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Report

Geotechnical Investigation for Coastal Erosion Vulnerability Assessment.

Bunbury, City of Bunbury WA.

Date: 6 December 2024
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EXECUTIVE SUMMARY

A geotechnical investigation has been carried out as part of a coastal erosion assessment at Bunbury in the City of Bunbury, Western Australia. During the investigation ground geophysical and intrusive geotechnical testing was conducted within a 2000m (Bunbury South) and a 1580m (Bunbury North) corridor of coastal beach and dune formation adjacent to the Bunbury Oceanic Drive which has been identified as an at-risk site as part of Watchspot # 24.

The investigation scope consisted of acquiring multi-channel analysis of surface waves data as a series of specified transects either along-shore (parallel to the coast) or cross-shore (perpendicular to the coast) and cone penetration testing at spot locations along these transects. This was supplemented with geological mapping of surface rock outcrops and topographic survey using high resolution aerial photogrammetry for the generation of a surface level model and orthomosaic image.

The acquired MASW dataset was processed for the generation of seismic velocity sections along the transects showing variations in the seismic shear wave velocity of the subsurface material to a target depth of 10-15m below ground level (BGL). The seismic velocity sections were calibrated with the CPT plots and demarcated into velocity ranges representing different material types and conditions for the generation of interpreted geological sections consisting of loose to compacted sediment and variably weathered to fresh rock.

The interpreted geological sections have been compiled to develop subsurface models of the level to rock substrate (relative to AHD) and overlying sand thickness within the region between the foreshore and the settlement. This model will be used to assess the potential vulnerability of the site to erosion and future inundation risk, and whether there is a continuous rock barrier located below the ground surface of sufficient strength and height that may prevent the advancement of erosion to the settlement.

The following observations have been made:

- Interpreted rock substrate was observed along all the transects and within the maximum target investigation depth of 10-15m BGL with the Bunbury North site generally having shallower rock than the south.
- Interpreted top of rock substrate on the along-shore transects on the beach ranges from -10.0mAHD to 2.5mAHD with most surveyed beach sections having rock about the 0 mAHD mark except for the first 570m of Transect 2 showing rock at approximately -10 mAHD.
- Interpreted level to top of rock substrate along the long-shore road transects located approximately 100 to 150m from the shoreline was observed to be generally consistent at 5 mAHD for both Bunbury North and South.
- Sand thickness across the two sites ranged from 0 to approximately 15m generally increasing further away from the shoreline. The southern end of Mindalong Beach within the Bunbury South site showed a significant increase in sand thickness due to low rock level and thick dunes.

CONTENTS

1 INTRODUCTION

At the request of The Government of Western Australia Department of Transport (DoT), GBG Group carried out a geotechnical investigation at Bunbury, City of Bunbury in November 2024. During the investigation seismic geophysical testing and intrusive geotechnical testing was conducted within a 2000m and a 1580m corridor of coastal beach and dune formation which has been identified as an at-risk site as part of Watchspot #24.

The objective of the investigation was to provide detailed mapping of the extent, elevation and consistency/strength of the rock underlying the coastal beach and dune formation. In particular, the key outcome of the investigation was to develop a subsurface model of the level to competent rock substrate (relative to AHD) within the region between the foreshore and the settlement. This model will be used to assess the potential vulnerability of the site to erosion and future inundation risk, and whether there is a continuous rock barrier located below the ground surface of sufficient strength and height that may prevent the advancement of erosion to the settlement.

To achieve the project objectives, data from the following investigation methods was acquired, processed and analysed to obtain the required subsurface information within the anticipated geological conditions:

1. **Geological mapping** of surface rock outcrops within the study area using high resolution photogrammetry.
2. **Geophysical testing** by way of Multi-channel Analysis of Surface Waves (MASW) to obtain seismic shear wave velocity models related to variations in subsurface material stiffness.
3. **Topographic survey** using Differential GNSS receiver and photogrammetry.

2 INVESTIGATION SITE

The investigation was carried out within approximate 2000m and 1580m corridors of coastal beach and dune formation the extents of which are shown as yellow dashed areas in Figures 1 and 2 as follows;

- Bunbury South – 2000m section from the Mindalong Beach car park to the Hayward St intersection.
- Bunbury North – 1580m section from the City of Bunbury Surf Life Saving Club to the car park on Casuarina Drive in the north.

Data was acquired as a series of transects for the seismic geophysical testing. These were positioned so as to best utilise existing roads, tracks, and beach whilst not impacting on native vegetation and in order to ensure the most optimal, efficient and economic acquisition methodology. Data was not acquired where surface obstructions were present such as thick vegetation, steep topography or where the beach was inundated with seawater. Photographs showing the typical site conditions are provided in Figures 3 and 4. Topography at the sites was generally flat to undulating and surface level ranged from 0mAHD to 8mAHD. Topographic maps showing surface level are provided in Appendix C drawings 3142E-14 and 3142E-15.

Figure 1: The extent of the geophysical investigation (yellow polygon) at the Bunbury South site. Aerial imagery from drone photogrammetry (main image) and Google Maps (inset image).

Figure 2: The extent of the geophysical investigation (yellow polygons) at the Bunbury North site. Aerial imagery from drone photogrammetry (main image) and Google Maps (inset image).

Figure 3: Site conditions at Bunbury including the northern along-shore transect (left image) and southern along-shore track (right image).

Figure 4: Example site conditions at Bunbury including beach (left image) and road (right image).

3 INVESTIGATION METHODOLOGY

3.1 FIELD SURVEY LOGISTICS

Geophysical data acquisition was carried out from the 20th to 22nd and 25th to 28th November 2024 by a two-person team from GBG Group consisting of qualified geophysicists. CPT data acquisition was carried out by a technician from Probedrill on 26th and 27th November 2024. Where required, the site work was carried out under appropriate traffic and pedestrian management commissioned by the City of Bunbury.

Prior to the commencement of data acquisition, a site assessment was carried out with the traffic management team. Potential concerns and issues including the placement of and access to the MASW transects were addressed.

The site work for the investigation consisted of a total of 6958m of MASW profiling acquired as 6 along-shore transects (parallel to the coast) and 7 cross-shore transects (perpendicular to the coast). Details of the acquired MASW transects are provided in Table 1. The extents of the MASW transects overlaid onto aerial imagery are shown in Appendix A drawings 3142E-01 for Bunbury South and 3142E-02 for Bunbury North.

Table 1 – Acquired MASW Transects (Coordinates in GDA2020, MGA Zone 50).

Transect	Orientation	Start Coordinate		End Coordinate		Length
ID		East	North	East	North	(m)
MASW-01	Along-shore	371501.2	6308247.5	371965.9	6310182.4	1960
MASW-02	Along-shore	371403.2	6308241.2	371927.3	6310138.4	1976
MASW-03	Cross-shore	371458.2	6308401.5	371532.8	6308436.0	88
MASW-04	Cross-shore	371643.4	6309128.6	371700.0	6309111.7	64
MASW-05	Cross-shore	371811.7	6309817.0	371858.3	6309784.0	64
MASW-06	Cross-shore	371916.2	6310128.0	371956.1	6310089.7	56
MASW-07	Along-shore	372523.3	6311700.0	372602.6	6312006.0	320
MASW-08	Along-shore	372467.9	6311722.0	372515.8	6311982.0	278
MASW-09	Cross-shore	372515.9	6311981.0	372563.7	6311919.0	80
MASW-10	Along-shore	372685.6	6312326.0	373018.7	6313189.0	992
MASW-11	Along-shore	372654.2	6312388.0	372973.2	6313209.0	928
MASW-12	Cross-shore	372756.1	6312668.0	372840.5	6312647.0	104
MASW-13	Cross-shore	372886.5	6312980.0	372910.4	6312940.0	48

3.2 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES

MASW is a seismic geophysical method that utilises phase and frequency information to calculate Shear wave (S-wave) velocities in vertical layer models averaged over an array of linearly spaced geophones. These 1D models can be laterally stacked to provide 2D cross-sections of S-wave velocity in layers. Under most circumstances it is an indicator of material stiffness and as such the method can be used to provide quantitative results on the compaction of the subsurface material.

MASW data was acquired using a Geode (Geometrics) seismograph connected to a receiver array of 24 geophones set at 1m intervals for a total array length of 23m. The receiver array was mobilised on a land streamer whereby the geophones are mounted on base plates attached to webbing, and either towed behind a 4WD vehicle or manually pulled by the field team. Seismic energy was generated using summed impacts from a PEG-40 (R.T. Clark) vehicle mounted accelerated weight drop (AWD) or softened steel sledgehammer with source points made at a constant offset from the receiver array. MASW acquisition parameters are provided in Table 2. Photographs of MASW data acquisition are shown in Figure 5.

Table 2 – MASW Acquisition Parameters

Parameter	Value
Number of geophones	24
Geophone spacing	1 m
Array length	23 m
Geophone frequency	4.5 Hz
Record length	1 s
Sample interval	0.125 ms
Source	40kg AWD / 5.9kg Sledgehammer
Source offset	4 m
Sounding interval	8m
Source stacks	3

Figure 5: MASW data acquisition using a seismic streamer and AWD.

The MASW data was observed to be of high quality with the seismic records having high signal to noise ratio. The generated overtone images plotting phase velocity against frequency mostly showed a prominent dispersion curve of the surface wave component. The first four soundings of Transect 7 and the second section of Transect 8 (238-278m) failed to produce dispersion curves. Based on onsite observations, it is postulated that these sections are located on very shallow competent rock causing undetectable S-wave dispersion. The MASW data was processed using SurfSeis version 6++ (Kansas Geological Survey, 2017) with the following processing routine:

1. Import acquired seismic data files and apply geometry including geophone spacing, source offset and sounding interval.
2. Generate overtone images giving the percentage intensity of phase velocity versus frequency for each seismic record (Figure 6).
3. Pick the maximum intensity across the useful range of frequencies for each overtone image resulting in a dispersion curve.

4. Run the dispersion curves through a 10-layer inversion algorithm to produce 1D soundings plotting seismic S-wave velocity with depth.

The S-wave velocity soundings were compiled with reference to distance along the transects and gridded with Surfer version 25 (Golden Software, 2023). The resulting contoured cross-sections show the variation in the modelled S-wave velocity of the subsurface material in metres per second laterally along each of the transects and with elevation.

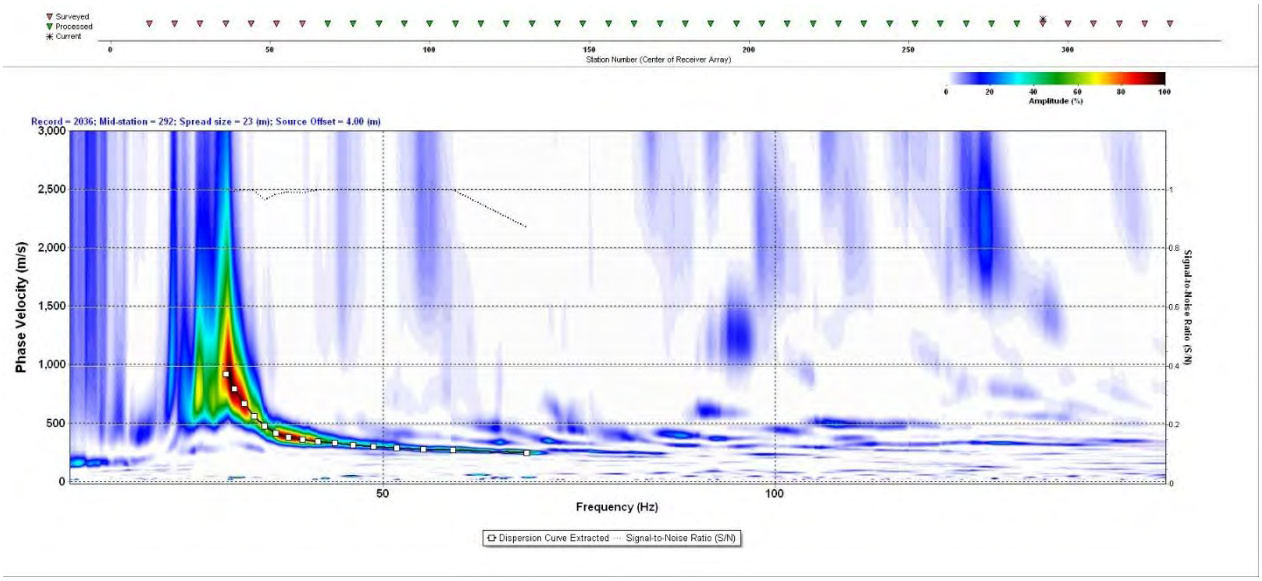


Figure 6: MASW overtone image with high signal to noise ratio and picked dispersion curve.

3.3 SPATIAL POSITIONING AND PHOTOGRAMMETRY

Spatial positioning of the acquired geophysical transects was achieved using Reach RS2+ (Emlid) GNSS receivers with a coordinate recorded for each MASW sounding location. Coordinates of the geophysical transects have been provided in GDA2020, MGA zone 50 for horizontal component and Australian Height Datum (mAHD) for vertical component. An accuracy of +/-0.2m is expected for both vertical and horizontal components.

To achieve precise reduced levels referenced to AHD, the positioning data was acquired with Real-Time Kinematics (RTK) using a Geoscience Australia AUSCORS station in Binningup for the base corrections. Details of the AUSCORS station used for this investigation are provided in Table 3.

Table 3 – Details of AUSCORS station

Parameter	Value
Mount Point	BINN00AUS0
Latitude	S 33° 9' 11.46477"
Longitude	E 115° 41' 51.10028"
Ellipsoidal height (m)	-23.805

A reduced level of 0.0mAHD is considered to be the Mean Sea Level (MSL) for the purpose of this investigation. This relationship for Mean Sea Level was established by the Geoscience Australia Survey in 1971*.

*http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/datums-projections/australian-height-datum-ahd

Aerial photogrammetry was carried out to obtain an up-to-date high-resolution aerial image and a surface level model of the survey area. Data was acquired with a Mavic 3E (DJI) multi-rotor drone with RTK capability for the capture of multiple overlapping images.

The acquired photogrammetry images were processed using Metashape Professional (Agisoft) for the generation of a point cloud, surface level model and orthomosaic image of the survey area. Note for this investigation, vegetation has not been removed during the processing stage and as such the height of existing vegetation needs to be considered when assessing surface levels.

4 RESULTS AND INTERPRETATION

4.1 PRESENTATION OF RESULTS

The results of the geotechnical investigation at Bunbury, City of Bunbury are presented in Appendices B and C of this report as follows:

Appendix B – Geophysical and Interpreted Sections

- **3142E-03.** Transect 1 (0-1000m) seismic S-wave velocity model and interpreted geological section.
- **3142E-04.** Transect 1 (1000-1960m) seismic S-wave velocity model and interpreted geological section.
- **3142E-05.** Transect 2 (0-1000m) seismic S-wave velocity model and interpreted geological section.
- **3142E-06.** Transect 2 (1000-1976m) seismic S-wave velocity model and interpreted geological section.
- **3142E-07.** Transects 03 and 04 seismic S-wave velocity model and interpreted geological section.
- **3142E-08.** Transects 05 and 06 seismic S-wave velocity model and interpreted geological section.
- **3142E-09.** Transects 07 and 08 seismic S-wave velocity model and interpreted geological section.
- **3142E-10.** Transect 09 seismic S-wave velocity model and interpreted geological section.
- **3142E-11.** Transect 10 seismic S-wave velocity model and interpreted geological section.

- **3142E-12.** Transect 11 seismic S-wave velocity model and interpreted geological section.
- **3142E-13.** Transects 12 and 13 seismic S-wave velocity model and interpreted geological section.

Appendix C – Modelled Level to Surface, Top of Rock and Sand Thickness

- **3142E-14 and 3142E-15.** Contoured surface level models derived from aerial photogrammetry.
- **3142E -16 and 3142E -17.** Contoured level to modelled top of rock.
- **3142E -18 and 3142E -19.** Class post map level to modelled top of rock.
- **3142E -20 and 3142E -21.** Contoured modelled sand thickness over rock / Depth to top of rock.
- **3142E -22 and 3142E -23.** Class post map modelled sand thickness over rock / Depth to top of rock.

4.2 SEISIMC SHEAR WAVE VELOCITY SECTIONS

The seismic S-wave velocity (Vs) sections modelled from the MASW data acquired along the along-shore and cross-shore transects are presented at the top of each drawing in Appendix B. These sections show variations in the modelled Vs as per the colour scale with velocity ranging from 150m/s to 1000m/s representing a wide range of material types and conditions.

Seismic S-wave velocity is governed by the elastic properties of the medium that the wave propagates through as shown in the equation below. In particular, it is primarily a function of soil density, void ratio and effective stress. As such calculated values can provide a useful guide to the subsurface material condition with increasing velocity an indication of increasing material stiffness.

Seismic S-wave velocity $$V_s = \sqrt{\frac{G}{\rho}}$$

where; G = Shear modulus,
ρ = In-situ material density

4.3 INTERPRETED GEOLOGICAL SECTIONS

Below the seismic S-wave velocity sections are the interpreted geological sections based on detectable seismic velocity contrasts. Four classes have been defined representing different subsurface material conditions as follows:

1. **Very low seismic S-wave velocity** (Vs <250m/s). Representing the lowest seismic velocities modelled during the investigation, this class is interpreted as sediment of low compaction from either the beach or dune formation.

2. **Low seismic S-wave velocity** (Vs 250-300m/s). This class is interpreted as sediment of moderate compaction due to increased depth of cover on the beach and dune formation, or due to development adjacent to the settlement.

3. **Moderate seismic S-wave velocity** (Vs 300-450m/s). This class is interpreted as low strength variably weathered rock. Where continuous and at base of the sections it likely represents a transitional zone to stronger, more competent underlying rock. Where present as isolated anomalies within the interpreted sediment, it is likely to represent partially lithified sediment or rock lenses.

4. **Moderate to high seismic wave velocity** (Vs >450m/s). This class is interpreted as moderate strength slightly weathered to fresh rock. It is typically observed at the base of the sections as competent rock underlying the variably weathered rock. Two rock types fall under this category in this site being the lower velocity Limestone and the higher velocity Basalt observed to the north of the site and near the Bunbury Surf Lifesaving Club.

4.4 CALIBRATION WITH GEOTECHNICAL TESTING AND ROCK MAPPING

The results of the CPTs are presented in Appendix D showing the plots of cone tip resistance in mega-pascals against depth in metres. The CPT plots are also shown in Appendix B and overlayed onto the interpreted geological sections with the following observations being made:

- **CPT-01 on Transect 02 / 03** – refusal of 75MPa was at a depth of 1.7m Below Ground Level (BGL) which corresponds to an interpreted partially lithified lens or boulders within the beach sand.

- **CPT-02 on Transect 02 / 04** – refusal of 68MPa was at a depth of 2.3m Below Ground Level (BGL) which corresponds to interpreted bedrock.

- **CPT-03 on Transect 02 / 05** – refusal of 72MPa was at a depth of 1.7m Below Ground Level (BGL) which corresponds to interpreted bedrock.

- **CPT-04 on Transect 02 / 06** – refusal of 58MPa was at a depth of 2.7m Below Ground Level (BGL) which corresponds to interpreted bedrock.

- **CPT-05 on Transect 08** – refusal of 49MPa was at a depth of 2.62m Below Ground Level (BGL) which corresponds to interpreted bedrock.

- **CPT-06 on Transect 11 / 12** – refusal of 65MPa was at a depth of 1.0m Below Ground Level (BGL) which corresponds to interpreted bedrock.

- **CPT-07 on Transect 11 / 13** – refusal of 80MPa was at a depth of 2.3m Below Ground Level (BGL) which corresponds to interpreted bedrock.

The differences in the modelled level to low strength and moderate strength rock as interpreted from the MASW transects and from the CPT data can be attributed to the fact that the geophysical methods

used are broad scale whilst the CPT is a point method. Geophysical methods sample a volume of subsurface material with the calculated depths at any particular point representing an average value over this volume. The CPT method samples the subsurface directly below the probe and is influenced by local variations in the subsurface such as rock floaters, highly weathered zones or lenses of partially lithified sediment. The differences in the type of subsurface sampling of the methods will not adversely affect the results as the CPT results have been used to constrain the geophysics interpretation and as such the results represent the best modelled fit between the datasets.

Surface outcropping basaltic rock was observed at the northern end of Back Beach towards Wyalup-Rocky point and along the southern end of Point Casuarina Beach which can be identified on the orthomosaic image from the aerial photogrammetry.

4.5 MODELLED LEVEL TO TOP OF ROCK AND SAND THICKNESS

Subsurface models for the level to top of rock substrate and overlying sand thickness within the region between the coastal foreshore and settlement are presented in Appendix C. These have been generated by digitising the interface between the interpreted sediment and underling rock profile from the interpreted geological sections along the acquired along-shore and cross-shore transects. The modelled sand thickness was then generated by subtracting this from the surface level model obtained from the photogrammetry. The sand thickness can also be considered to be the depth to top of rock where rock exists within the depth of investigation. Interpreted rock depths and levels should be analysed in conjunction with interpreted seismic sections in Appendix B. The following subsurface models have been provided:

- **Contoured Surface Level Model** (drawings 3142E-14 to 3142E-15) – generated from the aerial photogrammetry, this presents the level to ground surface ranging from 0mAHD to 20mAHD. Note: vegetation height has not been removed from these models.
- **Contoured Level to Top of Rock Substrate** (drawings 3142E-16 to 3142E-17) – this presents the level to the top of rock substrate ranging from -10mAHD to 6mAHD.
- **Classed Post Map Level to Top of Rock Substrate** (drawings 3142E-18 to 3142E-19) – this presents the level to the top of rock substrate along the acquired transects at 2m level increments from <-4mAHD to 8mAHD.
- **Contoured Sand Thickness / Depth to Top of Rock** (drawings 3142E-20 to 3142E-21) – this presents the thickness of sand overlying the rock substrate ranging from 0mBGL to 15mBGL.
- **Classed Post Map Sand Thickness / Depth to Top of Rock** (drawings 3142E-22 to 3142E-23) – this presents the thickness of sand overlying the rock substrate along the acquired transects at 2m depth increments from <2mBGL to >12mBGL.

The following limitations should be considered when assessing the subsurface models for the level to top of rock substrate and overlying sand thickness:

The expected accuracy of the top of rock substrate modelled from this investigation is +/-0.5mAHD. Similarly, an accuracy of +/-0.5m is expected for the modelled sand thickness over rock. The quoted accuracies have been based on consideration of the accuracy of the GNSS receivers used during the site work, 1D inversion of the MASW dataset using a 10-layer model and expected undulations in the sand/rock interface. Note the quoted accuracies are only valid along the geophysical transects. Values given between transects have been interpolated in the contour maps and as such the accuracy in this case is indeterminable.

The generated contours will give the general trend of the top of rock profile however will not image local variations when the extent of these is less than transect spacing. Spatially small features such as karst sinkholes or pinnacle features may not be imaged. The significance of this limitation is considered minor for this investigation since although local geological features such as pinnacles may not be represented in the data, the generated surface of the top of rock will show the broad trends in the geology over the site which is suitable for a coastal erosion assessment.

Transition zones including between fresh and weathered rock and between sediment and lithified/partially lithified sediment may be gradational and as such the interface between these layers are not well defined.

The calculated levels to the top of rock will only be valid along the geophysical transects. Values shown on the contour maps not on the transects have been interpolated using the krigging algorithm and as such the accuracy of these levels is indeterminable. The contour surface will give the general trend of the interface however may not image local variations, it is recommended that the interpreted geological sections presented in Appendix B be used to obtain more accurate top of rock levels and overlying sand thickness.

5 PROJECT SUMMARY

A geotechnical investigation has been carried out as part of a coastal erosion assessment at Bunbury in the City of Bunbury, Western Australia. During the investigation ground geophysical and intrusive geotechnical testing was conducted within a 2000m and a 1580m corridor of coastal beach and dune formation adjacent to the Bunbury settlement which has been identified as an at risk site as part Watchspot # 24.

The investigation scope consisted of acquiring multi-channel analysis of surface waves data as a series of specified transects either along-shore (parallel to the coast) or cross-shore (perpendicular to the coast). This was supplemented with geological mapping of surface rock outcrops and topographic survey using high resolution photogrammetry for the generation of a surface level model and orthomosaic image.

The acquired MASW dataset was processed for the generation of seismic velocity sections along the transects showing variations in the seismic shear wave velocity of the subsurface material to a target depth of 10-15m below ground level. The seismic velocity sections were calibrated with the CPT plots and demarcated into velocity ranges representing different material types and conditions for the generation of interpreted geological sections consisting of loose to compacted sediment and variably weathered to fresh rock.

The interpreted geological sections have been compiled to develop subsurface models of the level to rock substrate (relative to AHD) and overlying sand thickness/ depth to top of rock within the region between the foreshore and the settlement. This model will be used to assess the potential vulnerability of the site to erosion and future inundation risk, and whether there is a continuous rock barrier located below the ground surface of sufficient strength and height that may prevent the advancement of erosion to the settlement.

The methods used during the investigation are geophysical and as such the results are based on indirect measurements and the processing and interpretation of seismic wave signals calibrated with intrusive geotechnical testing. The findings in this report represent the professional opinions of the authors, based on experience gained during previous similar investigations.

We trust that this report and the attached drawings provide you with the information required. If you require clarification on any points arising from this investigation, please do not hesitate to contact the undersigned on 08 9354 6300.

For and on behalf of
GBG GEOTECHNICS (AUSTRALIA)

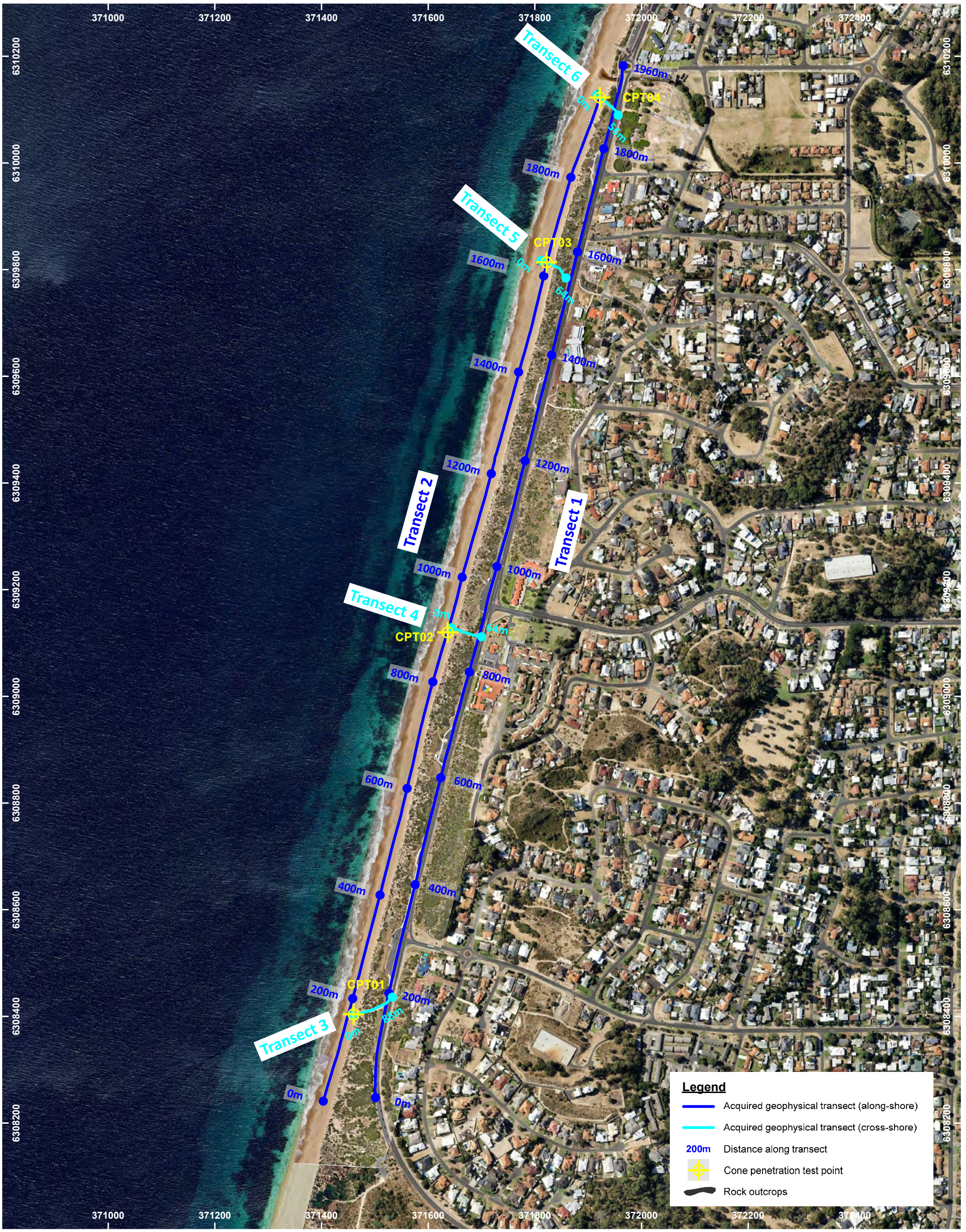
BAQIR AL ASADI
Senior Geophysicist

APPENDIX A – INVESTIGATION SITE MAP

GBGGROUP

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

INVESTIGATION SITE MAP - BUNBURY SOUTH



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

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Date	27 November 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-01	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

INVESTIGATION SITE MAP - BUNBURY NORTH

NOTES

Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	27 November 2024	Paper Size	A3
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DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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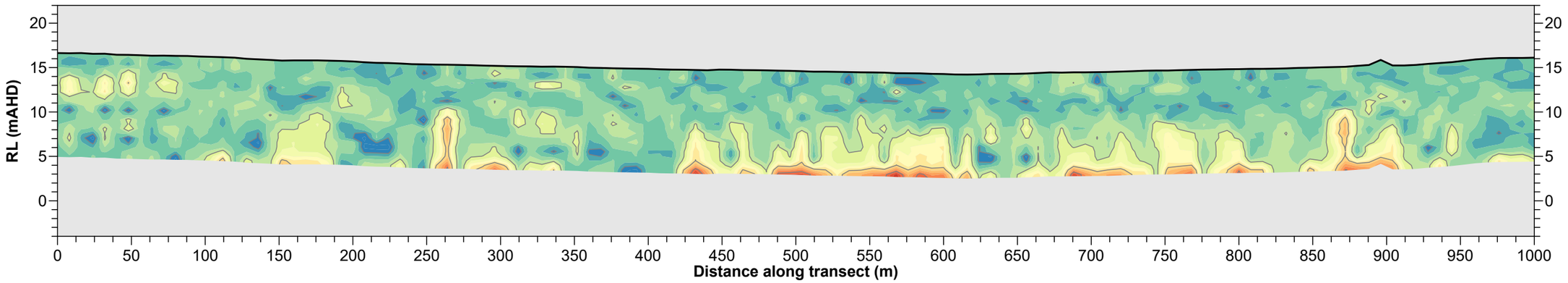
APPENDIX B – GEOPHYSICAL AND INTERPRETED SECTIONS

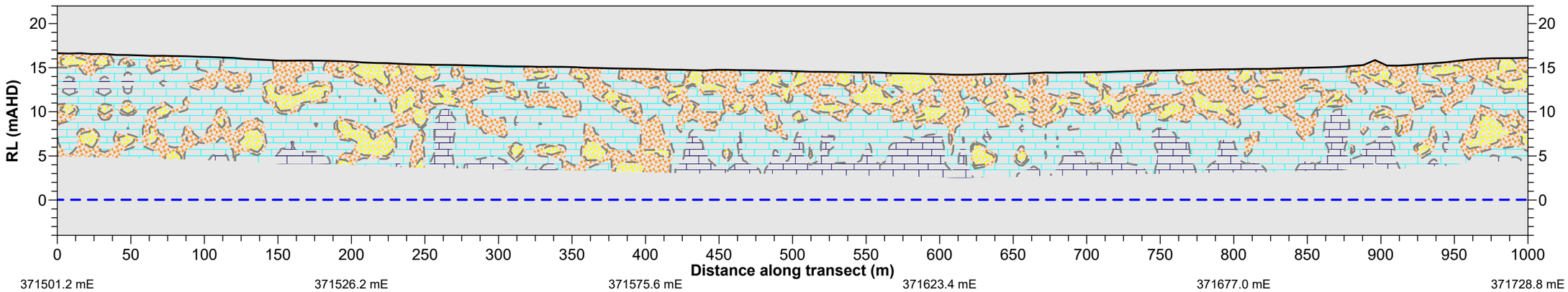
GBGGROUP

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

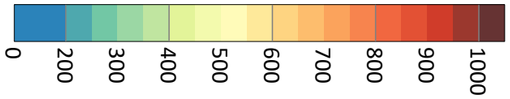
TRANSECT 01 (0-1000m) - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 01 (0-1000m) - INTERPRETED GEOLOGICAL SECTION



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA		Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-03	Revision	0

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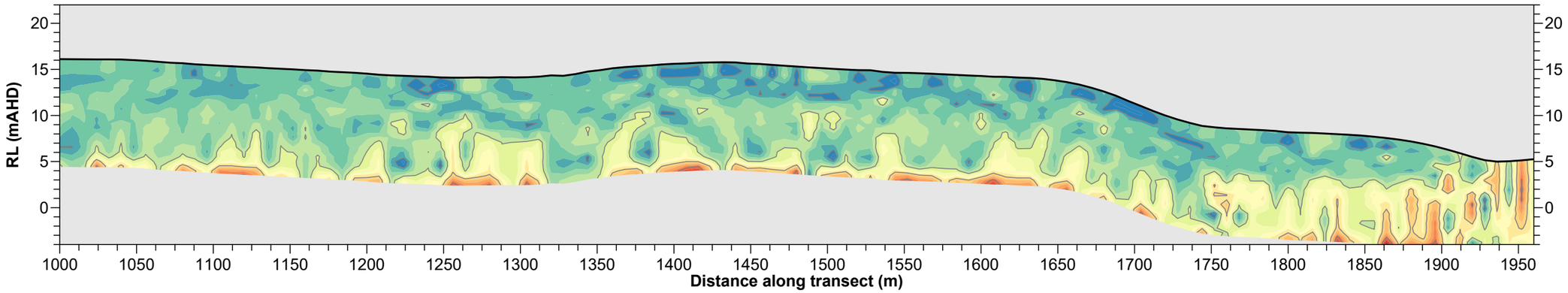
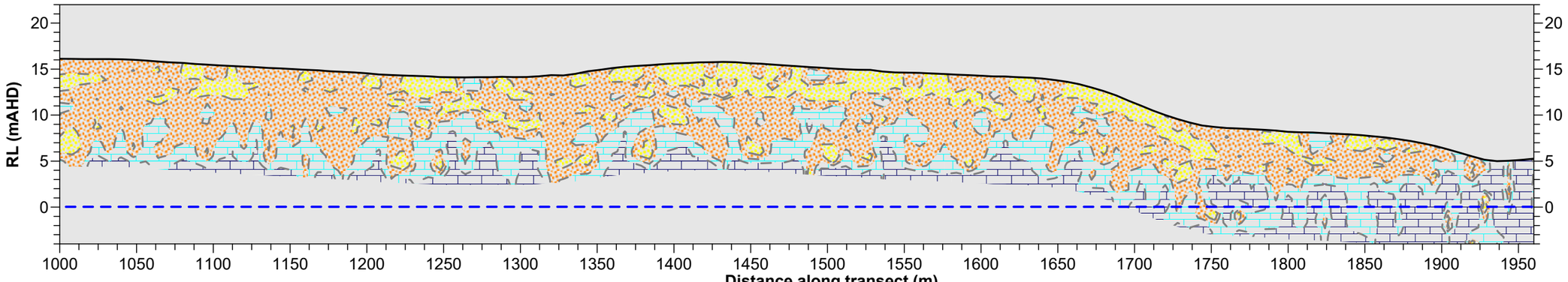
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

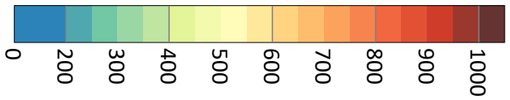
TRANSECT 01 (1000-1960m) - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 01 (1000-1960m) - INTERPRETED GEOLOGICAL SECTION



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-350 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 350-475 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 475 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-04	Revision	0

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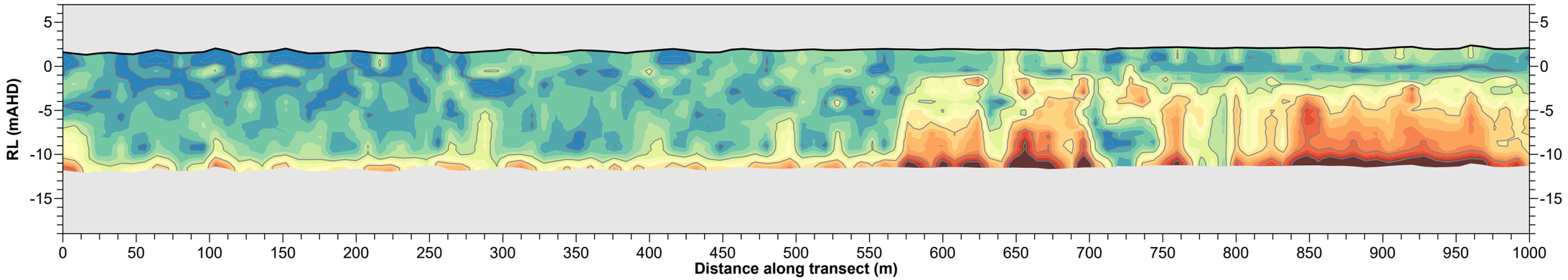
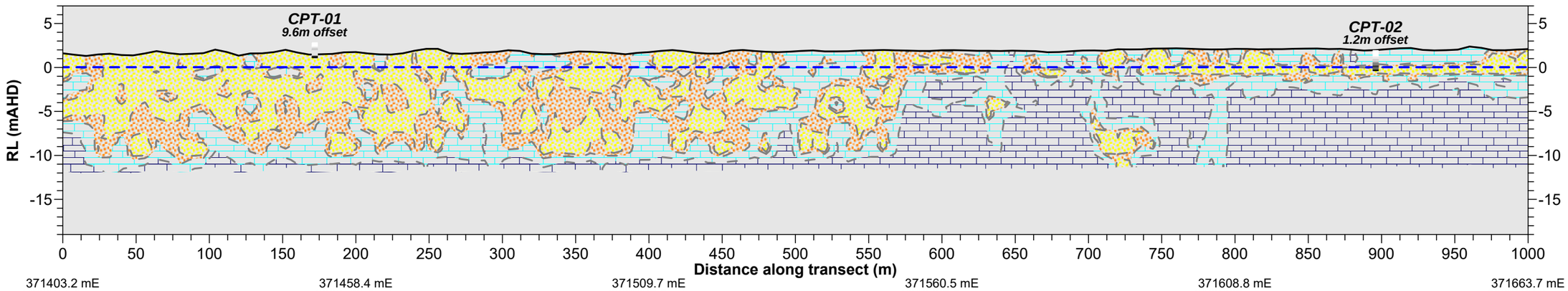
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

TRANSECT 02 (0-1000m) - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 02 (0-1000m) - INTERPRETED GEOLOGICAL SECTION



371403.2 mE
6308241.2 mN

371458.4 mE
6308433.5 mN

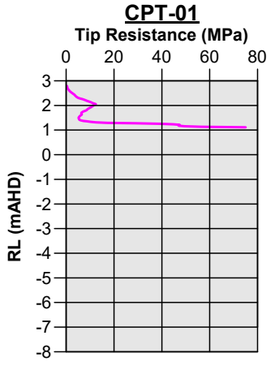
371509.7 mE
6308627.5 mN

371560.5 mE
6308827.5 mN

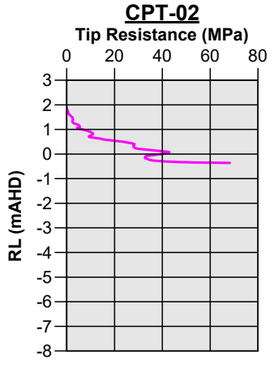
371608.8 mE
6309027.1 mN

371663.7 mE
6309223.3 mN

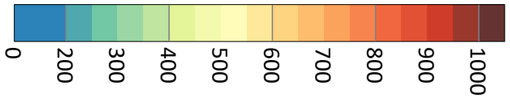
CPT-01



CPT-02



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-05	Revision	0

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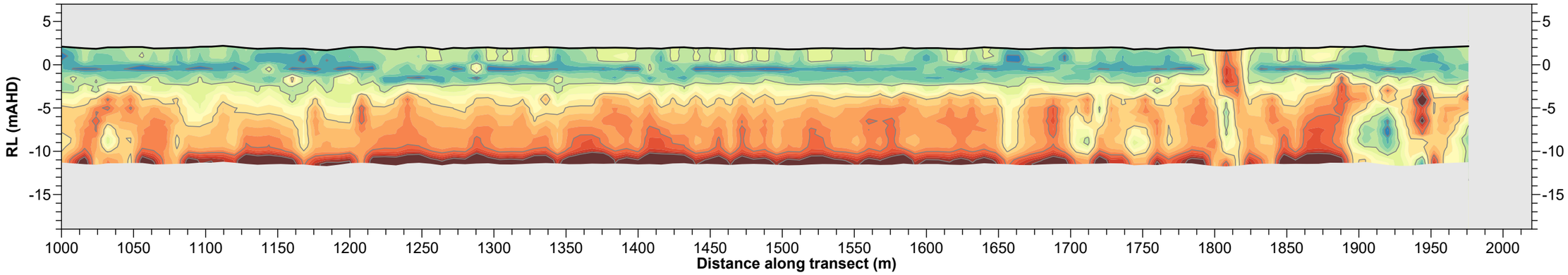
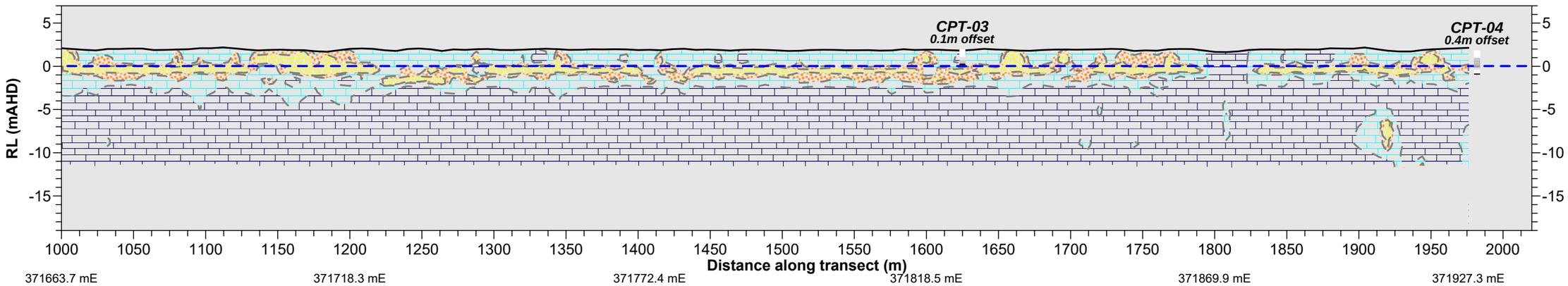
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

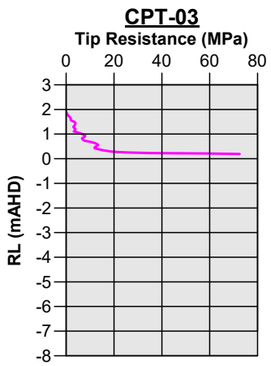
TRANSECT 02 (1000-1984m) - SEISMIC SHEAR WAVE VELOCITY MODEL



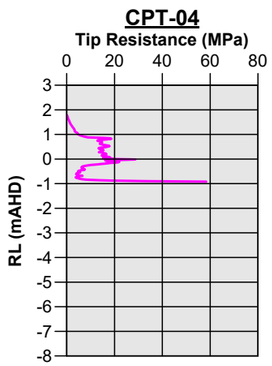
TRANSECT 02 (1000-1984m) - INTERPRETED GEOLOGICAL SECTION



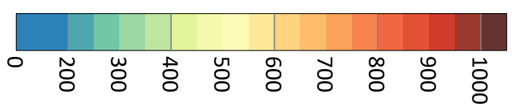
CPT-03



CPT-04



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-06	Revision	0

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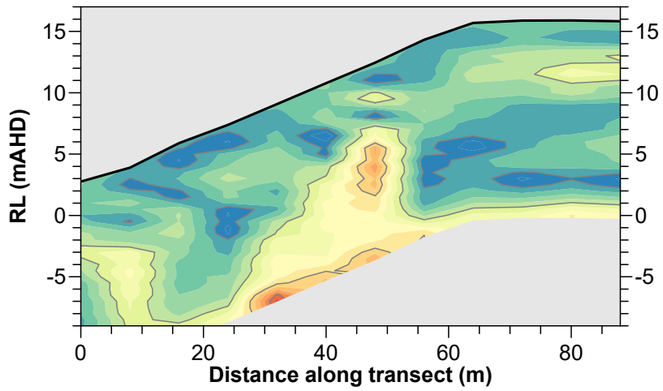
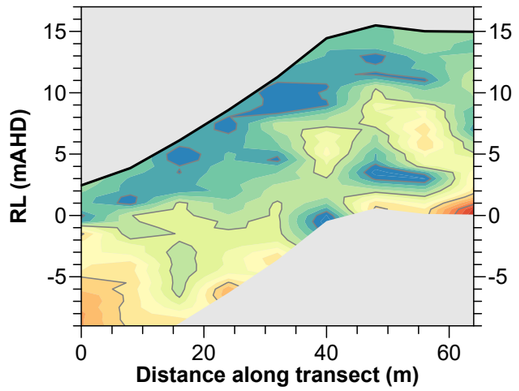
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

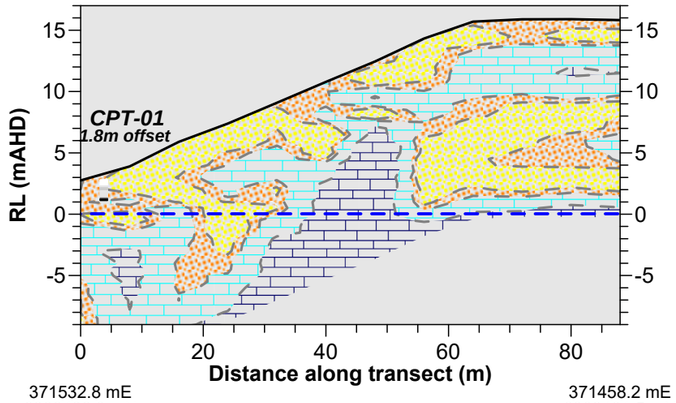
TRANSECT 03 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 04 - SEISMIC SHEAR WAVE VELOCITY MODEL



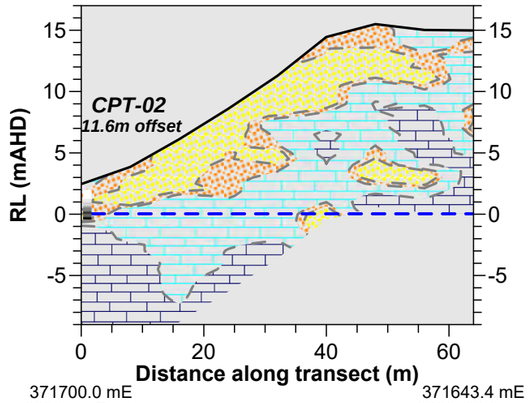
TRANSECT 03 - INTERPRETED GEOLOGICAL SECTION



371532.8 mE
6308436.0 mN

371458.2 mE
6308401.5 mN

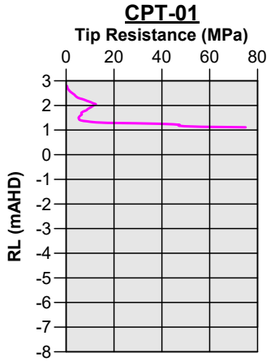
TRANSECT 04 - INTERPRETED GEOLOGICAL SECTION



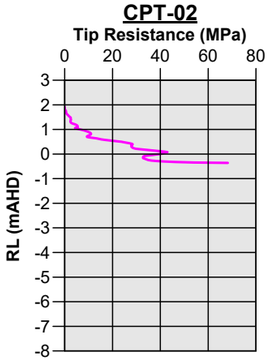
371700.0 mE
6309111.7 mN

371643.4 mE
6309128.6 mN

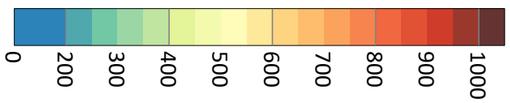
CPT-01



CPT-02



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

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	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:1000H, 1:500V	Drawn	PJE
		Drawing	3142E-07	Revision	0

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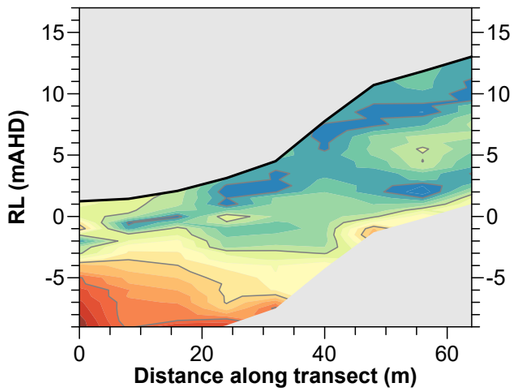
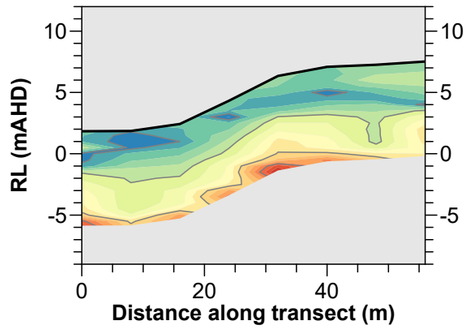
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

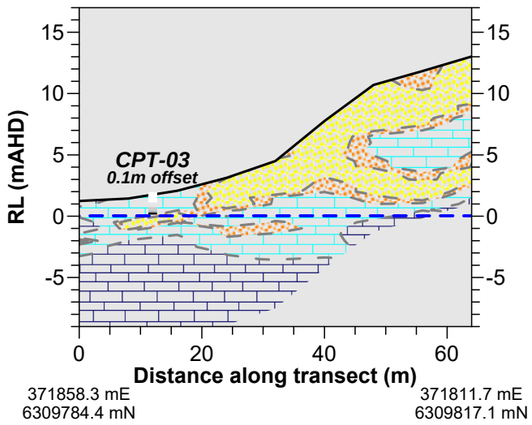
TRANSECT 05 - SEISMIC SHEAR WAVE VELOCITY MODEL



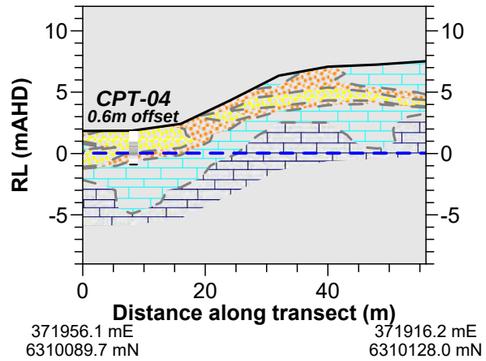
TRANSECT 06 - SEISMIC SHEAR WAVE VELOCITY MODEL



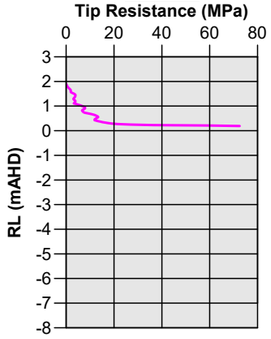
TRANSECT 05 - INTERPRETED GEOLOGICAL SECTION



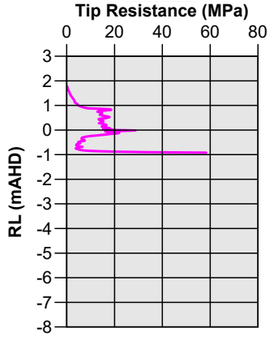
TRANSECT 06 - INTERPRETED GEOLOGICAL SECTION



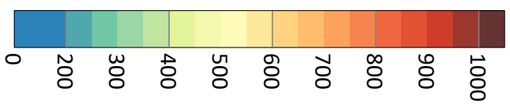
CPT-03



CPT-04



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

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Levels are given in Australian Height Datum (AHD).

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	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:1000H, 1:500V	Drawn	PJE
		Drawing	3142E-08	Revision	0

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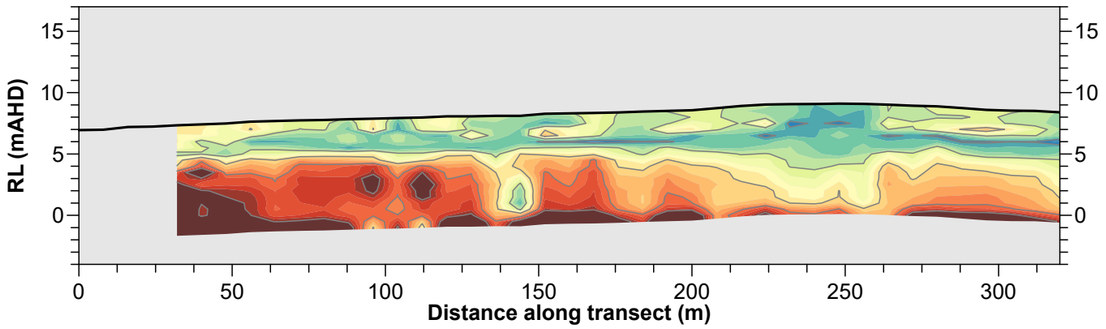
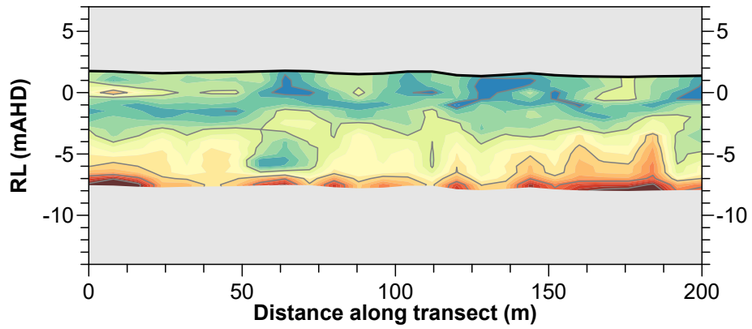
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

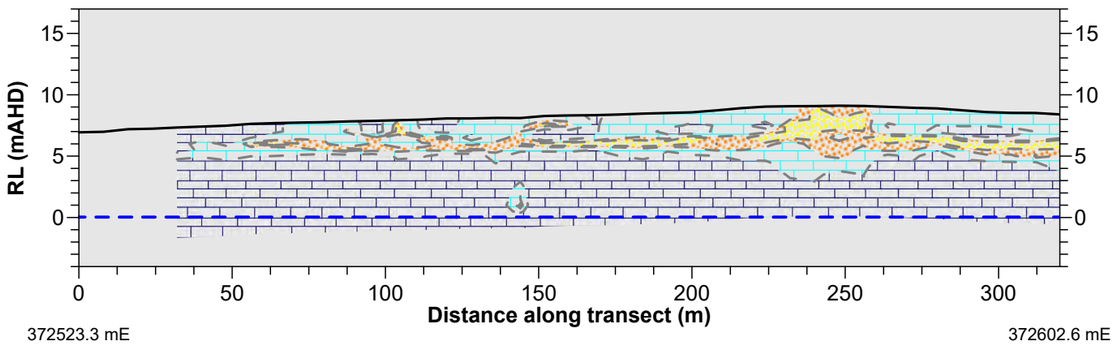
TRANSECT 07 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 08 - SEISMIC SHEAR WAVE VELOCITY MODEL



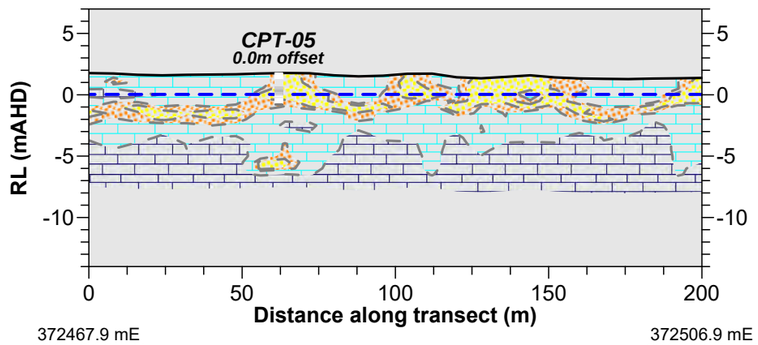
TRANSECT 07 - INTERPRETED GEOLOGICAL SECTION



372523.3 mE
6311700.2 mN

372602.6 mE
6312006.1 mN

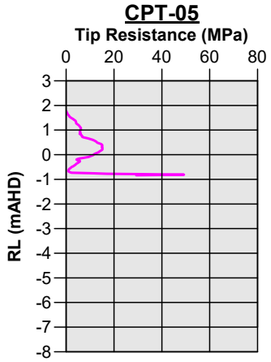
TRANSECT 08 - INTERPRETED GEOLOGICAL SECTION



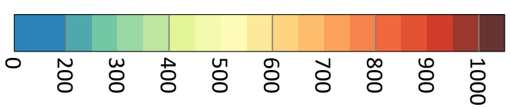
372467.9 mE
6311721.8 mN

372506.9 mE
6311908.7 mN

CPT-05



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:2000H, 1:500V	Drawn	PJE
		Drawing	3142E-09	Revision	0

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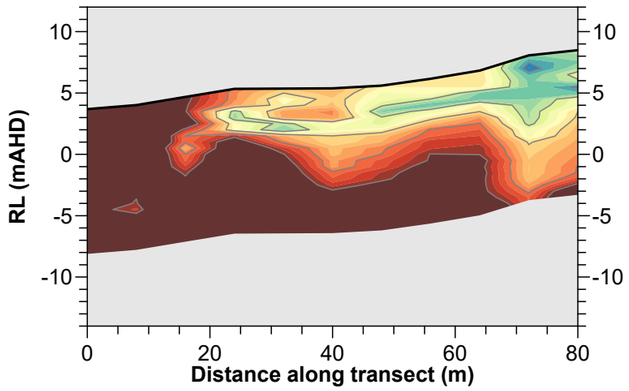
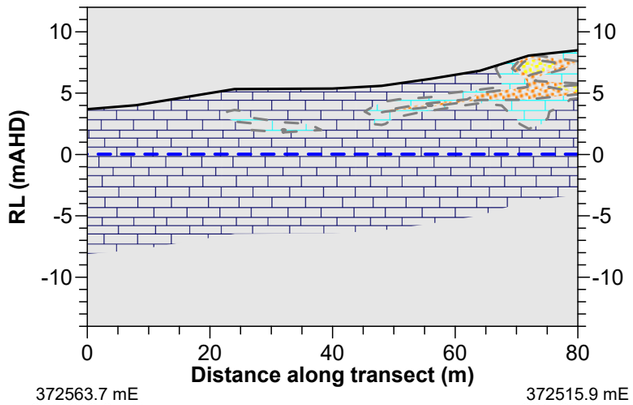
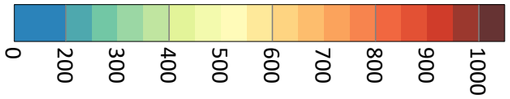
TRANSECT 09 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 09 - INTERPRETED GEOLOGICAL SECTION



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 400 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:1000H, 1:500V	Drawn	PJE
		Drawing	3142E-10	Revision	0

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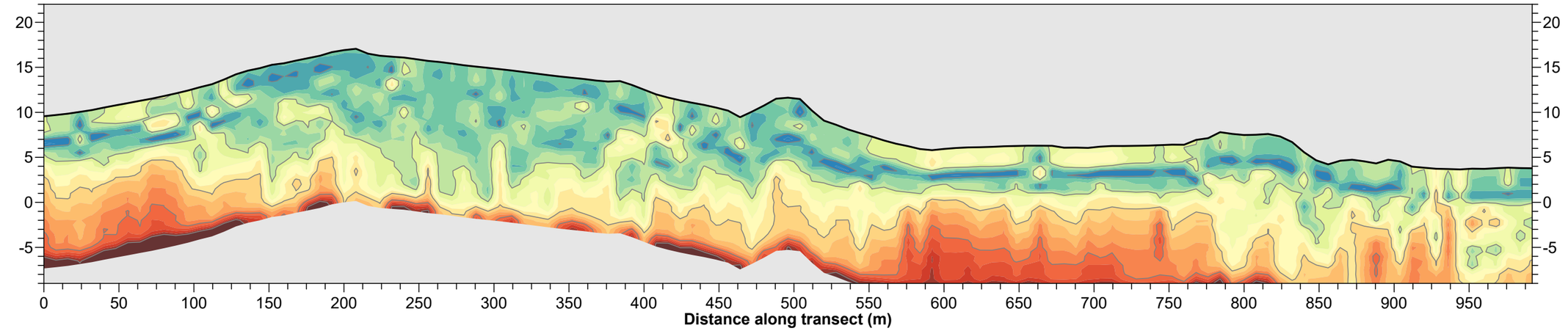
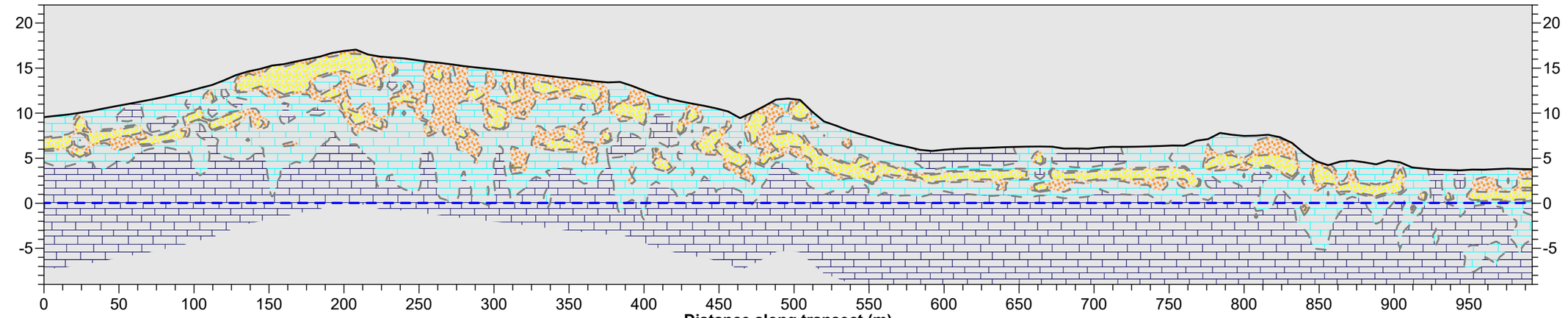
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

TRANSECT 10 - SEISMIC SHEAR WAVE VELOCITY MODEL

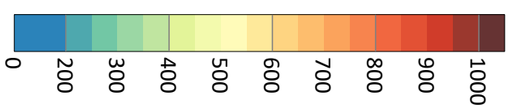


TRANSECT 10 - INTERPRETED GEOLOGICAL SECTION



372685.6 mE 6312325.6 mN	372792.0 mE 6312479.5 mN	372854.1 mE 6312635.5 mN	372875.1 mE 6312832.1 mN	372946.0 mE 6313016.3 mN	373018.7 mE 6313189.2 mN

SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-11	Revision	0

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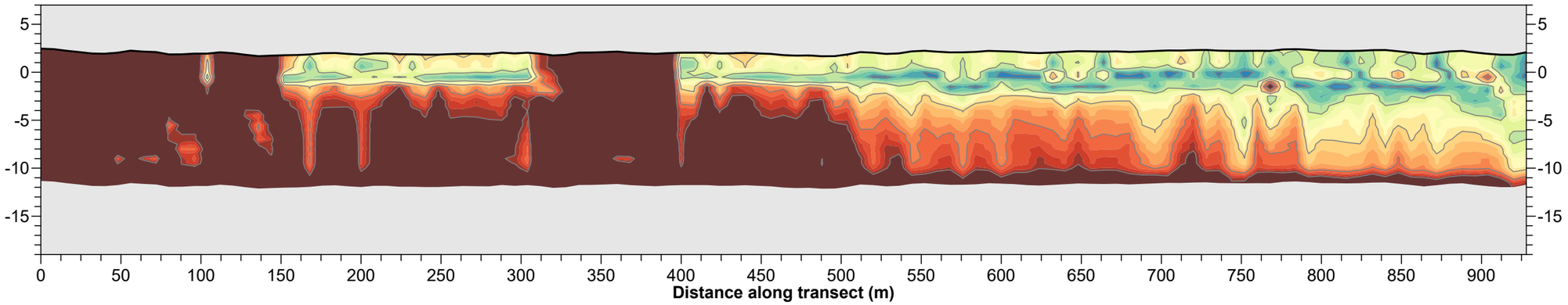
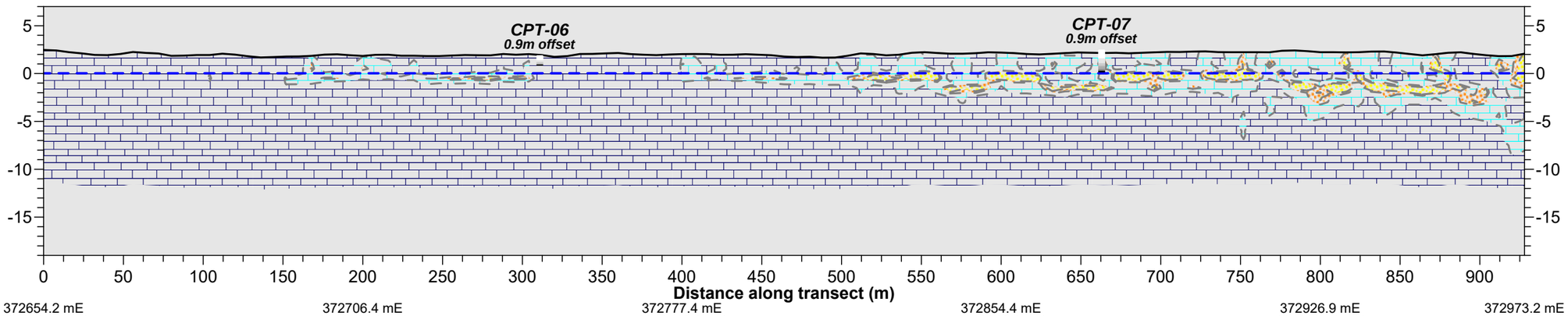
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

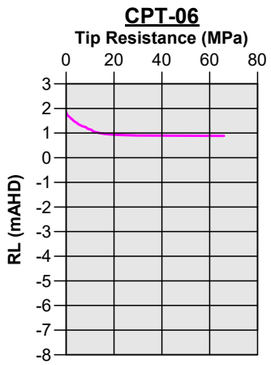
TRANSECT 11 - SEISMIC SHEAR WAVE VELOCITY MODEL



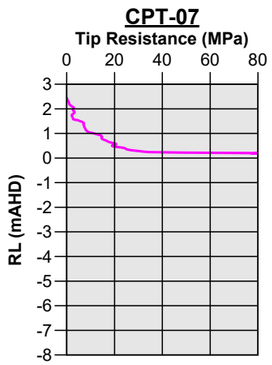
TRANSECT 11 - INTERPRETED GEOLOGICAL SECTION



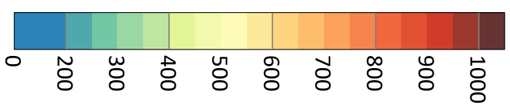
CPT-06



CPT-07



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	28 Nov 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142E-12	Revision	0

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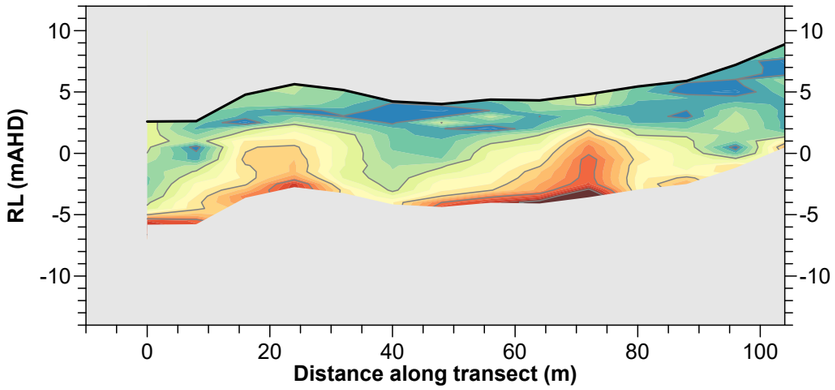
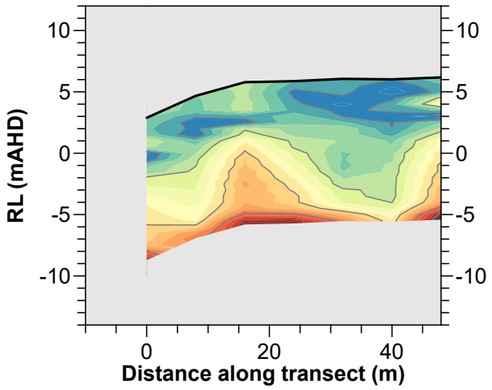
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

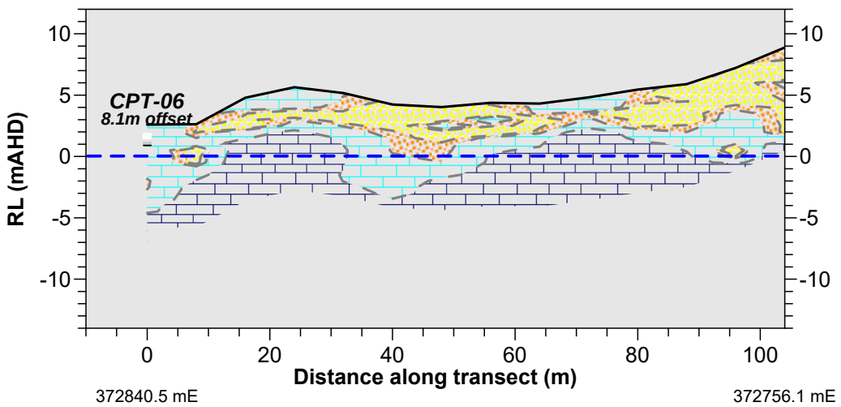
TRANSECT 12 - SEISMIC SHEAR WAVE VELOCITY MODEL



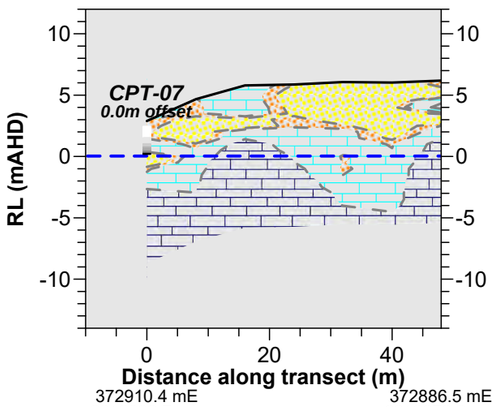
TRANSECT 13 - SEISMIC SHEAR WAVE VELOCITY MODEL



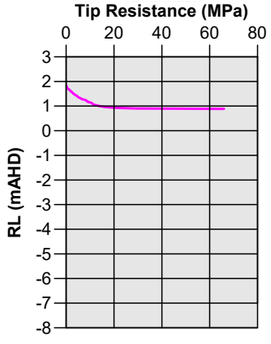
TRANSECT 12 - INTERPRETED GEOLOGICAL SECTION



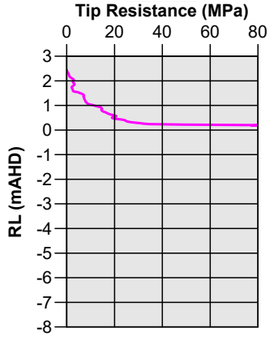
TRANSECT 13 - INTERPRETED GEOLOGICAL SECTION



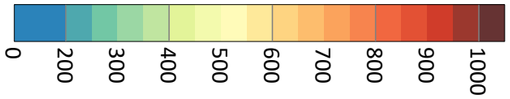
CPT-06



CPT-07



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-300 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 300-450 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 450 m/s.
- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

Tip Resistance (MPa)

- 0 to <5
- 5 to <10
- 10 to <15
- 15 to <20
- 20 to <25
- 25 to <30
- 30 to <35
- 35 to <40
- 40 to <45
- 45 to <50
- Equal to or >50

NOTES

Drawing to be used in conjunction with Report 3142E.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	2 Dec 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA	Scale	1:1000H, 1:500V	Drawn	PJE
		Drawing	3142E-13	Revision	0

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APPENDIX C – MODELLED LEVELTO TOP OF ROCK AND SAND THICKNESS

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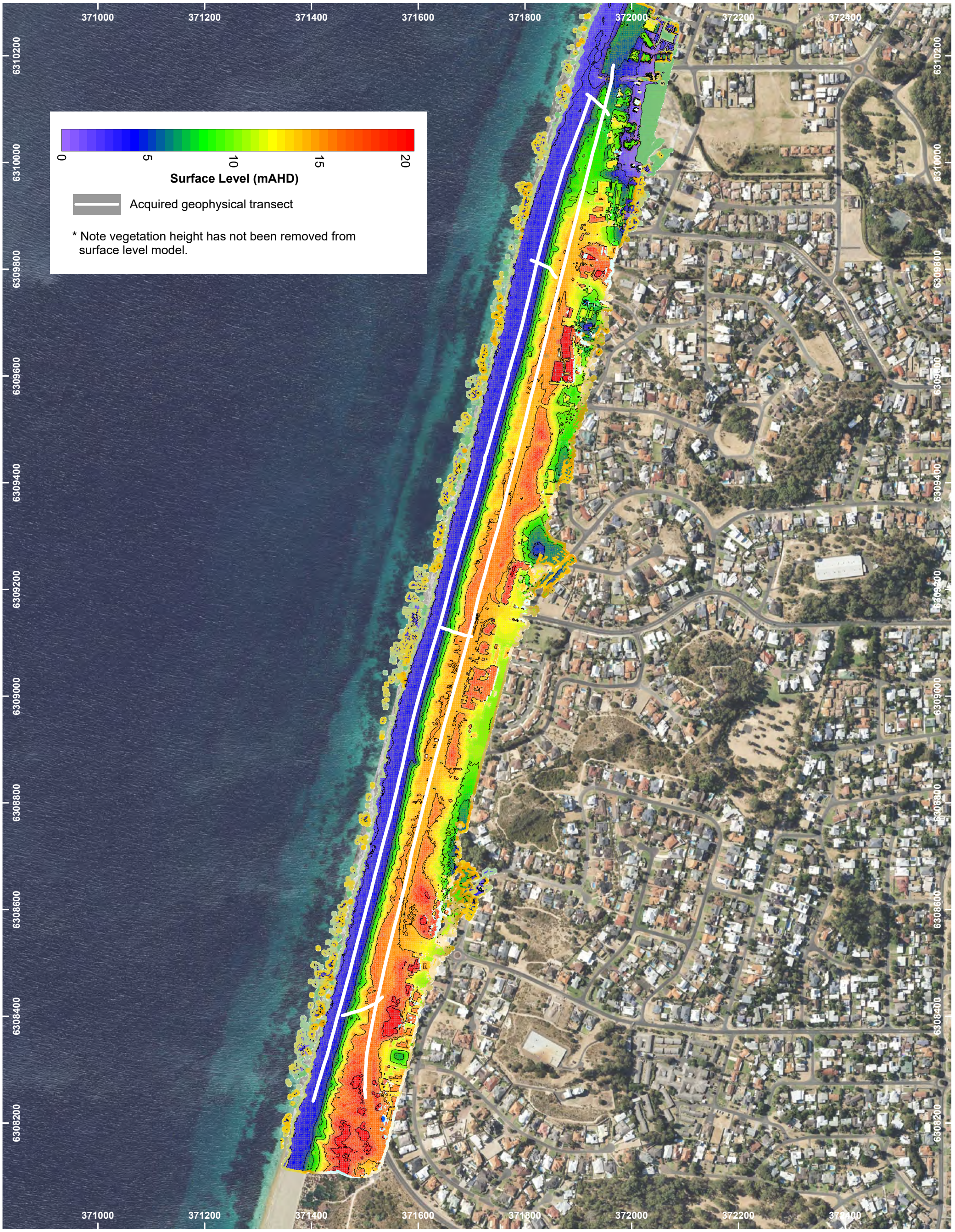
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CONTOURED LEVEL TO TOP OF ROCK (SOUTH)



NOTES

Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-14	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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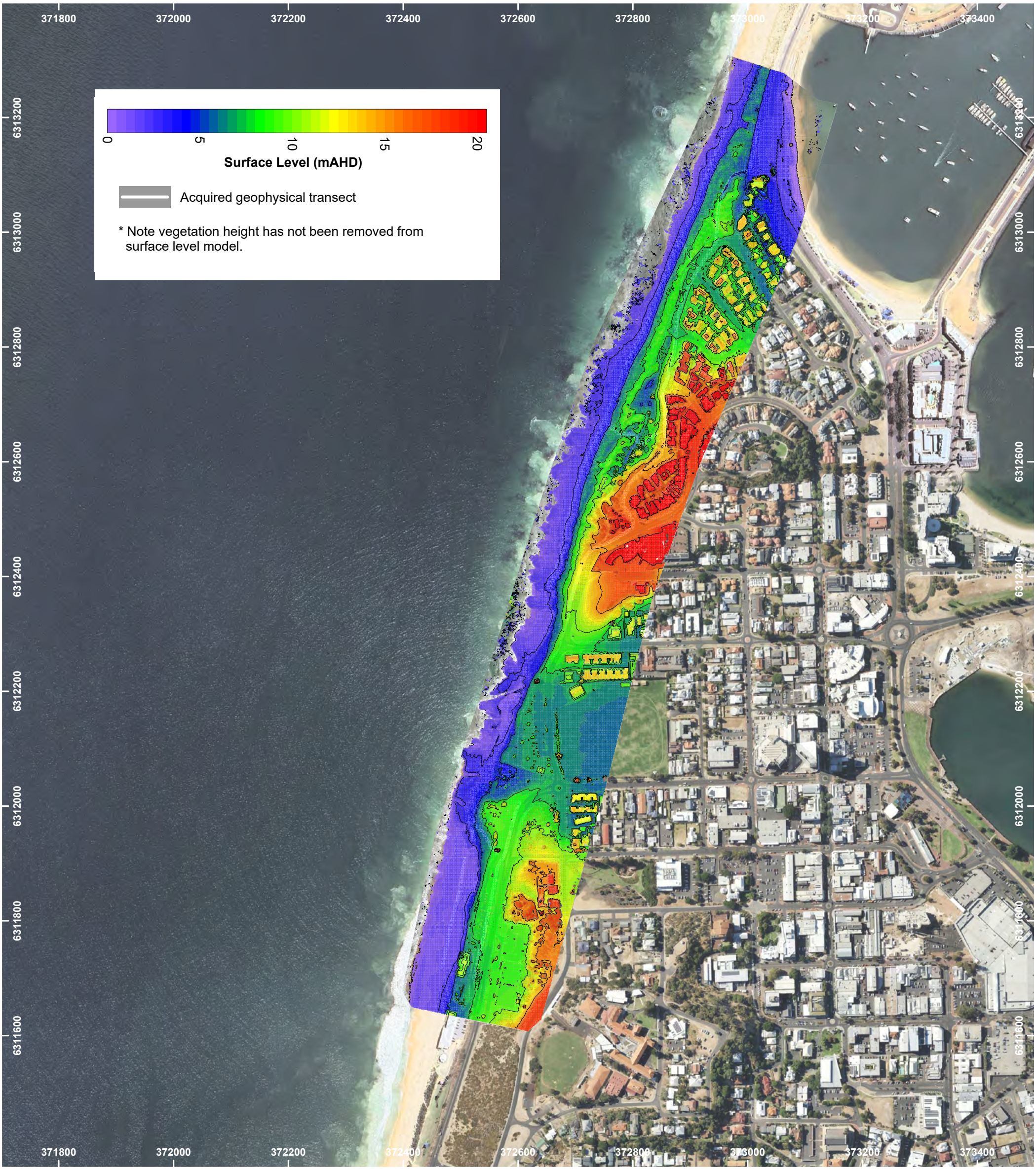
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

SURFACE LEVEL MODEL (NORTH)



NOTES Drawing to be used in conjunction with GBG report 3142E. Map Projection GDA2020 MGA Zone 50. Aerial image from Google Earth Pro and GBG photogrammetry.	N	Date	3 December 2024	Paper Size A3	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA
		Scale	1:6500	Drawn QA	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA
		Drawing	3142E-15	Revision 0	

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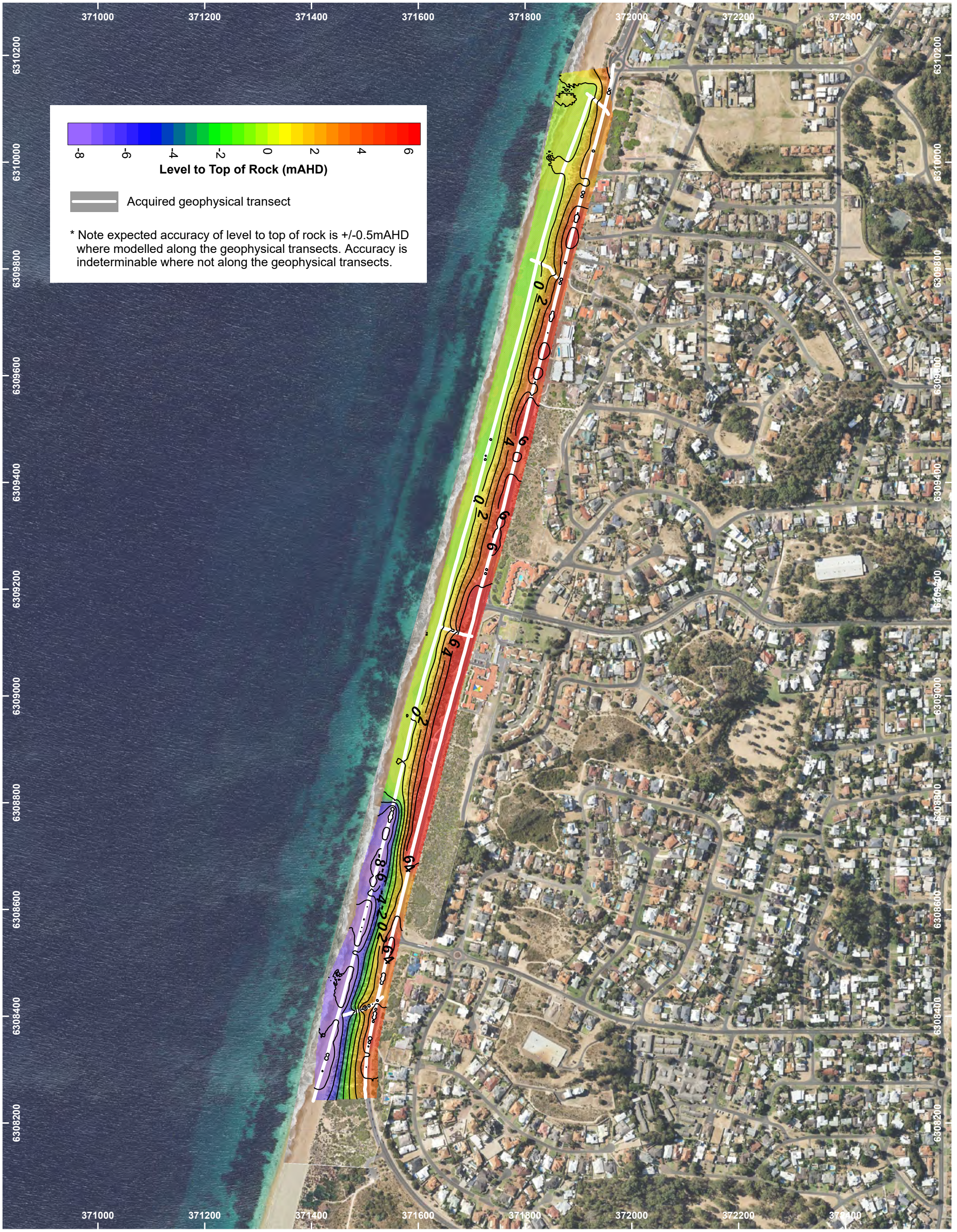
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CONTOURED LEVEL TO TOP OF ROCK (SOUTH)



NOTES Drawing to be used in conjunction with GBG report 3142E. Map Projection GDA2020 MGA Zone 50. Aerial image from Google Earth Pro and GBG photogrammetry.	N	Date	3 December 2024	Paper Size	A3
		Scale	1:6500	Drawn	QA
		Drawing	3142E-16	Revision	0

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GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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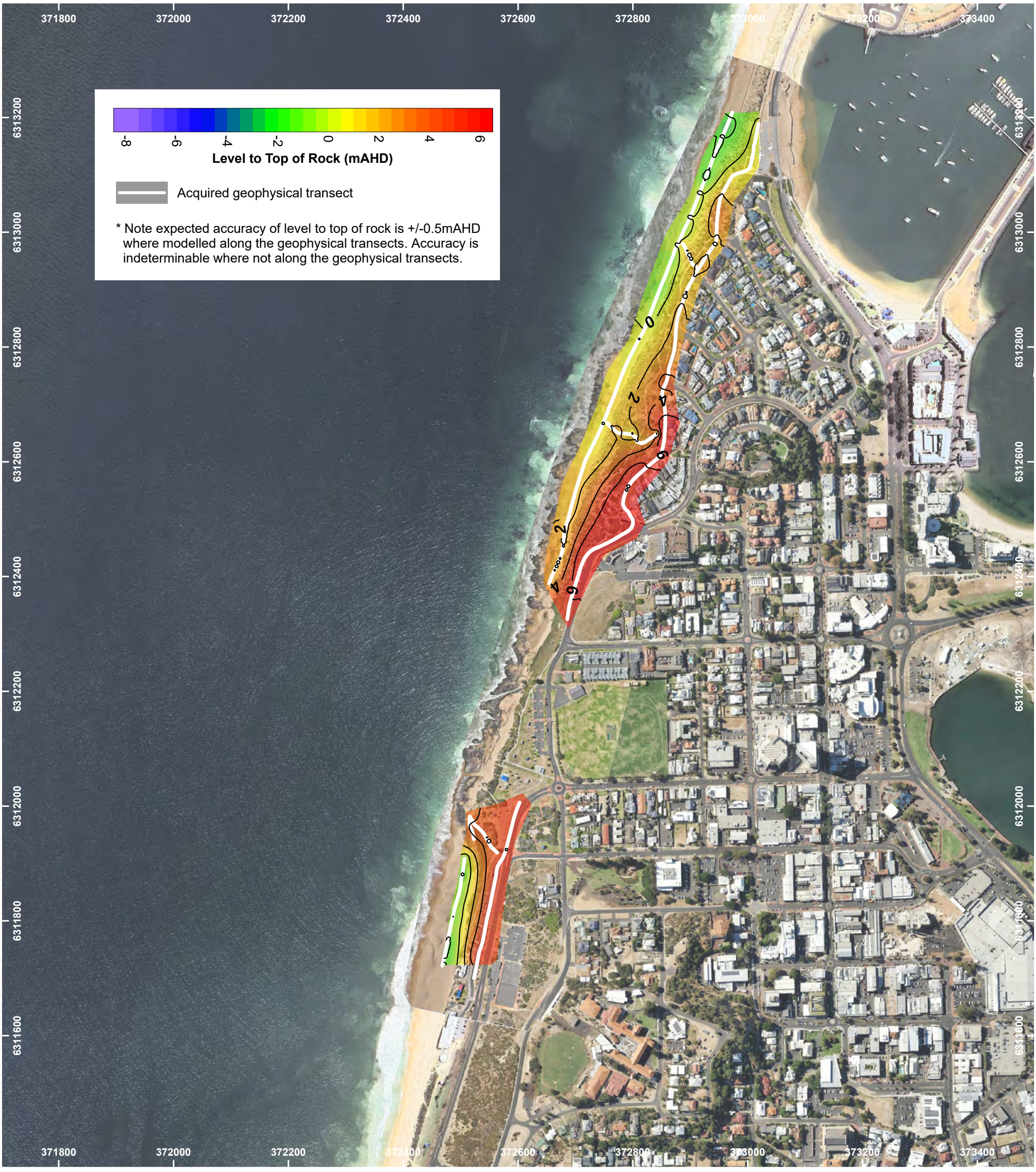
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CONTOURED LEVEL TO TOP OF ROCK (NORTH)



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-17	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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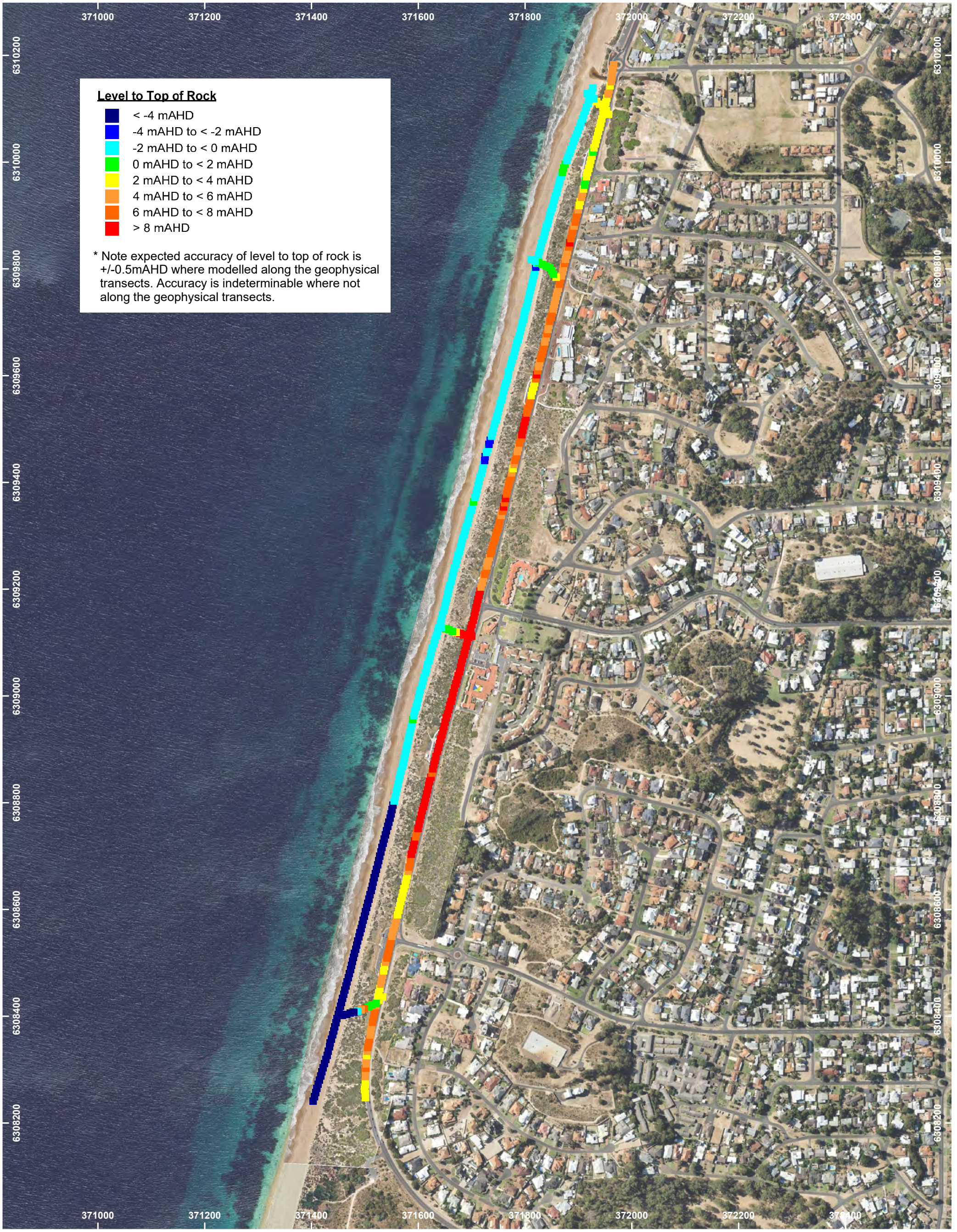
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CLASSED POST MAP LEVEL TO TOP OF ROCK (SOUTH)



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-18	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

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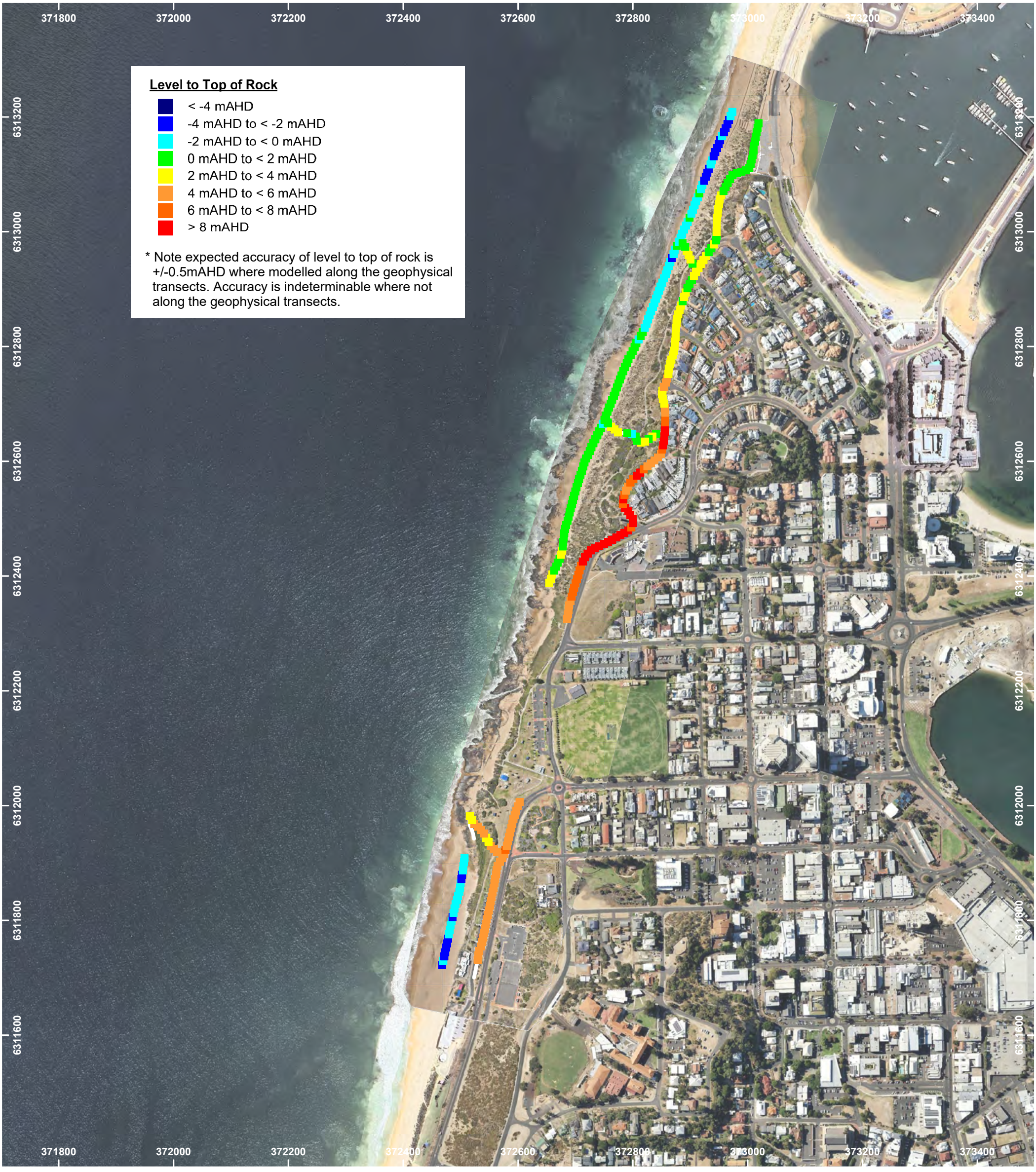
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CLASSED POST MAP LEVEL TO TOP OF ROCK (NORTH)



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-19	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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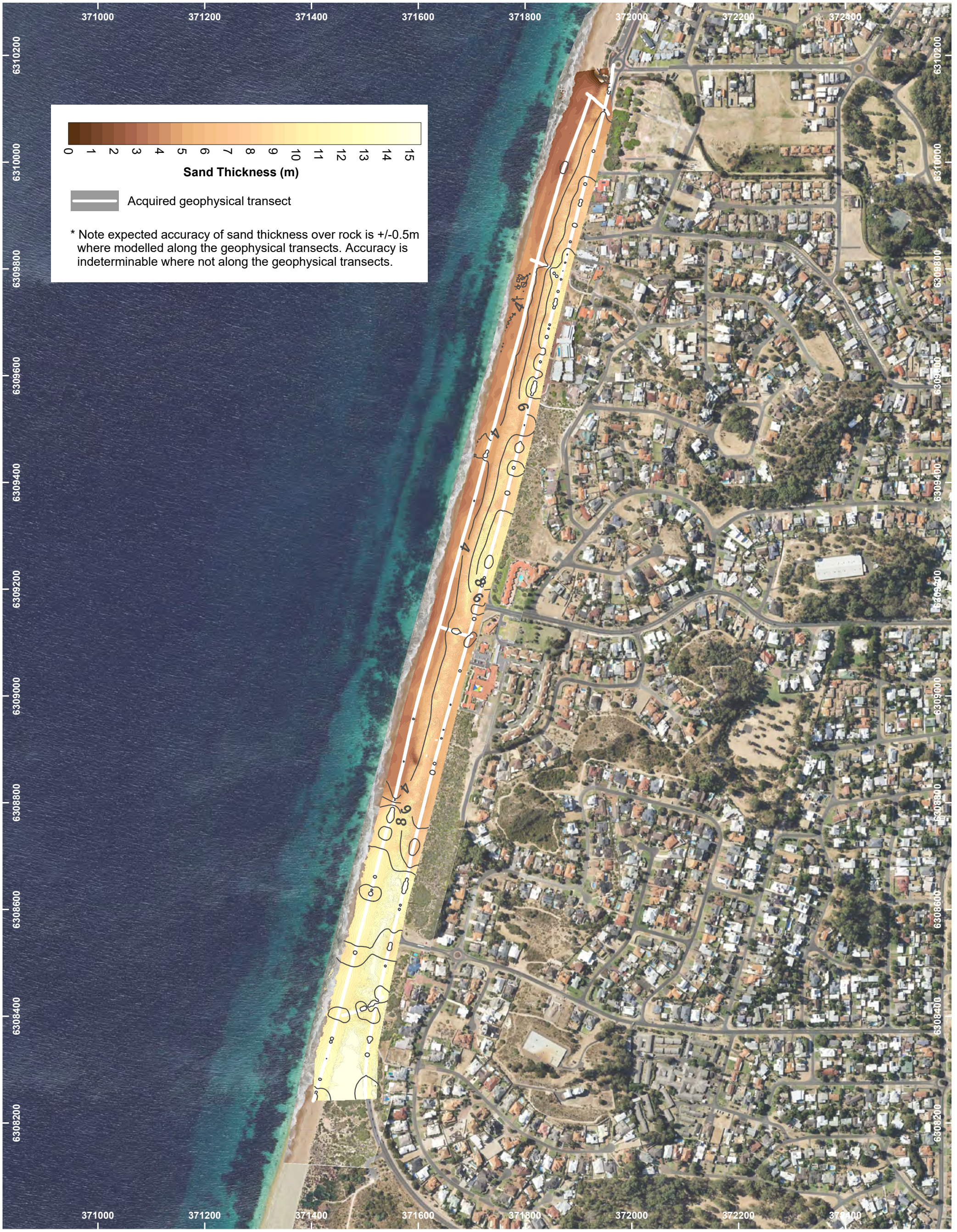
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CONTOURED SAND THICKNESS OVER ROCK (SOUTH)



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-20	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. BUNBURY, CITY OF BUNBURY WA

GBGGROUP
GB Geotechnics (Australia) Pty Ltd
ABN: 77 009 550 869
Telephone: 08 9354 6300
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GBGGROUP

GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CONTOURED SAND THICKNESS OVER ROCK (NORTH)

NOTES

Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

N

Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-21	Revision	0

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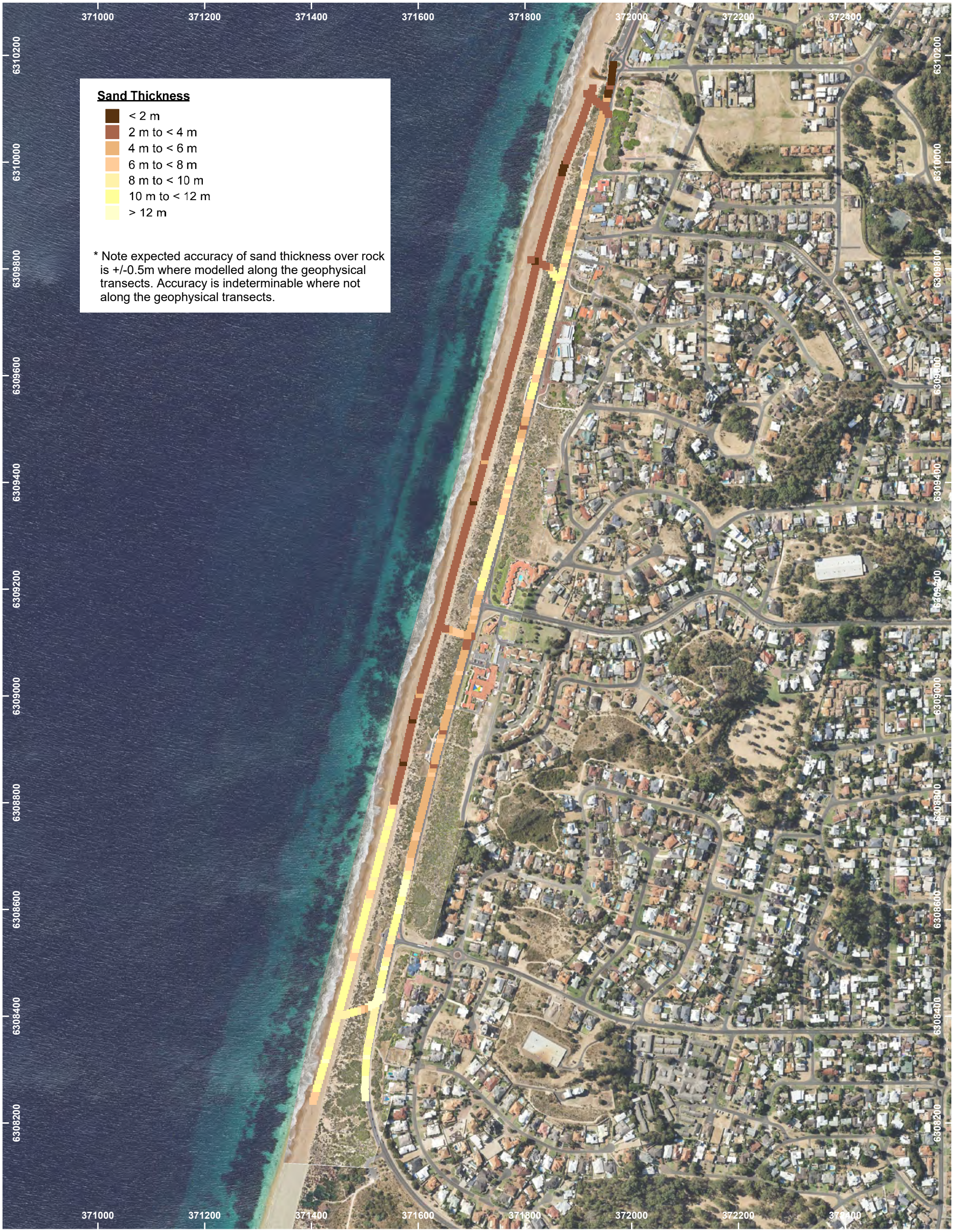
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CLASSED POST MAP SAND THICKNESS OVER ROCK (SOUTH)



NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

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Date	3 December 2024	Paper Size	A3
Scale	1:6500	Drawn	QA
Drawing	3142E-22	Revision	0

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GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT BUNBURY, CITY OF BUNBURY WESTERN AUSTRALIA

CLASSED POST MAP SAND THICKNESS OVER ROCK (NORTH)

NOTES
Drawing to be used in conjunction with GBG report 3142E.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro and GBG photogrammetry.

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Date	3 December 2024	Paper Size	A3
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Drawing	3142E-23	Revision	0

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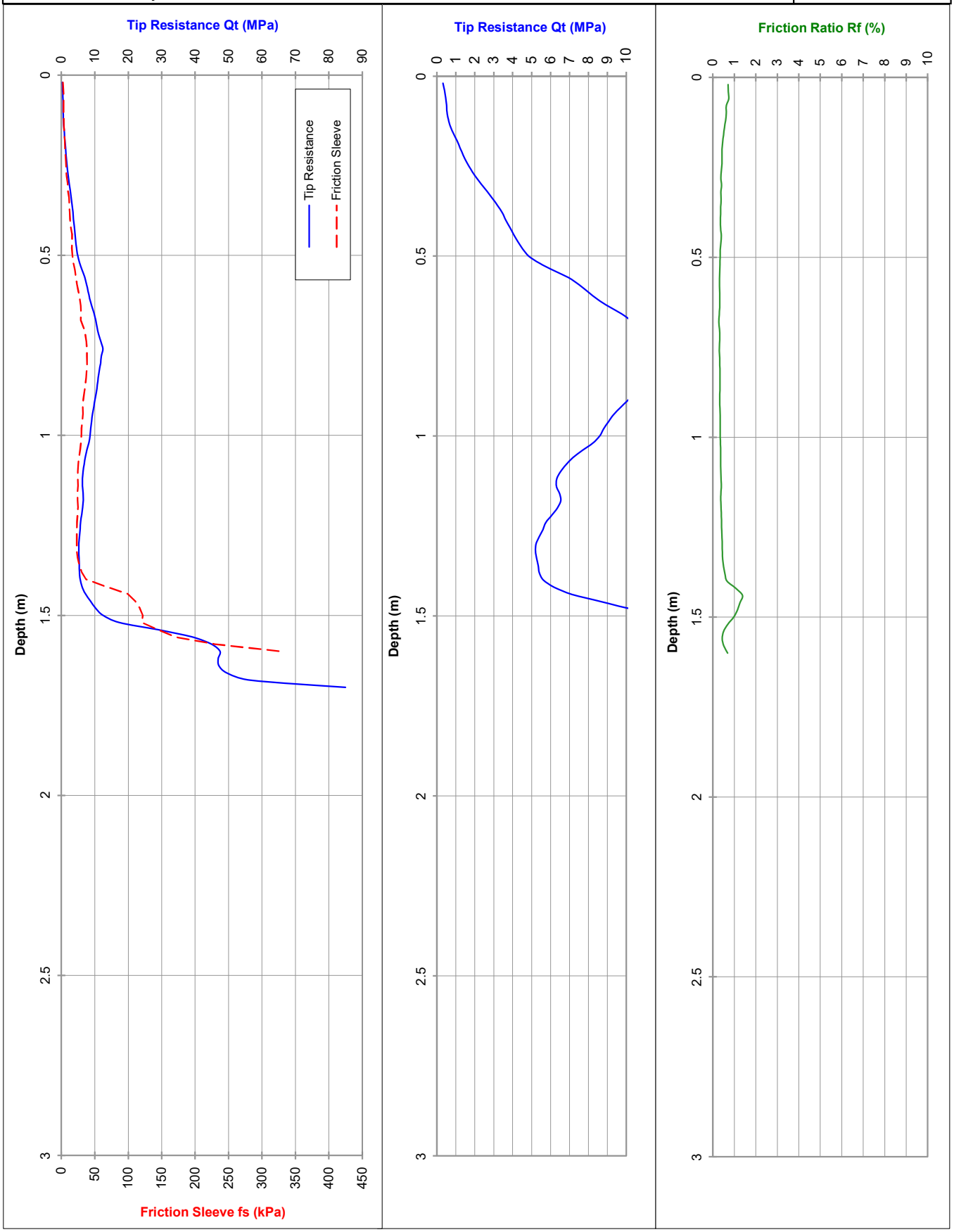
APPENDIX D – CONE PENETRATION TEST PLOTS

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern & Southwest Coastal	RL (m): 3.71	**CPTU 01**
LOCATION: Bunbury	Co-ords: 371460.38mE, 6308403.73mN	27-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): Dry to 1.7

Dummy probe to (m):

Refusal: 85 MPa + Rod Friction

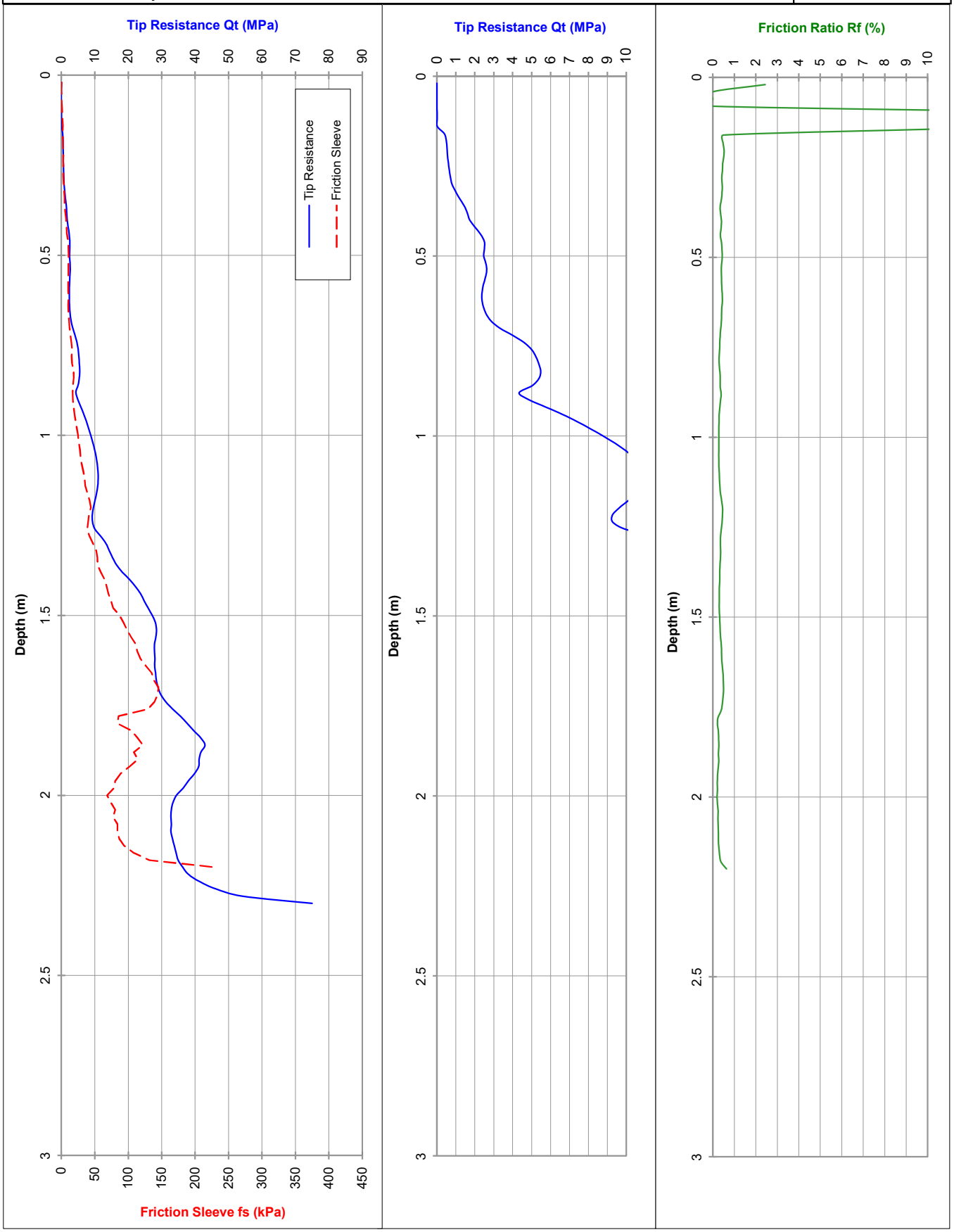
Cone I.D.: EC03

File: GB0107M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	GBG Group	Job No.: 3142	Probe I.D
PROJECT:	Southern & Southwest Coastal	RL (m): 3.13	**CPTU 02**
LOCATION:	Bunbury	Co-ords: 371636.86mE, 6309120.44mN	27-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): 1.8

Dummy probe to (m):

Refusal: 75 MPa + Rod Friction

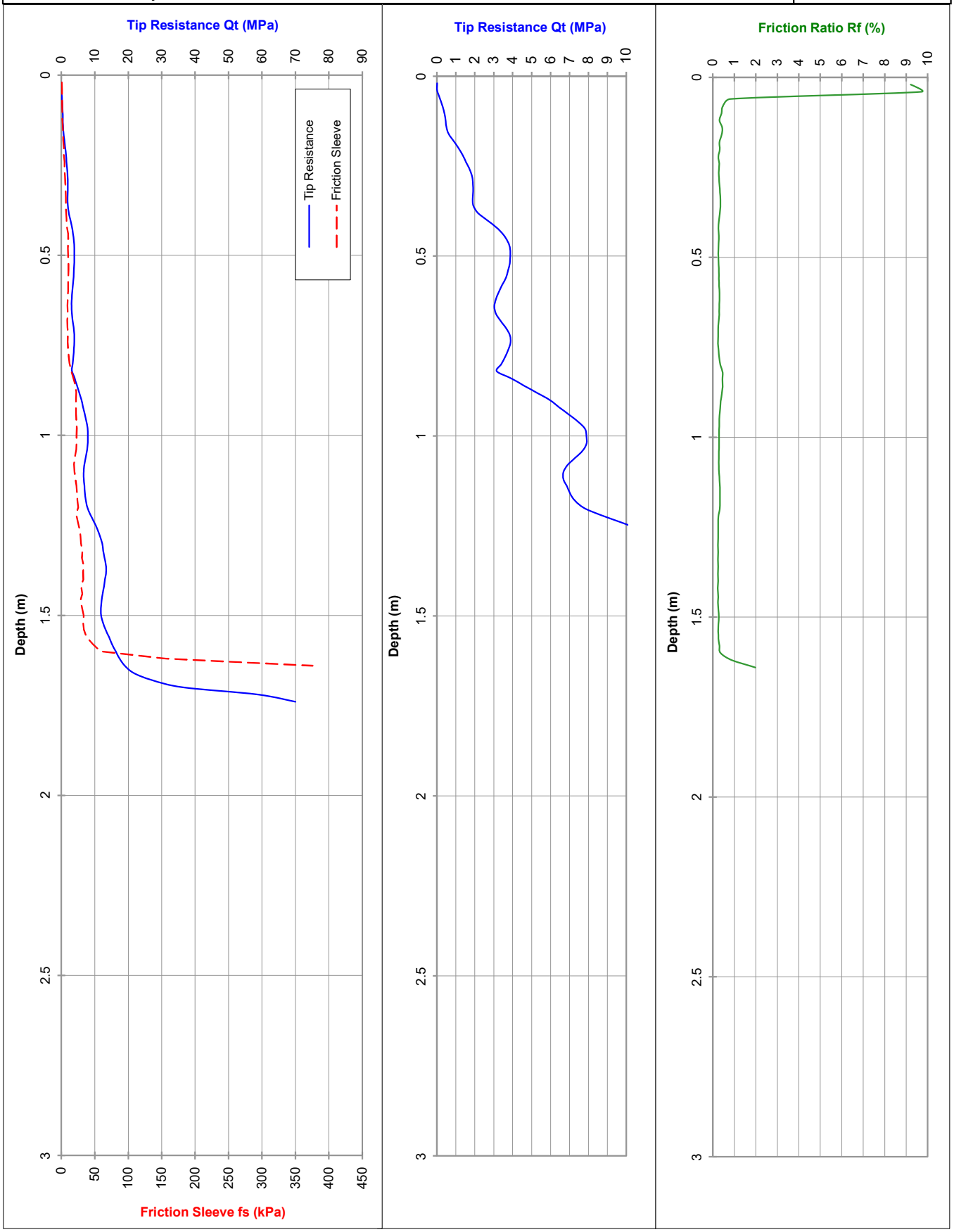
Cone I.D.: EC03

File: GB0108M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern & Southwest Coastal	RL (m): 2.39	**CPTU 03**
LOCATION: Bunbury	Co-ords: 371822.88mE, 6309814.97mN	27-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): Dry to 1.7

Dummy probe to (m):

Refusal: 70 MPa + Rod Friction

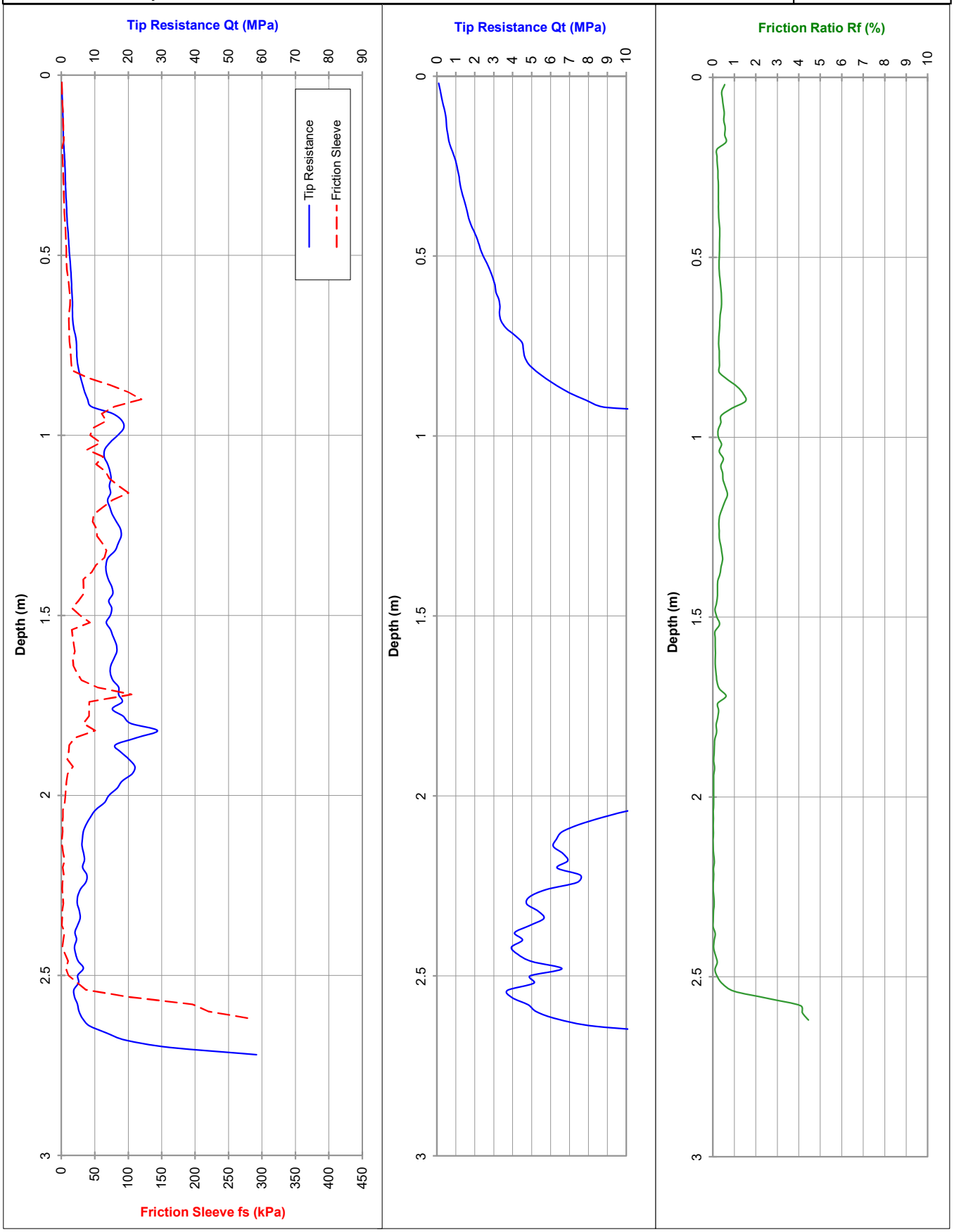
Cone I.D.: EC03

File: GB0109M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT:	GBG Group	Job No.: 3142	Probe I.D
PROJECT:	Southern & Southwest Coastal	RL (m): 3.81	**CPTU 04**
LOCATION:	Bunbury	Co-ords: 371923.3mE, 6310123.32mN	27-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): 2.0

Dummy probe to (m):

Refusal: Inclination

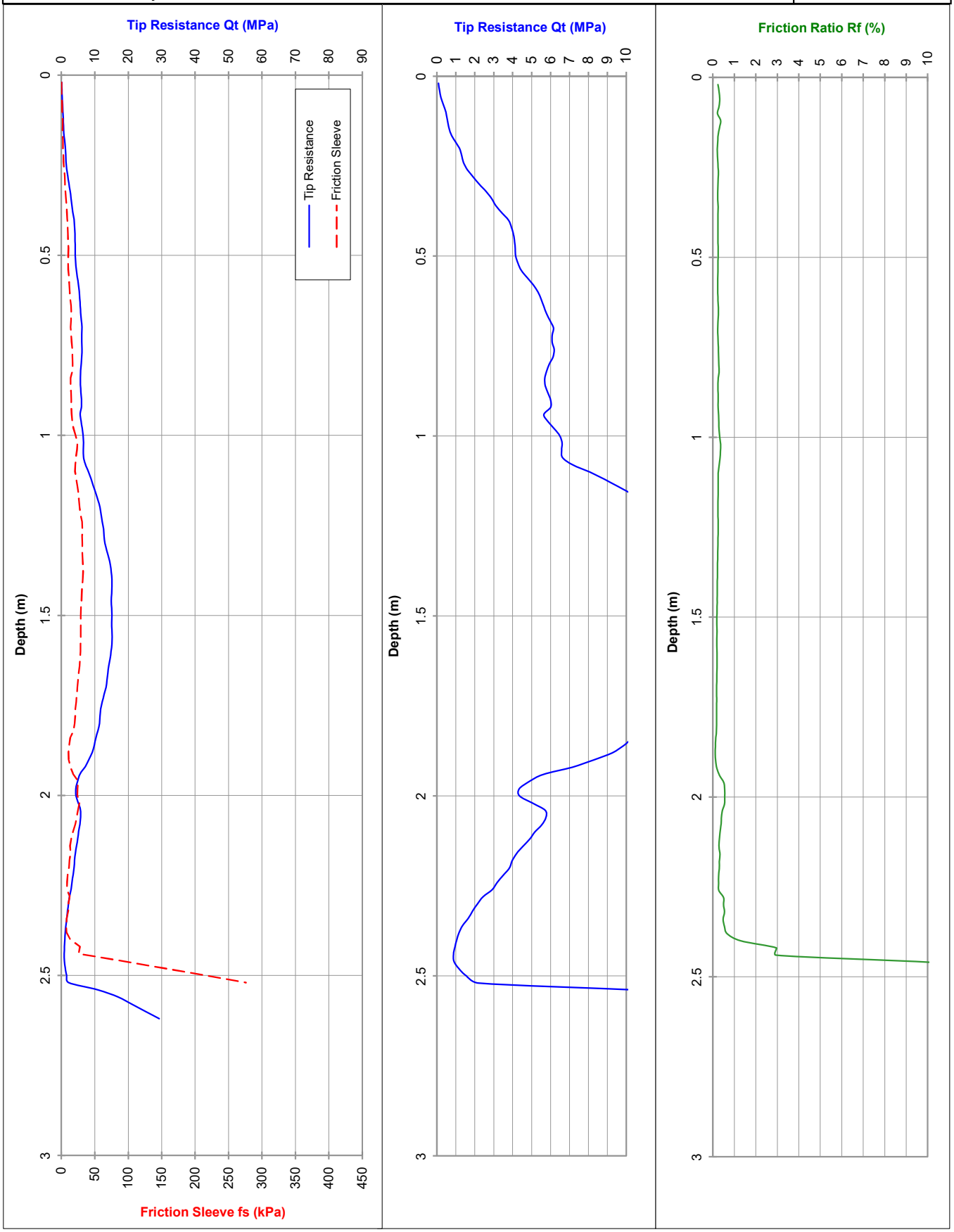
Cone I.D.: EC03

File: GB0110M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern & Southwest Coastal	RL (m): 1.57	**CPTU 05**
LOCATION: Bunbury	Co-ords: 372482.6mE, 6311783.07mN	26-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): Dry to 0.2

Dummy probe to (m):

Refusal: Inclination

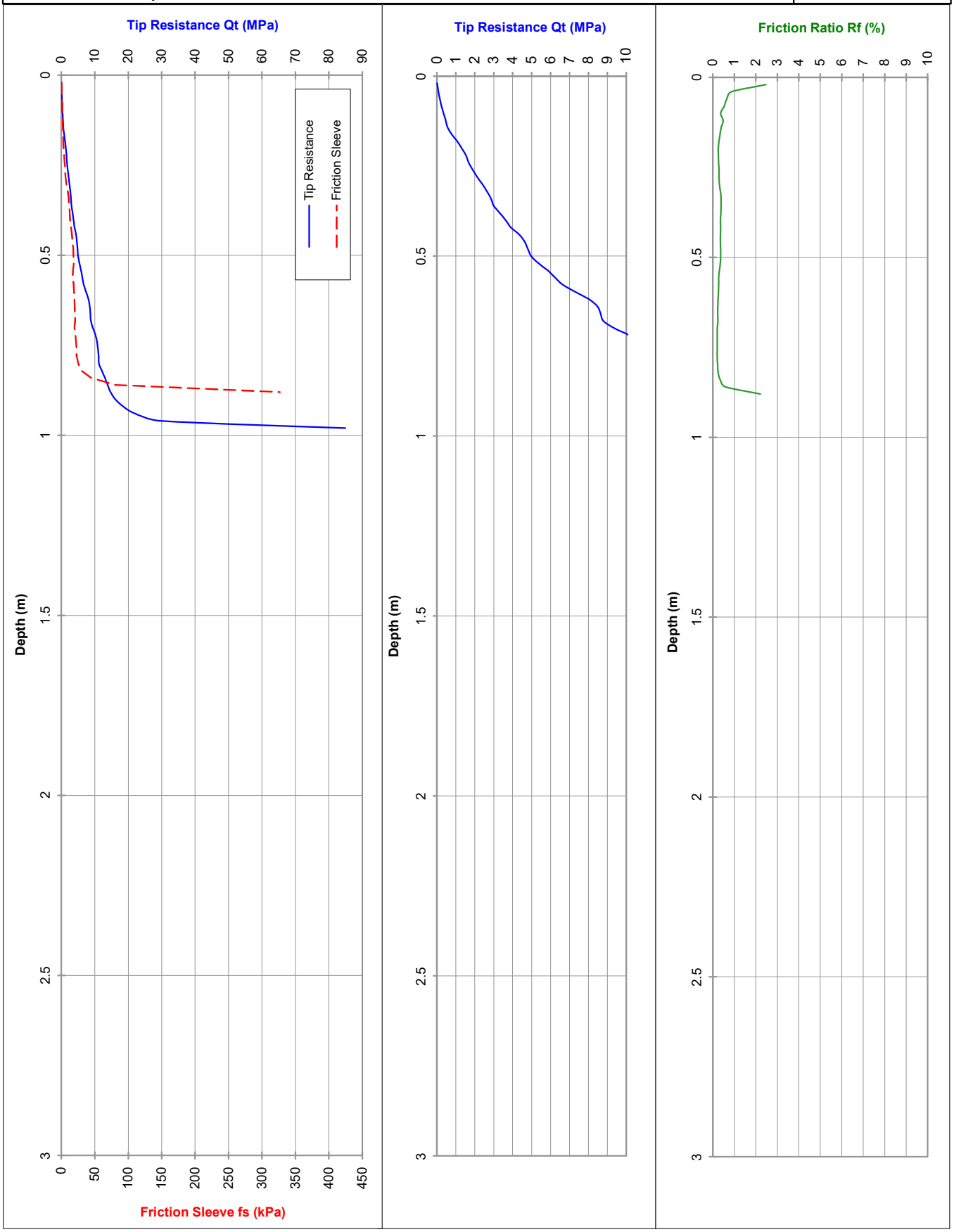
Cone I.D.: EC03

File: GB0106M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern & Southwest Coastal	RL (m): 2.17	**CPTU 06**
LOCATION: Bunbury	Co-ords: 372752.29mE, 6312673.69mN	26-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): Dry to 0.3

Dummy probe to (m):

Refusal: 85 MPa + Rod Friction

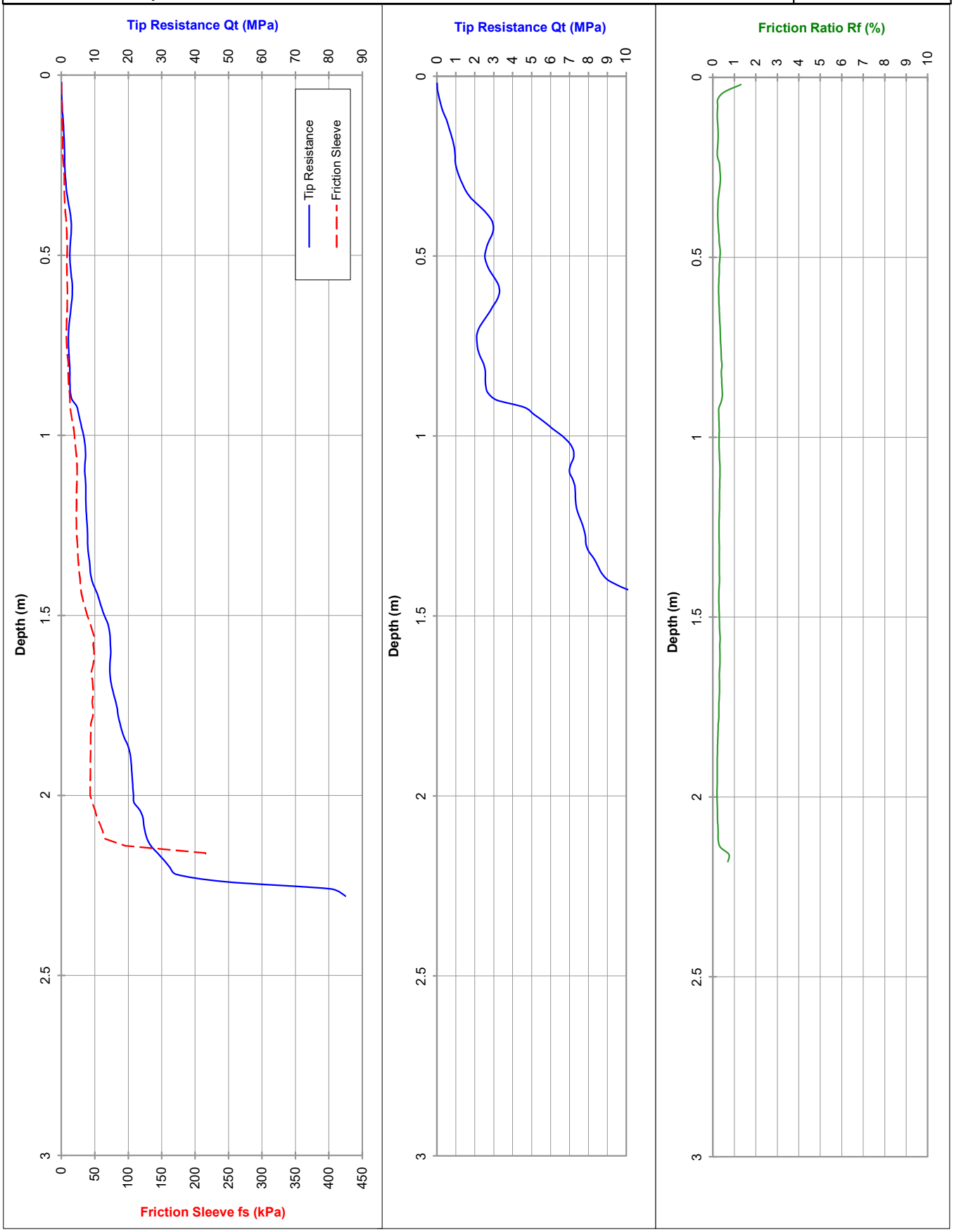
Cone I.D.: EC03

File: GB0105M1

Rig Type: 12t track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern & Southwest Coastal	RL (m): 2.39	**CPTU 07**
LOCATION: Bunbury	Co-ords: 372880mE, 6312976.34mN	26-Nov-24



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. water (m): Dry to 1.9

Dummy probe to (m):

Refusal: 85 MPa + Rod Friction

Cone I.D.: EC03

File: GB0104M1

Rig Type: 12t track (M1)

PROBEDRILL
GEOTECHNICAL SURVEY

CALIBRATION CERTIFICATE

CONE ID: EC03

Cone Type:	Compression
Calibration Date (qc/fs):	10 September 2024
Calibration Date (u):	12 March 2024
Preliminary Inspection:	Pass
Calibrated By:	Henky Lawer
Calibration Procedure:	ISO 22476-1:2012, IRTP 2001
Force Application:	Compression
Reference Equipment:	PT - S type 100kN Serial # 5126009 (Calibrated 10/03/23 - NATA approved Cert. No. 230664) Bongshin - S type 50kN Serial #I44427 (Calibrated 05/06/24 - NATA approved Cert. No. 241683) Digitron Panel Meter Serial #: 060213/01 (Calibrated 09/03/23 - NATA endorsed Report No. 230658, 230659, 230660)

Note: In accordance with AS1289 F5.1 the force calibration derived by NATA Calibration Certificates are converted to a qc reading in MPa and fs reading in kPa by dividing by 1000 mm² and 15000mm² respectively.

Results of Calibration:

qc (tip resistance):

Capacity: 100 (MPa)
Area 1000 (mm²)

Applied Load kN	Eqv. Pressure MPa	Mean Observed Reading Volts
0	0	0.000
10	10	0.779
20	20	1.560
30	30	2.341
40	40	3.126
50	50	3.907
60	60	4.691
70	70	5.473
80	80	6.258
90	90	7.040
100	100	7.824
90	90	7.054
80	80	6.279
70	70	5.503
60	60	4.722
50	50	3.941
40	40	3.157
30	30	2.371
20	20	1.585
10	10	0.798
0	0	0.001
R^2 Value =	1.000	

Zero Load Error: 0.01%
Max. Linearity 0.32%
Max. Hysteris 0.43%

MPa/Volt: 12.774

fs (sleeve friction):

Capacity: 2000 (kPa)
Area 15000 (mm²)

Applied Force kN	Eqv. Load kPa	Mean Observed Reading Volts
0	0	0.000
3	200	0.746
6	400	1.512
9	600	2.273
12	800	3.035
15	1000	3.797
18	1200	4.556
21	1400	5.319
24	1600	6.078
27	1800	6.838
30	2000	7.599
27	1800	6.867
24	1600	6.113
21	1400	5.358
18	1200	4.601
15	1000	3.841
12	800	3.079
9	600	2.314
6	400	1.546
3	200	0.770
0	0	0.003
R^2 Value =	1.000	

Zero Load Error: 0.05%
Max. Linearity 0.47%
Max. Hysteris 0.60%

kPa/Volt: 262.76

u (pore pressure):

Capacity: 3500 (kPa)
Position u2

Applied Pressure bar	Eqv. Pressure kPa	Mean Observed Reading Volts
0	0	0.000
3	300	0.494
6	600	0.988
9	900	1.482
12	1200	1.975
15	1500	2.468
18	1800	2.960
21	2100	3.449
25	2500	4.108
30	3000	4.921
35	3500	5.745
30	3000	4.935
25	2500	4.117
21	2100	3.462
18	1800	2.970
15	1500	2.477
12	1200	1.984
9	900	1.490
6	600	0.995
3	300	0.500
0	0	0.003
R^2 Value =	1.000	

Zero Load Error: 0.05%
Max. Linearity 0.26%
Max. Hysteris 0.23%

kPa/Volt: 609.18
Net Area (calibrated): 0.82

"Class 1" Application Accuracy achieved (in accordance with ISO 22476:2012 classification)

Calibration Checked & Authorised: Kylie Walker

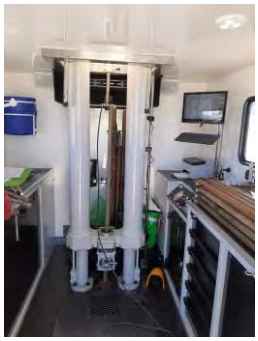
Job Details

Client:	GBG Maps	**Date of Job:**	26/11/24
Rep:	Peter Eccleston	**Tip Diameter:**	35.92
Location:	Bunbury	**Sleeve Diameter:**	35.97

PROBEDRILL
GEOTECHNICAL SURVEY

MOROOKA (M2)

11 tonne track mounted CPT Rig



SPECIFICATIONS

Overall Dimensions	Width: 2.3m; Length: 5.3m; Height: 3.2m (while travelling) Height: 4.4m (while probing)
Gross Weight	11 tonne
Ground Bearing Capacity	0.38 kg/cm^2 (37kPa / 5.4psi)
Speed (Low/High)	Low gear: 8.3km High gear: 12km/h on level ground
Grade ability	60%
Engine	Mitsubishi (3910cc) 110 HP @ 2,800 rpm
Fuel Tank	80 L (Diesel)
Drive System	HST
Tracks	600mm wide rubber tracks
Levelling Jacks	0.8m stroke

EQUIPMENT / FEATURES

Other Equipment / Features	2.4m x 1.2m Plastic Bog Boards 1 x 9kg ABE Fire extinguisher Air conditioned work cabin and drive cabin
Transport	Prime Mover & 10m Drop-deck trailer with ramps

SERVICES

Geotechnical Services provided	CPT, CPTu, SCPT, SCPTu (1, 5, 10, & 15 tonne cones) DMT, SDMT Dissipation Testing Ball Penetrometer CPT casing for additional rod support Dual Tube (percussion) sampling Piston Sampling MOSTAP and PROBEDRILL soil sampling Vane Shear Testing (Electronically driven) Vibrating Wire Installation Water Sampling Standpipe Installation (20mm; 32mm & 50mm)