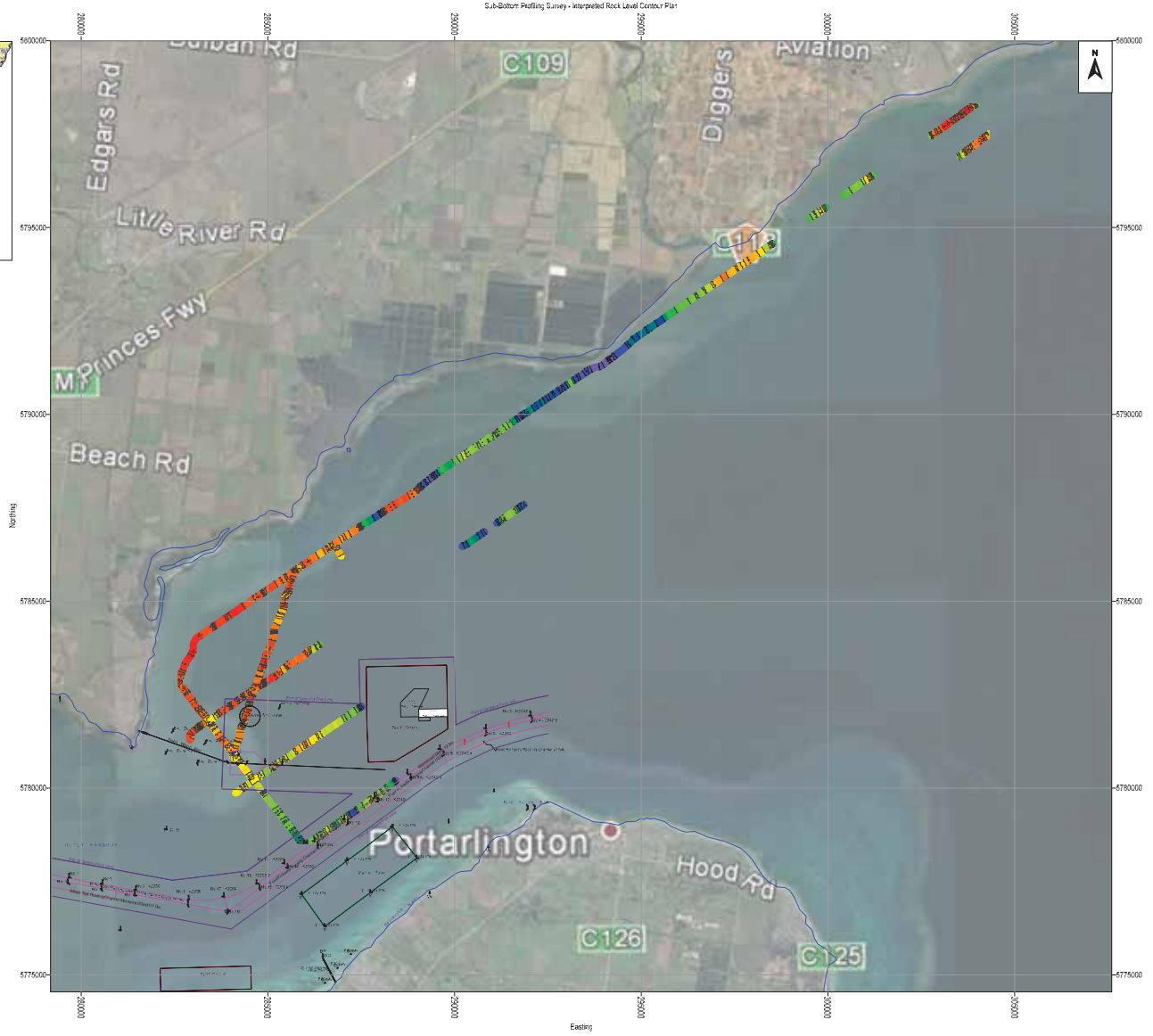
Figure A2



Sub-Bottom Profiling Survey - Interpreted Rock Level Contour Plan



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Wilson Spit study (GHD 2016)

Bay West SBP, SSS and MM Survey (GHD 2016)

Top of Rock Map (mCD)

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Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria

Bay West Project

Offshore Geophysical Investigation

SBP, MM and SSS Survey

scale 1:60,000 date 16/09/2016

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Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

Job No. 31/34451

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Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Interpreted Rock Level Contour Plan

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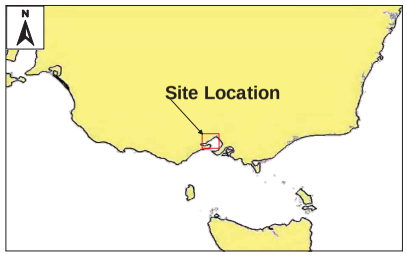
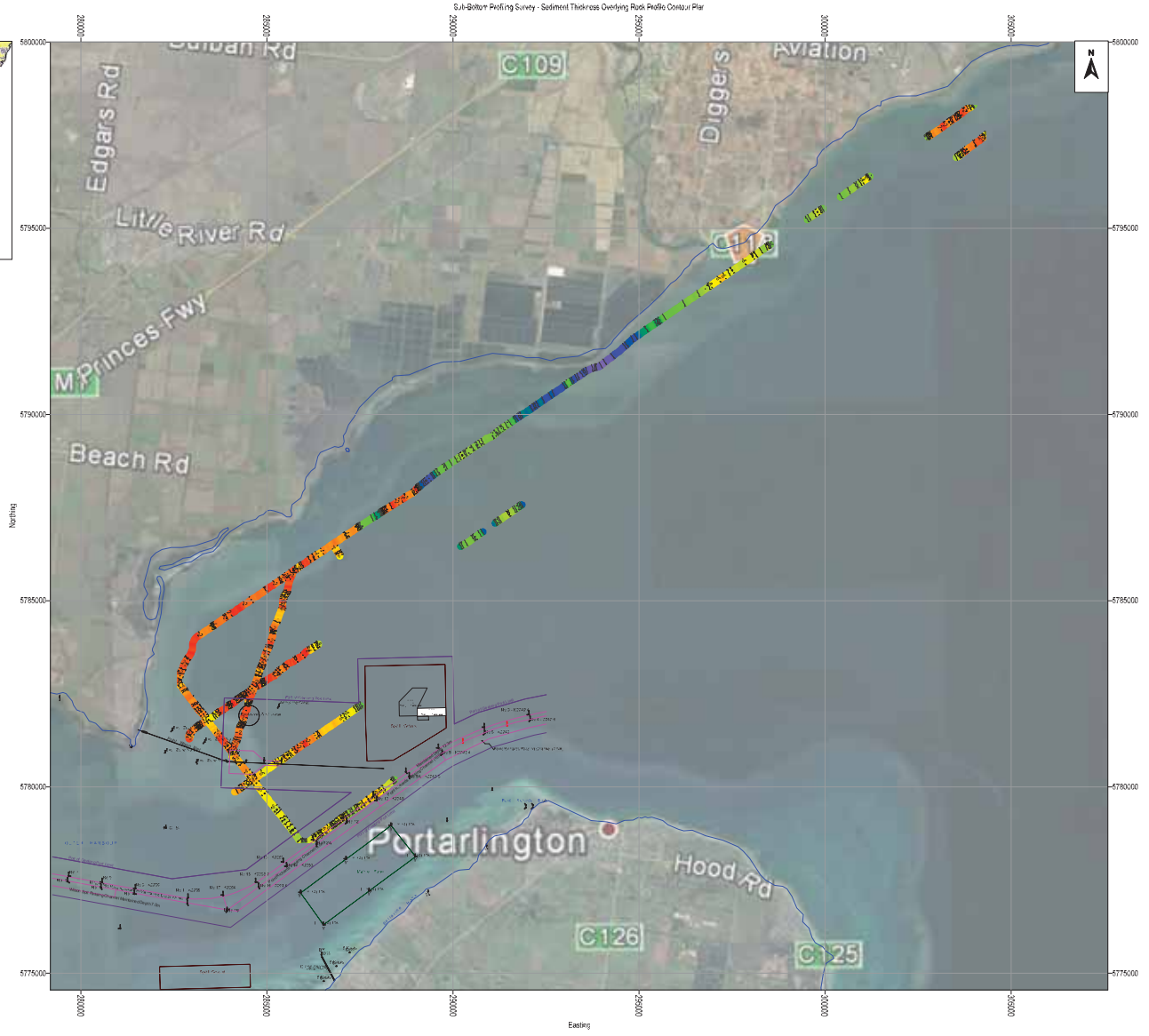


Sub-Bottom Profiling Survey - Sediment Thickness Overlying Rock Profile Contour Plan



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Bay West SBP, SSS and MM Survey (GHD 2016)

Soil Thickness Map (m)

Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria

Bay West Project

Offshore Geophysical Investigation

SBP, MM and SSS Survey

scale 1:60,000 date 16/09/2016

Scale: 1:60000 @ A1

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Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

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Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Sediment Thickness Contour Plan

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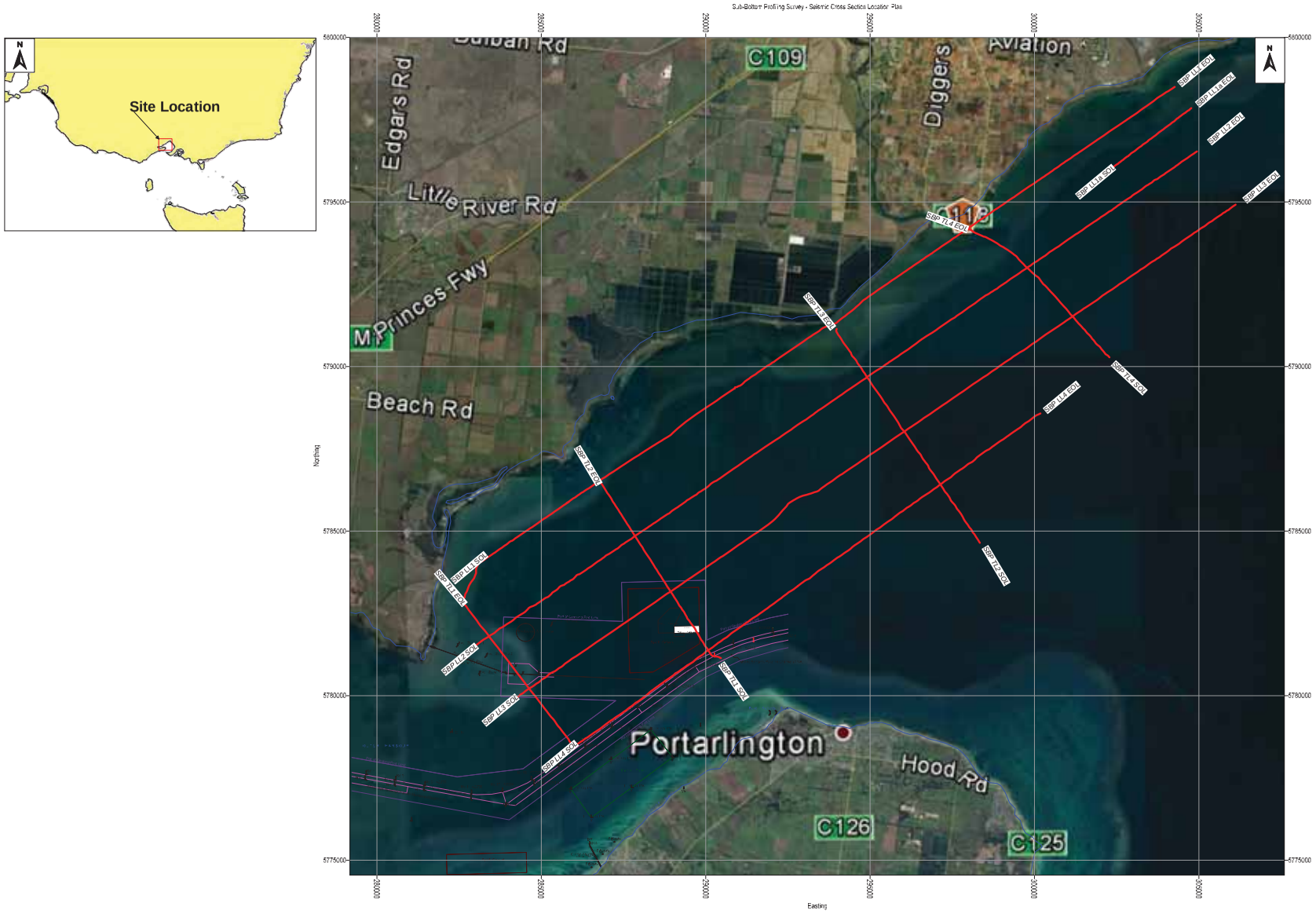
Figure A4



Source: Infrastructure Victoria; Google Earth Pro

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Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Seismic Cross Section Location Plan

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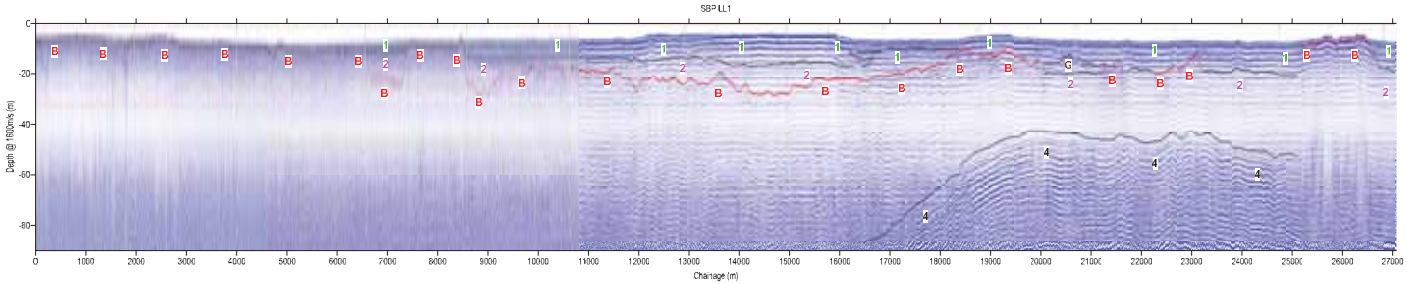
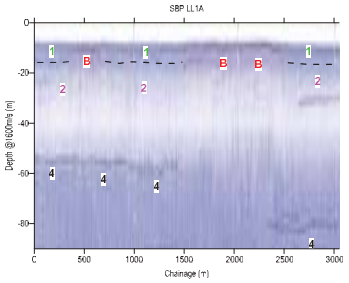
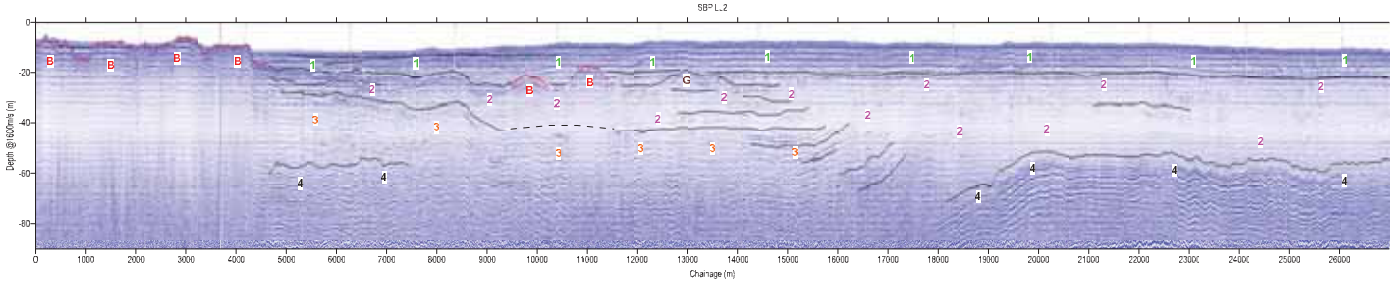
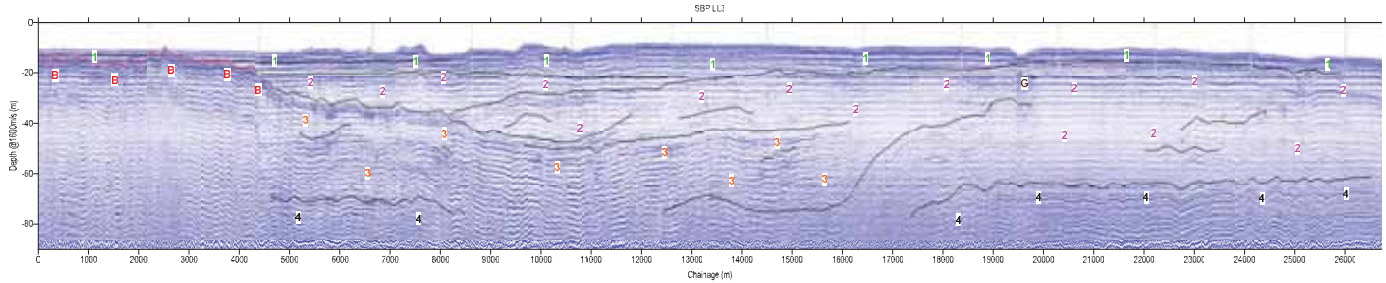
Figure A5

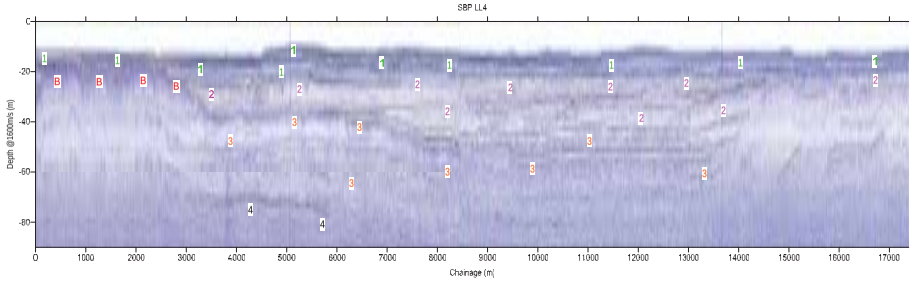




KEY
1 - Unit 1
2 - Unit 2
3 - Unit 3
4 - Unit 4
B - Basalt
G - Gravel







Source: Infrastructure Victoria; Google Earth Pro

GHD
marineEarthsciences
INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria
Bay West Project
Offshore Geophysical Investigation
SBP, MM and SSS Survey
scale As Shown date 16/09/2016

Scale: 1:50000 @ A1
0 2000 4000 6000
m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

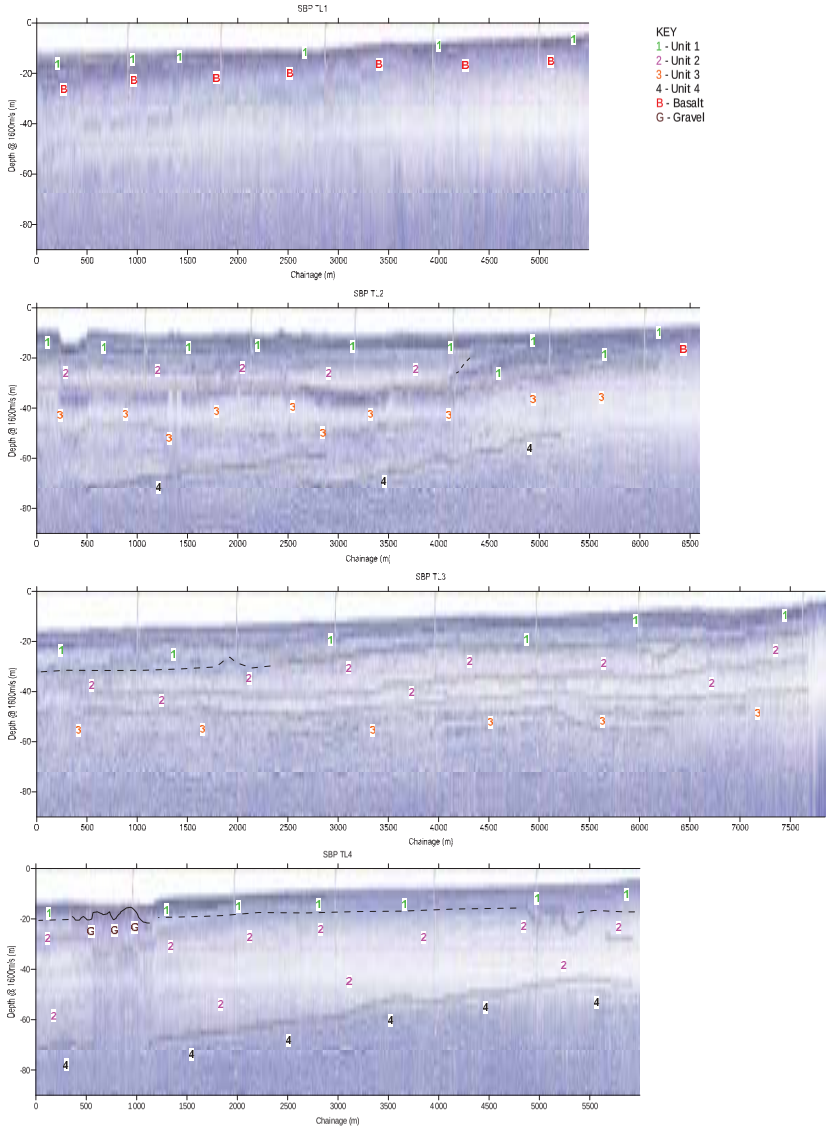
Job No. 31/34451
file ref G:/31/34451/Tech/Geophysics/Report/Figures/

Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Interpreted Seismic Cross Sections

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A6



Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria
Bay West Project
Offshore Geophysical Investigation
SBP, MM and SSS Survey
scale As Shown date 16/09/2016

Scale: 1:25000 @ A1
0 1000 2000 3000
m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

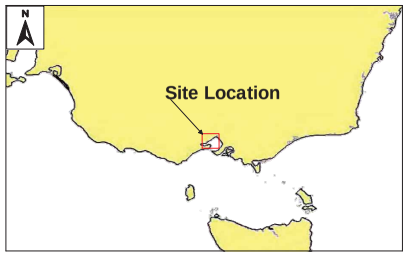
Job No. 31/34451
file ref G:/31/34451/Tech/Geophysics/Report/Figures/

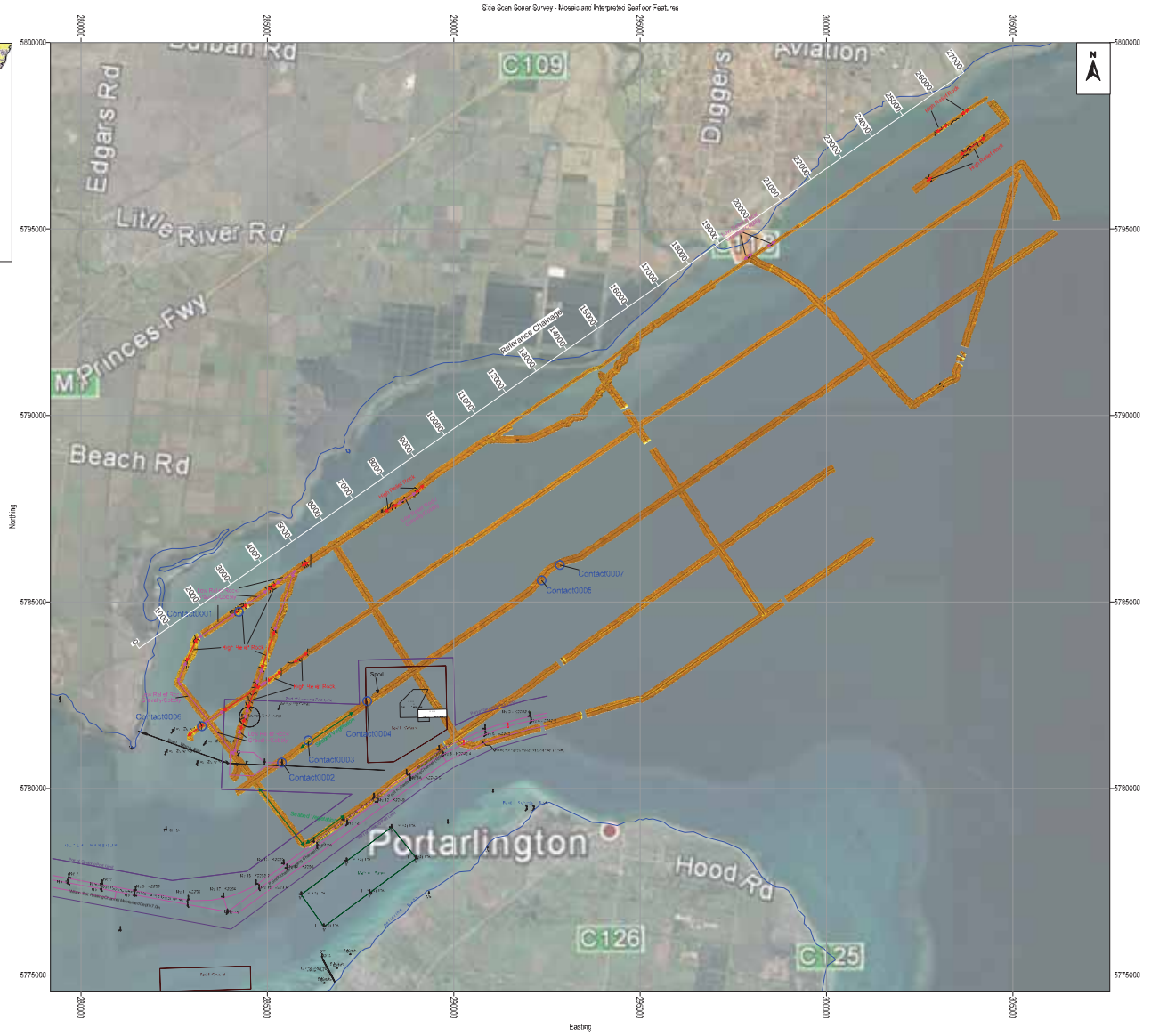
Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Interpreted Seismic Cross Sections

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A7





Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria
Bay West Project
Offshore Geophysical Investigation
SBP, MM and SSS Survey
scale 1:60,000 date 16/09/2016

Scale: 1:60000 @ A1
0 2000 4000 6000
m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

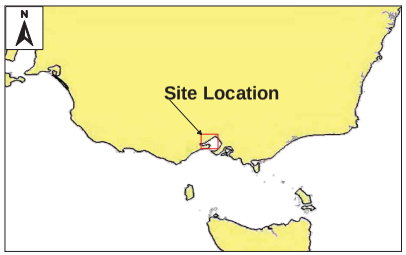
Job No. 31/34451
file ref G:/31/34451/Tech/Geophysics/Report/Figures/

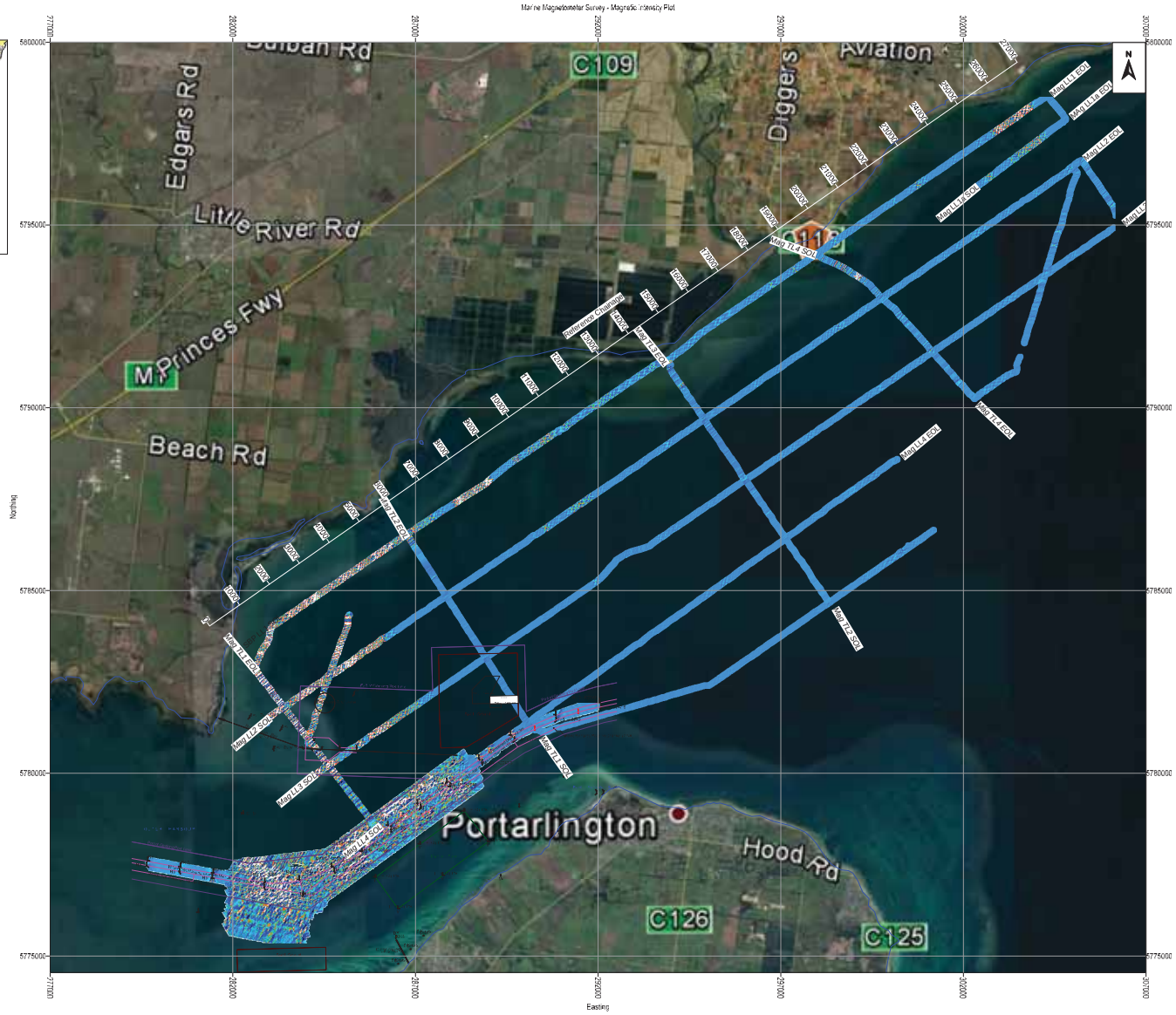
Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Sonar Mosaic and Interpreted Features

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A8





LEGEND:

Wilson Spit study (GHD 2016)

Bay West SBP, SSS and MM Survey (GHD 2016)

Magnetic Intensity Map

Source: Infrastructure Victoria; Google Earth Pro

GHD marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria

Bay West Project

Offshore Geophysical Investigation

SBP, MM and SSS Survey

scale 1:60,000 date 16/09/2016

Scale: 1:60000 @ A1

0 2000 4000 6000

m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

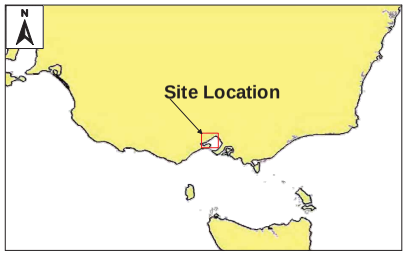
Job No. 31/34451
file ref G:/31/34451/Tech/Geophysics/Report/Figures/

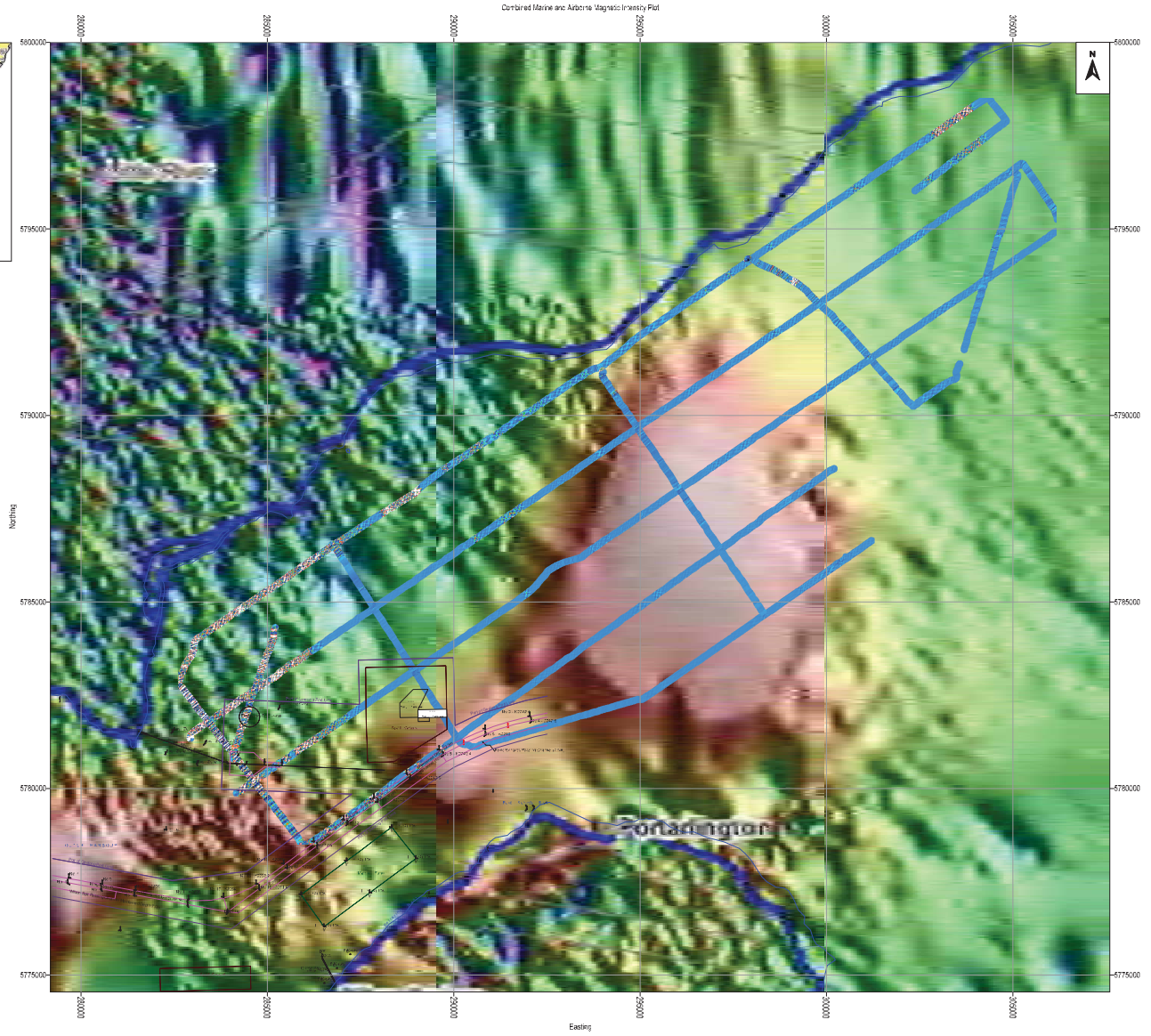
Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Marine Magnetic Intensity Plot

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A9





Source: Infrastructure Victoria; Google Earth Pro

GHD
marineEarthsciences

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria
Bay West Project
Offshore Geophysical Investigation
SBP, MM and SSS Survey
scale 1:60,000 date 16/09/2016

Scale: 1:60000 @ A1
0 2000 4000 6000
m

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

Job No. 31/34451
file ref G:/31/34451/Tech/Geophysics/Report/Figures/

Bay West Geophysical Investigation
Offshore SBP MM and SSS Survey
Combined Marine and Airborne Magnetics

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au/ghdgeotechnics

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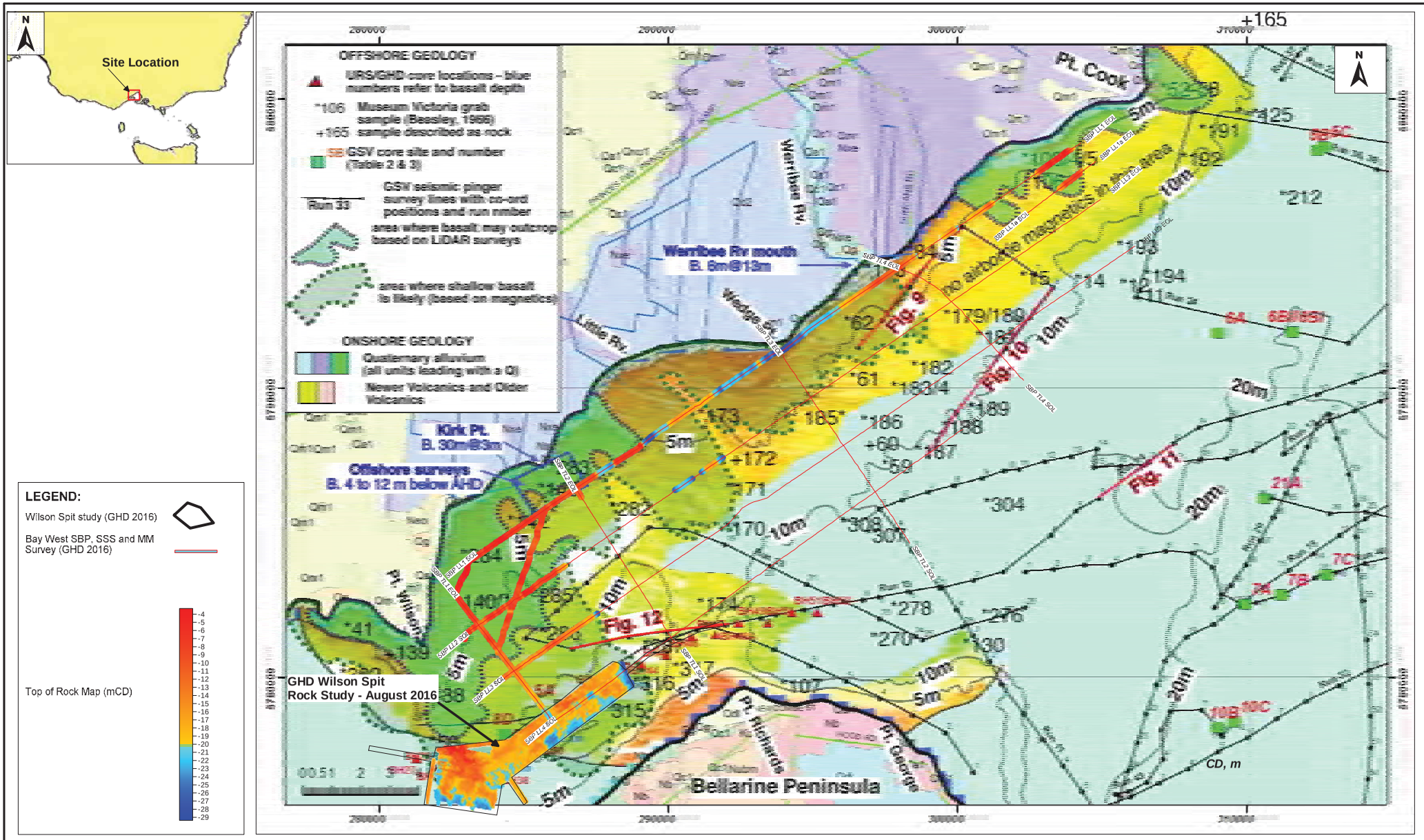
Figure A10



GHD

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria		
Bay West Geotechnical Study		
Geophysical Investigation		
SBP SSS and MM Geophysics Survey		
scale	as shown	date 10/09/2016

Axes Scale: 1:120000 @ A3

0 2000 4000 6000

Metres

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

Job No.: **31/34451** ©

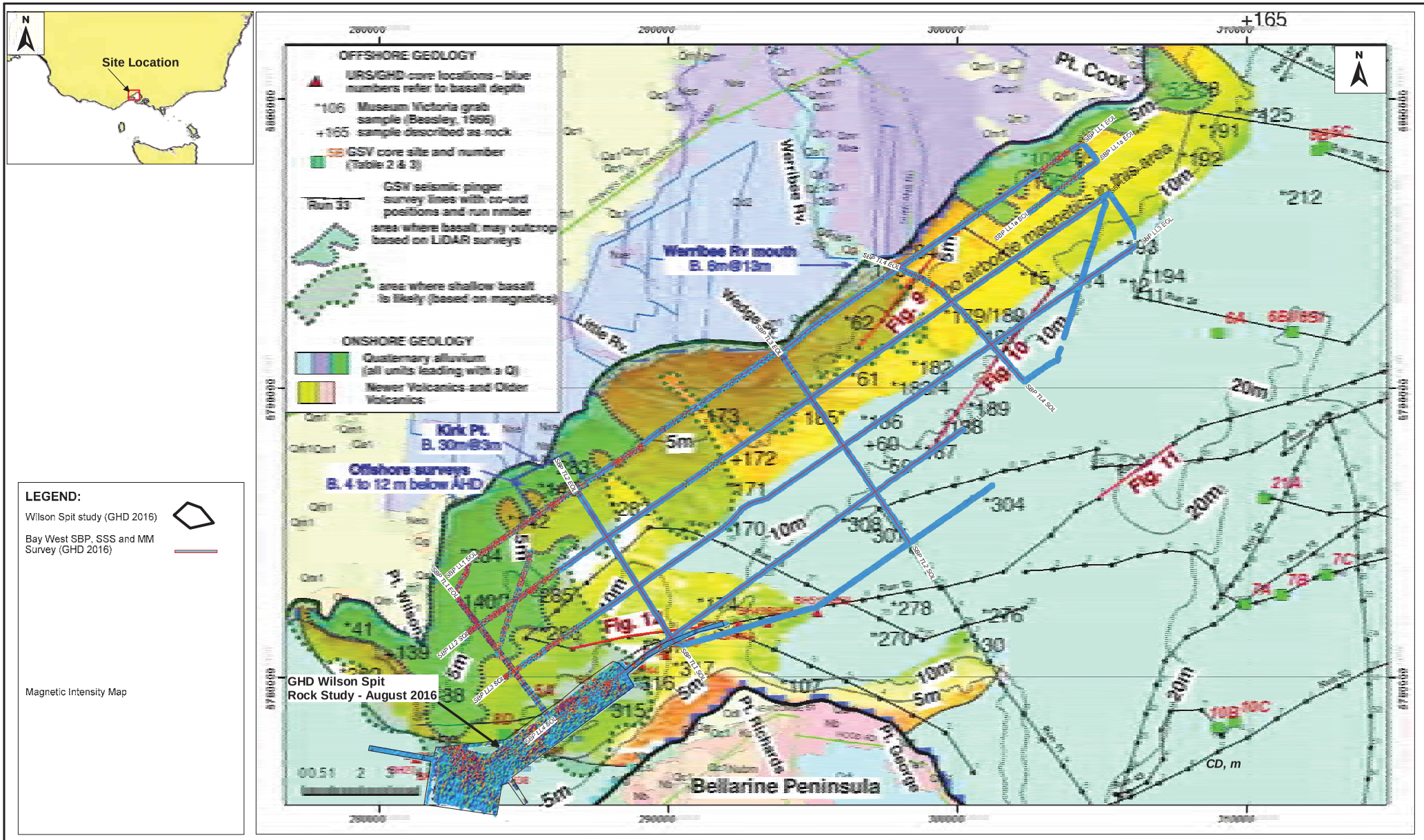
Ref file: N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Bay West Geophysics
Geophysical Investigation Top of Rock Map
Combined with Interpretive Map by Holdgate 2016

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A11

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au



GHD

INFRASTRUCTURE VICTORIA

Client: Infrastructure Victoria		
Bay West Geotechnical Study		
Geophysical Investigation		
SBP SSS and MM Geophysics Survey		
scale	as shown	date 10/09/2016

Axes Scale: 1:120000 @ A3

0 2000 4000 6000

Metres

Projection: Transverse Mercator
Horizontal Datum:MGA 1994
Grid: GDA 1994 MGA Zone 55

Job No.: **31/34451** ©

Ref file: N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Bay West Geophysics
Geophysical Investigation-Magnetic Intensity Map
Combined with Interpretive Map by Holdgate 2016

N:/AU/Melbourne/Projects/31/34451/Tech/Geophysics/Report/Figures/

Figure A12

Level 8, 180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au

Appendix B - (URS and GHD BH information and Borehole Logs and core photos)

Content

GEOTECHNICAL BOREHOLE BH27

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520	Logged By: KF	Sea Bed Relative Level: 5.80 mbCD	Client: Victorian Regional Channels Authority
	Checked By: DW	Coordinates: 5777163.00 mN	
	Date Started: 26-2-14	281273.00 mE	
	Date Finished: 26-2-14	Area: WSC2	Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	MVS	0			**SEAWATER** Sea bed at 5.8 m below CD														
		6		SC	**Clayey SAND**: fine to coarse grained, pale brown to orange brown, mottled grey, clay is low plasticity, white alteration, with some gravels, fine to medium grained White alteration decreasing with depths from 6.1 mbCD	M	VSt			BH27_6.0-6.4 430mm recovery BH27_6.4-6.85	Drilling is firm, possibly a crust at 5.8 mbCD Inferred thin layer of QS at 5.8 mbCD Drilling is soft at 5.9 mbCD Drilling is firm at 6.85 mbCD	-	34	18	33.3	-	107.5 (NFP)	>600, 580, 500	7, 8, 13 N=21
		7		CL	**Sandy CLAY**: medium plasticity, orange brown mottled pale grey, sand is fine grained, uniform, some silt														
		9			**Sandy CLAY**: medium plasticity, orange brown mottled pale grey, sand is fine grained, uniform, some silt With trace gravels and cobble, gravels are fine to coarse grained, 3mm to 15mm, rounded to sub-rounded, dark grey, white, cobble is sub-angular, 31mm x 20mm at 9.8 mbCD		VSt			BH27_9.0-9.4 440mm recovery BH27_9.4-9.80 BH27_9.80-9.85	Drilling is hard at 9.85 mbCD	-	37	23	56.9	-	108	380, 380, 220	5, 5, 10 N=15
		12		CH	**CLAY**: high plasticity, orange brown mottled pale grey, sands becoming fine to coarse grained, poorly sorted, rounded, grey quartz sands, no cobbles	M/W	VSt			BH27_12.0-12.4 BH27_12.4-12.6		1.61	61	41	78.0	284	>140	280, 370, 260	7, 9, 15 N=24
		13		GP SP	With some gravels, medium to coarse grained, up to 15mm, rounded, cemented, white at 12.6 mbCD **GRAVELS**: gravels are brown, white, lithics, subrounded to rounded, up to 20mm		L MD			BH27_12.65-12.8 BH27_12.8-12.85	Drilling is firm, possibly high sand content at 12.85 mbCD								
		14			**SAND**: some clay, sand is medium to coarse grained, well sorted, rounded, pale brown, orange, white, grey quartz sands, clay is orange brown Sands becoming fine grained sands, pale grey, uniform at 12.8 mbCD														

REMARKS: Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
NFP: Shear vane did not fully penetrate sample tube

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

GEOTECHNICAL BOREHOLE BH27

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 26-2-14
Date Finished: 26-2-14

Sea Bed Relative Level: 5.80 mbCD
Coordinates: 5777163.00 mN 281273.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	MVS	15		CH	CLAY: high plasticity, orange brown mottled pale grey, some sand, sand is medium grained, rounded		VSt			BH27_15.0-15.4 390mm recovery BH27_15.4-15.85		1.28	88	58	98.6	182	-	230, 320, 300	3, 3, 10 N=13
		16																	
		17																	
		18		SM	Silty SAND: fine to medium grained, orange brown mottled pale grey	W	VD			BH27_18.1-18.55	Refusal of attempted tube sample BH27_18.0-18.1, after 100mm. No sample recovery.	-	ND	ND	31.1	-	-	-	7, 10, 30/120mm N=40+
		19																	
		20																	
		21		CH	CLAY: high plasticity, brown mottled orange brown, trace nodules, nodules are sandy, yellow brown, and nodules are cemented, white Clay becoming grey at 21.1 mbCD	M	St			BH27_21.0-21.45									4, 4, 4 N=8
		22			END OF BOREHOLE AT 21.45 m CD - TARGET DEPTH														
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS: ND: Not determined, not relevant to sand

GEOTECHNICAL BOREHOLE BH28

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling		Project No.: 43513982	Project Reference: Future Channel Improvement Options
Drill Type: DB520	Logged By: KF Checked By: DW Date Started: 17-2-14 Date Finished: 17-2-14	Sea Bed Relative Level: 8.90 mbCD Coordinates: 5776846.00 mN 281927.00 mE Area: WSC2	Client: Victorian Regional Channels Authority Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER** Sea bed at 8.9 m below CD														
	UNCON	9		CH	CLAY: high plasticity, grey and pale grey, trace sand, sands are fine to medium grained, rounded, uniform, grey to clear, trace shell fragments, shells are 1 to 4mm, white, cream, orange, trace organic matter	W	VS			BH28_9.0-9.4 350mm recovery BH28_9.4-9.65 BH28_9.65-9.85	Drilling is very soft at 8.9 mbCD	-	67	41	90.4	-	0	0, 0, 0	
		10		CH	CLAY: high plasticity, grey, some sand, sands are fine to medium grained, rounded, uniform, grey to clear, trace shell fragments, shells are 1 to 4mm, white, cream, orange														0, 0, 0, N=0
	QS	11																	
		12		CH	CLAY: high plasticity, dark brown mottled orange brown and grey, trace sand, sands are fine to coarse grained, rounded, grey to clear, with some gravels, 5-20mm, white, cemented nodules, cemented sands	M/W	VSt			BH28_12.0-12.4 360mm recovery BH28_12.4-12.85	Drilling becoming firmer at 11.85 mbCD Alternating lenses of hard and soft sediment from 12.85 mbCD	1.52	66	41	77.7	274	NP	330, 330, 360	6, 9, 12 N=21
	MVS	13																	
		14																	

REMARKS: Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
NP: No penetration of shear vane

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

URS

GEOTECHNICAL BOREHOLE BH28

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520	Logged By: KF	Sea Bed Relative Level: 8.90 mbCD	Client: Victorian Regional Channels Authority
	Checked By: DW	Coordinates: 5776846.00 mN	
	Date Started: 17-2-14	281927.00 mE	
	Date Finished: 17-2-14	Area: WSC2	Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	MVS	15		CH	CLAY: high plasticity, pale brown to orange mottled pale grey, with some sand, sands are fine to coarse grained, rounded, grey to clear, with some gravels, 5-20mm, white, cemented nodules, cemented sands	W	St			BH28_15.0-15.4 415mm recovery BH28_15.4-15.85		1.45	59	37	83.9	149	68	90, 90, 100	0, 4, 13 N=17
		16		SW	Gravelly SAND: sands are fine to coarse grained, up to 2mm, rounded, uniform, red, orange, black, grey, some quartz, some lithics, gravels are up to 22mm, sub-rounded to sub-angular		L												
		17																	
		18		SP	SAND: fine grained, pale brown to white, rounded, uniform	W	MD			BH28_18.15-18.4	Refusal of attempted tube sample BH28_18.0-18.15, after 150mm. No sample recovery. Alternating lenses of hard and soft sediment continues at 19 mbCD								
				CH	CLAY: high plasticity, pale grey mottled pale brown orange, trace fine grained sand	W	St			BH28_18.4-18.6 BH28_18.6-19.0 460mm recovery		-	63	44	91.7	-	86	190, 230, 200	9, 4, 3 N=7
		19																	
		20																	
		21			CLAY: high plasticity, pale grey to grey, trace fine grained sand Becoming mottled orange brown at 21.2 mbCD Becoming pale grey to grey at 21.25 mbCD	W	S			BH28_21.0-21.45									0, 0, 3 N=3
		22			END OF BOREHOLE AT 21.45 m CD - TARGET DEPTH														
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS:

GEOTECHNICAL BOREHOLE BH29

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling		Project No.: 43513982	Project Reference: Future Channel Improvement Options
Drill Type: DB520	Logged By: KF Checked By: DW Date Started: 28-2-14 Date Finished: 28-2-14	Sea Bed Relative Level: 9.10 mbCD Coordinates: 5776948.00 mN 282360.00 mE Area: WSC2	Client: Victorian Regional Channels Authority Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8			Sea bed at 9.1 m below CD														
	UNCON	9		CH	CLAY: high plasticity, grey, some sand, sand is fine to medium grained, rounded, trace shells, whole shells up to 23mm, shell fragments, up to 5mm, white	W	VS			BH29_9.5-9.9 420mm recovery	Drilling is soft at 9.1 mbCD	-	69	41	94.6	-	4	0, 0, 0	
		10		CH	CLAY: high plasticity, grey and pale grey, trace sand, sand is fine to coarse grained, rounded, trace shells, whole shells up to 23mm, shell fragments, up to 5mm, while					BH29_9.9-10.25								0, 0, 0 N=0	
		11																	
	QS	12				M/W	St			BH29_12.0-12.4 260mm recovery		NA+	89	54	84.0	NA+	85	320, 240, 260	
										BH29_12.4-12.85									1, 2, 4 N=6
	MVS	13		CL	CLAY medium plasticity, orange pale brown mottled pale grey, decreasing sand content to trace sands, becoming fine to coarse sands, becoming trace gravels, fine to medium grained, rounded to sub-rounded up to 7mm No longer trace gravels at 12.6 mbCD						Drilling becomes firm at 12.85 mbCD								
		14																	

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology
NA+: Sample too disturbed, not able to be tested by laboratory
NP: No penetration of shear vane

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

GEOTECHNICAL BOREHOLE BH29

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 28-2-14
Date Finished: 28-2-14

Sea Bed Relative Level: 9.10 mbCD
Coordinates: 5776948.00 mN
282360.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	MVS	15		CL	CLAY medium plasticity, orange pale brown mottled pale grey, decreasing sand content to trace sands, becoming fine to coarse sands, becoming trace gravels, fine to medium grained, rounded to sub-rounded up to 7mm Becoming pale grey mottled orange, sands are quartz sands, grey, clear, sub-rounded at 15.4 mbCD		VSt			BH29_15.0-15.4 455mm recovery BH29_15.4-15.85		1.36	41	27	84.8	118	NP	>600, >600, >600	2, 4, 6 N=10
		16									Drilling is soft at 15.85 mbCD								
		17																	
		18					D				Refusal at 300mm of attempted tube sample BH29_18.0-18.3, no sample recovery								
				SW GP SP	SAND: fine to medium grained, pale grey, uniform GRAVELS: fine grained, up to 6mm, predominantly quartz gravels, trace lithics, clear, grey, rounded to sub-rounded SAND: fine grained, pale grey, uniform	W				BH29_18.3-18.4 BH29_18.4-18.52 BH29_18.52-18.75	Sands blocking rods Refusal at 200mm of attempted tube sample BH29_18.75-18.95, no sample recovery	-	NA	NA	8.9	-	-	.31/100mm	16, N=31
		19																	
	BS	20		GC	INTERBEDDED BASALT GRAVELS AND CLAY: basalt gravels are coarse grained, dark grey, grey-green and orange colouration, vesicular, extremely weathered, up to 27mm, rounded, with gravelly/sandy clay, medium to high plasticity, green to grey to pale grey, sands medium grained						Change in lithology, no longer clean sands at 19.9 mbCD								
		21				M	VSt H			BH29_21.0-21.1 BH29_21.1-21.15 BH29_21.15-21.2	Drilling becomes firmer at 20.9 mbCD Refusal of SPT sample at 380mm on basalt								20, 29, 7 (5BB)/80mm N=36**
					END OF BOREHOLE AT 21.40 m CD - TARGET DEPTH		VSt			BH29_21.2-21.3 BH29_21.3-21.4									
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS: NA: Insufficient sample for analysis
*Refusal of SPT at 250mm
**Refusal of SPT at 380mm

URS

GEOTECHNICAL BOREHOLE BH30

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 14-2-14
Date Finished: 14-2-14

Sea Bed Relative Level: 9.00 mbCD
Coordinates: 5776720.00 mN
282608.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8			Sea bed at 9 m below CD														
	UN	9		CL	NO SAMPLE COLLECTED		VS				No sample recovery of attempted tube sample BH30_9.0-9.4								
				CH	CLAY: high plasticity, grey and dark grey, with some gravels, fine to medium grained gravels, trace shells and shell fragments up to 2mm, white, trace fine to coarse sands					BH30_9.4-9.85									0, 0, 0 N=0
		10				W	VS			BH30_9.85-10.25		-	65	40	77.5	-	0*	0, 0, 0*	
		11																	
	QS	12		CH	CLAY: high plasticity, grey and dark grey, with some gravels, fine to medium grained gravels, trace shells and shell fragments up to 2mm, white, trace fine to coarse sands		F			BH30_12.0-12.4 420mm recovery BH30_12.4-12.6 BH30_12.6-12.85		0.76	77	46	92.6	20	89	200, 170, 200	
				CH	CLAY: high plasticity, pale grey to green mottled pale brown, with some sand, sand is medium grained to coarse grained, rounded, dark brown, grey Cementation evident in sandy clay, white, sandy at 12.55 mbCD						Drilling is soft at 12.85 mbCD Gravel lense at 13.4 mbCD Drilling is soft at 13.5 mbCD Hard layer at 14.7 mbCD								2, 2, 3 N=5
	BS	13																	
		14																	

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**
___ Inferred boundary between geologic units (ie. MVS and QS)
___ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UN- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology
*Shells preventing accurate shear vane and penetrometer readings
BH30A coordinates: E 282611 N 5776715

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

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GEOTECHNICAL BOREHOLE BH30

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 14-2-14
Date Finished: 14-2-14

Sea Bed Relative Level: 9.00 mbCD
Coordinates: 5776720.00 mN
282608.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
		15			END OF BOREHOLE AT 15.00 m CD - REFUSAL ON BASALT (INFERRED)						Refusal of attempted tube sample BH30A_15.0, no sample recovery.								
		16																	
		17																	
		18																	
		19																	
		20																	
		21																	
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS:

URS

GEOTECHNICAL BOREHOLE BH31

URS Australia
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Phone (03) 8699 7500
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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 3-3-14
Date Finished: 3-3-14

Sea Bed Relative Level: 9.70 mbCD
Coordinates: 5776904.00 mN, 282641.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER** Sea bed at 9.7 m below CD														
	UNCON	10		CH	**CLAY**: high plasticity, grey, with some sand, sand is grey, medium grained, rounded, with trace shells, whole up to 9mm, fragments, up to 5mm, white, with trace organic matter	W	VS			BH31_10.2-10.6 300mm recovery		-	64	40	86.8	-	0	0, 0, 0	
				CH	**CLAY**: high plasticity, grey, with some sand, sand is grey, medium grained, rounded, with trace shells, whole up to 9mm, fragments, up to 5mm, white, with trace organic matter					BH31_10.6-11.05									0, 0, 0 N=0
	QS	12		CH	**CLAY**: high plasticity, pale grey mottled grey, mottled green, mottled orange, with trace sand, sand is fine to coarse grained Becoming mottled pale brown to orange brown, increased sand content, with some sand at 12.6 mbCD		St			BH31_12.0-12.4 430mm recovery		1.30	77	45	83.1	130	84	240, 210, 160	
	BS	13								BH31_12.4-12.85									1, 3, 3 N=6
		14																	

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology

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GEOTECHNICAL BOREHOLE BH31

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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 3-3-14
Date Finished: 3-3-14

Sea Bed Relative Level: 9.70 mbCD
Coordinates: 5776904.00 mN
282641.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
WB- CA	BS	15		GC	INTERBEDDED BASALT GRAVELS AND CLAY: weathered basalt gravels (brown-red, vesicular, highly weathered, trace clay) and gravelly clay (medium plasticity, dark brown mottled pale grey, basalt gravels are red-brown, brown and dark brown, up to 24mm, highly weathered, vesicular, subrounded, some sands, sand is coarse grained)		D VS D			BH31_15.0-15.1 150mm recovery BH31_15.1-15.55	Refusal of tube sample BH31_15.0-15.1 at 100mm	-	-	-	-	-	NP	>600, >600, >600	12, 12, 25 N=37
		16			END OF BOREHOLE AT 15.55 m CD - REFUSAL ON BASALT														
		17																	
		18																	
		19																	
		20																	
		21																	
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS: NP: No penetration of shear vane

GEOTECHNICAL BOREHOLE BH32

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Phone (03) 8699 7500
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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 18-2-14
Date Finished: 24-2-14

Sea Bed Relative Level: 9.20 mbCD
Coordinates: 5776090.00 mN
282908.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8			Sea bed at 9.2 m below CD														
	UNCON	9		CH	CLAY: high plasticity, grey, trace sands, sands are fine grained, trace shells, fragments and whole shells, up to 30mm, white	W	VS			BH32_9.7-10.1 400mm recovery		-	67	41	97.9	-	4.5	0, 0, 0	
		10			Becoming grey with some brown mottling at 10.1 mbCD					BH32_10.1-10.55									0, 0, 0 N=0
		11		CH	CLAY: high plasticity, grey - dark grey, trace shells, whole and fragments, up to 25mm														
		12					VS			BH32_12.0-12.4 400mm recovery		0.65	80	50	94.1	10	9	10, 10, 10	
	QS	13		CH	CLAY: high plasticity, dark grey - black - green, trace shell fragments, up to 4mm		S			BH32_12.4-12.5 BH32_12.5-12.7 BH32_12.7-12.85									0, 0, 1 N=1
				CH	Sandy CLAY: high plasticity, pale grey to grey to green, sand is fine grained to medium grained, some white cementation														
	BS	14																	

REMARKS: Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals.

___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology
BH32A coordinates E 282911 N 5776667

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 10/7/14

GEOTECHNICAL BOREHOLE BH32

URS Australia
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Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 18-2-14
Date Finished: 24-2-14

Sea Bed Relative Level: 9.20 mbCD
Coordinates: 5776690.00 mN
282908.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	BS	15		CH	CLAY: high plasticity, pale grey some orange mottling, with trace sand, sand is fine grained		St			BH32_15.0-15.4 400mm recovery BH32_15.4-15.85	Refusal at 20 mm for attempted tube sample BH32_18.0, no recovery	1.19	105	75	92.8	93	89	230, 210, 200	2, 4, 5 N=9
		16																	
		17																	
		18		BASALT	BASALT: distinctly weathered, dark grey, iron staining, massive, highly vesicular, 2-4mm vesicles, carbonate coating, very high strength, with joints, sub-horizontal, 10 degrees, wavy - stepped, slighlty rough - rough, veneer slight carbonate/chlorite coating Becoming slighlty weathered, high strength at 19 mbCD														8DB Refus
Diamond Coring	BASALT	19			Becoming slighlty weathered with calcite inclusions, very high strength at 19.7 mbCD	RQD 67%					ROCK DEFECT 18.2 - 18.4 mbCD: joint, sub-vertical, 90 degrees, carbonate infill 18.5 - 18.6 mbCD: joint, 50 degrees, stepped, rough, veneer, green to yellow clay coating 19.5 - 19.65 mbCD: fracture zone, planar - irregular, rough, veneer, clay, calcite crystals 20.2 - 20.35 mbCD: joint, vertical, 95 degrees, stepped, rough, calcite minerals 20.5 - 20.7 mbCD: joint, sub-vertical, 20 degrees, stepped, slighlty rough, coated with hard carbonate	DEFECT SPACING 18 - 18.5 mbCD: 180-200 mm 18.5 - 18.85 mbCD: 150 mm 18.85 - 19.15 mbCD: 30 mm 19.15 - 19.5 mbCD: 80 mm 19.5 - 19.65 mbCD: 10 mm 19.65 - 20.2 mbCD: 550 mm 20.2 - 20.5 mbCD: 90 mm 20.5 - 20.7 mbCD: 40 mm								
		20																	
		21			END OF BOREHOLE AT 20.7 mbCD - TARGET DEPTH														
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS: DS- Defect spacing
RQD- Rock Quality Designation

GEOTECHNICAL BOREHOLE BH33

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520	Logged By: KF	Sea Bed Relative Level: 9.40 mbCD	Client: Victorian Regional Channels Authority
	Checked By: DW	Coordinates: 5776825.00 mN	
	Date Started: 3-3-14	282990.00 mE	
	Date Finished: 3-3-14	Area: WSC2	Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9			Sea bed at 9.4 m below CD														
	UNCON	10		CH	CLAY: high plasticity, grey, with some sand, medium grained, rounded, trace shell fragments, up to 8mm, white, trace organic matter	W	VS			BH33_9.9-10.3 360mm recovery		-	65	40	95.3	-	3	0, 0, 0	
										BH33_10.3-10.75									0, 0, 0 N=0
				CH	Increasing shell content at 10.4 mbCD CLAY: high plasticity, dark grey, trace shells, whole and fragments, up to 3mm, white, trace organic matter														
		11																	
	QS	12		CH	CLAY: high plasticity, dark grey, trace shells, whole and fragments, up to 3mm, white, trace organic matter					BH33_12.0-12.4 390mm recovery	Hydrogen sulphide odour at 12 mbCD	0.64	72	43	93.7	15	7	5, 10, 10	
				CH	Sandy CLAY: high plasticity, pale grey mottled pale brown orange, sand is fine to medium grained, rounded, poorly sorted, white, brown		F			BH33_12.4-12.85									0, 1, 3 N=4
	BS	13																	
		14																	

REMARKS: Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

GEOTECHNICAL BOREHOLE BH33

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 3-3-14
Date Finished: 3-3-14

Sea Bed Relative Level: 9.40 mbCD
Coordinates: 5776825.00 mN
282990.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
WB-CA	BS	15		GC	**INTERBEDDED BASALT GRAVELS AND CLAY:** basalt gravels (fine to coarse grained, up to 35mm, well sorted, subrounded, white, pale grey, yellow-brown) and gravelly/sandy clay (medium to high plasticity, pale grey mottled orange brown-pale brown, sand is medium grained, white, clear, dark brown, with some basalt gravels, brown mottled dark brown, red brown, up to 8mm, vesicular, weathered)					BH33_15.0-15.1 BH33_15.1-15.3	Refusal of attempted tube BH33_15.0 at 70mm, no recovery Refusal of attempted SPT sample BH33_15.1-15.3 at 200mm At 15.3 mbCD, refusal of drilling after 130mm, hard gravels								18, 8+5DB refusa
		16			END OF BOREHOLE AT 15.40 m CD - REFUSAL ON BASALT														
		17																	
		18																	
		19																	
		20																	
		21																	
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS:

URS

GEOTECHNICAL BOREHOLE BH34

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 27-2-14
Date Finished: 27-2-14

Sea Bed Relative Level: 9.50 mbCD
Coordinates: 5776612.00 mN
283222.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9			Sea bed at 9.5 m below CD														
	UNCON	10		CH	CLAY: high plasticity, grey, with trace sands, sands are medium grained, rounded, white, grey, trace shells, up to 3mm, white	W	VS			BH34_10.0-10.4 440mm recovery	Drilling is soft at 9.5 mbCD	-	64	39	98.8	-	0	0, 0, 0	
					Clay becoming pale brown mottled grey, increasod shell content, shells becoming up to 15mm at 10.4 mbCD					BH34_10.4-10.85									0, 0, 0 N=0
		11		CH	CLAY: high plasticity, dark grey, sand is fine grained, trace shell fragment and whole shells, up to 8mm, white														
		12								BH34_12.0-12.4 430mm recovery		0.53	81	52	98.3	11	6	0, 0, 0	
	QS				Sands becoming medium grained at 12.4 mbCD					BH34_12.4-12.65									
		13		CH	Lense of increased shell content (very high shell content) at 12.65 mbCD		VS			BH34_12.65-12.85	Sediment alternating between firm and soft layers from 12.9 mbCD								0, 0, 2 N=2
				CH	CLAY: high plasticity, pale grey mottled pale brown and pale grey, some sand, sand is medium grained, rounded														
	BS	14																	

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

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GEOTECHNICAL BOREHOLE BH34

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
Fax (03) 8699 7550

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 27-2-14
Date Finished: 27-2-14

Sea Bed Relative Level: 9.50 mbCD
Coordinates: 5776612.00 mN
283222.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	BS	15		CH	CLAY: high plasticity, pale grey, trace quartz sands, is fine to medium grained, rounded, white, brown, grey	M/W	St			BH34_15.0-15.4 445mm recovery BH34_15.4-15.75 BH34_15.75-15.85		1.31	81	56	85.8	121	88	150, 140, 140	2, 4, 12 N=16
		16		GC	GRAVEL: basalt gravels, fine to coarse grained, blue, pale grey, vesicular, weathered, up to 30mm, trace white cemented nodules 4mm to 15mm, some sandy clay, sands are medium to coarse grained, white, pale grey		D												
		17																	
		18			END OF BOREHOLE AT 17.75 m CD - REFUSAL ON BASALT						Refusal of attempted SPT sample at 17.75 mbCD								
		19																	
		20																	
		21																	
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS:

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GEOTECHNICAL BOREHOLE BH35

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
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Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 4-3-14
Date Finished: 4-3-14

Sea Bed Relative Level: 9.80 mbCD
Coordinates: 5776773.00 mN
283325.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9			Sea bed at 9.8 m below CD														
		10			NO SAMPLE COLLECTED						Drilling is very soft at 9.8 mbCD Attempted tube sample BH35_10.3-10.7, no recovery								
	UNCON	11		CL	**Sandy CLAY**: medium plasticity, grey - brown, sands are medium grained, round, brown, uniform, trace shell fragments, white, up to 4mm	W	VS			BH35_10.7-11.15									0, 0, 0
				CH	**CLAY**: high plasticity, pale grey - grey, some shells, whole and fragments, up to 30mm, trace gravels, trace organic matter					BH35_11.15-11.55 380mm recovery		-	69	41	83.7	-	0	0, 0, 0	n=0
		12		CH	**CLAY**: high plasticity, dark grey, some sand, sand is fine to medium grained, poorly sorted, with some shells, whole and fragments, up to 30mm. Becoming pale grey mottled pale brown - orange at 12.55 mbCD		VS			BH35_12.0-12.4 440mm recovery BH35_12.4-12.55 BH35_12.55-12.85		0.76	70	42	90.8	12	4	0, 0, 0,	
	QS			SP		M/W	F												2, 3, 5
	BS	13		CH	**SAND**: medium grained, pale grey mottled dark grey mottled pale brown-orange, uniform		L St				Drilling is firm at 12.85 mbCD Drilling is hard and gravelly at 13.1 mbCD Attempted SPT sample meets refusal after 20mm BH53_13.2-13.25								n=8
				GP	**Sandy CLAY**: high plasticity, pale grey mottled pale brown-orange, dark grey and white, sand is fine to medium grained, trace gravels, rounded to subrounded **GRAVEL**: basalt gravels up to 43mm, rounded to subrounded, brown mottled dark brown, vesicular, highly weathered, some pale grey and brown clay														50B refusal
		14			END OF BOREHOLE AT 13.23 m CD - REFUSAL ON BASALT														

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**

___ Inferred boundary between geologic units (ie. MVS and QS)
___ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCQN- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology

GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

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GEOTECHNICAL BOREHOLE BH36

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
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Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drilling Contractor: SouthWestern Drilling

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 28-2-14
Date Finished: 13-3-14

Sea Bed Relative Level: 9.70 mbCD
Coordinates: 5776537.00 mN
283590.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
		0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9			Sea bed at 9.7 m below CD														
Washboring - Casing Advancer	UNCON	10		CH	CLAY: high plasticity, grey to brown, some sand, sand is fine grained, some shells, whole shells up to 23mm, shell fragments, up to 8mm, white	W	VS			BH36_10.1-10.5 465mm recovery	Drilling is soft at 9.7 mbCD	-	67	41	98.2	-	0	0, 0, 0	
		11		CH	CLAY: high plasticity, dark grey, trace shell fragments, approximately 1 - 4mm, white, occasional whole shells, up to 25mm					BH36_10.5-10.95									0, 0, 0 N=0
	QS	12					VS			BH36_12.0-12.4 460mm recovery		0.70	83	55	99.2	12	0	0, 0, 0	
		13								BH36_12.4-12.85	Hydrogen sulphide odour at 12.85 mbCD								0, 0, 0 N=0
	BS	14		CH	CLAY: high plasticity, grey and pale grey						Hard lense (50mm) at 14 mbCD Drilling is firm at 14.35 mbCD								

REMARKS: Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals.

___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
MVS- Moorabool Viaduct Sands inferred geology
QS- Quaternary Sediment inferred geology
UNCON- Unconsolidated inferred geology
BS- Basaltic Soil inferred geology
BH36A coordinates E 283595 N 5776543

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GEOTECHNICAL BOREHOLE BH36

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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 28-2-14
Date Finished: 13-3-14

Sea Bed Relative Level: 9.70 mbCD
Coordinates: 5778537.00 mN
283599.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
VIB- CA		15		CH	CLAY: high plasticity, grey and pale grey		St			BH36_15.0-15.4 240mm recovery BH36_15.4-15.53		0.93	74	47	93.1	30	NP	>600, >600, >600	19, 5DB Refusal
				CL GC	Sandy CLAY: medium plasticity, dark brown, sand is fine to medium grained, rounded														
	BS	16		BASALT	Clayey GRAVELS: gravels are basaltic, medium grained, brown, dark grey, orange alteration, highly weathered, friable, clay is pale brown-orange														
		17			BASALT: fresh, dark grey, massive, some vesicles up to 1mm, with joints, sub-horizontal, planar, rough, with trace coating	RQD 38%													
		18				RQD 41%													
					NO CORE														
		19		BASALT	BASALT: fresh, dark grey, massive, some vesicles up to 1mm														
Diamond Coring					NO CORE	RQD 0%													
	BASALT	20		BASALT	BASALT: distinctly weathered, dark grey, fractured zone, planar to irregular, sub-horizontal, smooth to rough, coating with yellow to brown clay, stepped Becoming slightly weathered at 20.6 mbCD Becoming fresh at 20.8 mbCD														
		21			END OF BOREHOLE AT 21.0 mbCD - TARGET DEPTH														
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

ROCK DEFECT

16.8 to 16.9 mbCD: joint, sub-vertical, 50 degrees, irregular, 10-25mm thick, in filled with pale grey rock

17.2 mbCD: joint, sub-vertical, wavy, 20mm thick, yellow in fill, distinctly weathered

DEFECT SPACING

16.4 - 17.8 mbCD: 150 mm

17.8 -18.4 mbCD: 50 mm

18.74 - 19.4 mbCD: 300 mm

19.76 - 20.0 mbCD: 40 mm

20.0 - 20.6 mbCD: 20 mm

20.6 - 21 mbCD: 50mm

REMARKS: NP: No penetration of shear vane into sample
DS- Defect spacing
RQD- Rock Quality Designation

GEOTECHNICAL BOREHOLE BH37

URS Australia
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Phone (03) 8699 7500
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Drilling Contractor: SouthWestern Drilling		Project No.: 43513982	Project Reference: Future Channel Improvement Options
Drill Type: DB520	Logged By: KF Checked By: DW Date Started: 4-3-14 Date Finished: 4-3-14	Sea Bed Relative Level: 9.40 mbCD Coordinates: 5770698.00 mN 283746.00 mE Area: WSC2	Client: Victorian Regional Channels Authority Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	UNCON	0			**SEAWATER**														
		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9			Sea bed at 9.4 m below CD														
		10			NO SAMPLE COLLECTED						Drilling is soft at 9.4 mbCD								
				CH	CLAY: high plasticity, grey - brown, with some gravels, fine to medium grained gravels, trace shell fragments, up to 25mm, white, orange	W	VS			BH37_10.3-10.75									0, 0, 0 N=0
		11								BH37_10.75-11.15 375mm recovery		-	66	41	74.4	-	0	0, 0, 0	
				CH	CLAY: high plasticity, grey, trace shell fragments, up to 3mm, white														
		12					VS			BH37_12.0-12.4 130mm recovery	Hydrogen sulphide odour at 12 mbCD	0.72	80	50	100.0	10	4.5	0, 0, 0	
										BH37_12.4-12.85									0, 0, 0 N=0
		13			Clay becoming dark grey at 12.7 mbCD														
	QS	14																	

REMARKS: **Drilling undertaken using casing advancing technique, therefore cuttings were not obtained between sample intervals**
___ Inferred boundary between geologic units (ie. MVS and QS)
_ _ _ Observed change in lithology
. . . . . **Inferred change in lithology (depth of boundary not observed, marked as top of sample depth)**
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GEOTECH_SOILBORE 43513982 GEOTECHNICAL LOGS.GPJ GEOTECHNICAL_DTV2.GDT 15/7/14

GEOTECHNICAL BOREHOLE BH37

URS Australia
Level 6, 1 Southbank Boulevard, Southbank
Phone (03) 8699 7500
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Drilling Contractor: SouthWestern Drilling

Project No.: 43513982

Project Reference: Future Channel Improvement Options

Drill Type: DB520

Logged By: KF
Checked By: DW
Date Started: 4-3-14
Date Finished: 4-3-14

Sea Bed Relative Level: 9.40 mbCD
Coordinates: 5776698.00 mN
283746.00 mE
Area: WSC2

Client: Victorian Regional Channels Authority

Location: Port of Geelong

METHOD	GEOLOGY	DEPTH (mbCD)	GRAPHIC LOG	USCS CLASSIFICATION	DESCRIPTION OF STRATA	MOISTURE	CONSISTENCY/ REL DENSITY	SAMPLING TUBE	SPT	SAMPLE ID	DRILLERS COMMENTS	DRY DENSITY (t/m3)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	% FINES (%)	TRIAXIAL UU (kPa)	SHEAR VANE (kPa)	PENETROMETER (kPa)	SPT (blows)
Washboring - Casing Advancer	QS	15		CH	CLAY: high plasticity, pale grey mottled pale brown		S			BH37_15.0-15.4 445mm recovery BH37_15.4-15.65 BH37_15.65-15.75 BH37_15.75-15.85		1.03	71	42	100.0	60	18	40, 50, 50	0, 0, 0 N=0
		16			With some gravels, gravels are fine to medium grained, up to 22mm, white calcareous, friable at 15.65 mbCD No longer with some gravels, with some shells, up to 20mm, fragments up to 8mm, with some sand, medium grained, rounded, brown at 15.75 mbCD														
		17		CH	CLAY: high plasticity, grey and brown mottled						3 x 50mm thick lense of firmer sediment alternating with 200mm layers of soft sediment at 17.3 mbCD								
		18					S			BH37_18.0-18.4 430mm recovery BH37_18.4-18.6 BH37_18.6-18.8 BH37_18.8-18.85	Drilling is soft at 18 mbCD	-	86	54	96.0	-	20	40, 60, 60	
	BS	19		CH GP	Sandy CLAY: high plasticity, grey to green grey, sand is fine to medium grained, rounded, brown, grey, Increasing sand content, becoming mottled orange brown and mottled brown at 18.75 mbCD		VSt												4, 9, 22 N=31
					GRAVEL: basalt gravels up to 5mm, brown, rounded, weathered, with sands, sands are fine to medium grained, poorly sorted, brown, trace clay Basalt gravels becoming fine to coarse grained, poorly sorted, up to 45mm, dark brown, vesicular, extremely weathered at 20.3 mbCD						Hard drilling at 19.1 mbCD Drilling is soft at 19.3 mbCD Drilling is firm at 19.6 mbCD Attempted SPT sample only recovered 120mm, refusal after double bouncing at 20.3 mbCD							
		20					H												
					END OF BOREHOLE AT 20.40 m CD - REFUSAL ON BASALT														
		21																	
		22																	
		23																	
		24																	
		25																	
		26																	
		27																	
		28																	
		29																	

REMARKS: