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Report

Geotechnical Investigation for Coastal Erosion Vulnerability Assessment.

Kwinana Beach, City of Kwinana WA.

Date: 10 January 2025
Report Ref: 3142G

DOCUMENT HISTORY

DETAILS

Project number	3142G
Document Title	Geotechnical Investigation for Coastal Erosion Vulnerability Assessment
Site Address	Kwinana Beach, City of Kwinana WA
Report prepared for	The Government of Western Australia, Department of Transport

STATUS AND REVIEW

Revision	Prepared by	Reviewed by	Date issued
0	Baqir Al asadi	Peter Eccleston	10 January 2025

DISTRIBUTION

Revision	Electronic	Paper	Issued to
0	1	0	Michael Meuleners, Tim Stead - DoT

COMPANY DETAILS

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EXECUTIVE SUMMARY

A geotechnical investigation has been carried out as part of a coastal erosion assessment at Kwinana Beach in the City of Kwinana, Western Australia. During the investigation ground geophysical and intrusive geotechnical testing was conducted within an 800m corridor of coastal beach and dune formation adjacent to the Kwinana Beach settlement which has been identified as an at-risk site as part of Hotspot # 31.

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. 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.
- Interpreted top of rock substrate on the along-shore transects on the beach ranged from <16mAHD to 2.0mAHD and averages approximately -10mAHD and is overlain by an average of 12.0m of variably compacted sediment.
- Interpreted rock level was generally very deep across the site.
- Cone Penetrometer testing results did not show refusal at any test locations, which is consistent with deep rock shown on the MASW models.

CONTENTS

1 INTRODUCTION

At the request of The Government of Western Australia Department of Transport (DoT), GBG Group carried out a geotechnical investigation at Kwinana Beach, City of Kwinana in November 2024. During the investigation seismic geophysical testing and intrusive geotechnical testing was conducted within an 800m corridor of coastal beach and dune formation which has been identified as an at risk site as part of Hotspot #31.

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 an 800m corridor of coastal beach and dune formation the extents of which is shown as a yellow dashed area in Figure 1.

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 native vegetation and in order to ensure the most optimal, efficient and economical 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 2 and 3.

Topography at the sites was generally flat to undulating and surface level ranged from 0mAHD to 5mAHD. Topographic maps showing surface level are provided in Appendix C drawings 3095A-06.

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

Figure 2: Site conditions at Kwinana Beach showing location of beach transects.

Figure 3: Example site conditions at Kwinana Beach showing cross-shore transect locations.

3 INVESTIGATION METHODOLOGY

3.1 FIELD SURVEY LOGISTICS

Geophysical data acquisition was carried out from the 11th to 12th December 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 12th and 16th December 2024. Where required, the site work was carried out under appropriate traffic and pedestrian management commissioned by the City of Kwinana.

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 1824m of MASW profiling acquired as 5 along-shore transects (parallel to the coast) and 3 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 3142G-01.

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	382804.5	6430983.1	382950.0	6431201.9	264
MASW-02	Along-shore	382789.6	6430991.8	382893.3	6431181.7	232
MASW-03	Along-shore	382899.1	6431177.3	383119.2	6431565.6	520
MASW-04	Along-shore	382886.3	6431232.7	382916.6	6431301.7	80
MASW-05	Along-shore	382843.5	6431425.6	383032.7	6431718.7	384
MASW-06	Cross-shore	382721.2	6431011.3	382789.7	6431000.6	72
MASW-07	Cross-shore	382862.4	6431398.3	382951.1	6431331.9	120
MASW-08	Cross-shore	382963.2	6431558.9	383014.5	6431450.9	152

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 receiver array. MASW acquisition parameters are provided in Table 2. Photographs of MASW data acquisition are shown in Figure 4.

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	0.250 ms
Source	40kg AWD / 5.9kg Sledgehammer
Source offset	4 m
Sounding interval	8m
Source stacks	3

Figure 4: 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 showed a prominent dispersion curve of the surface wave component. 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 5).
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.

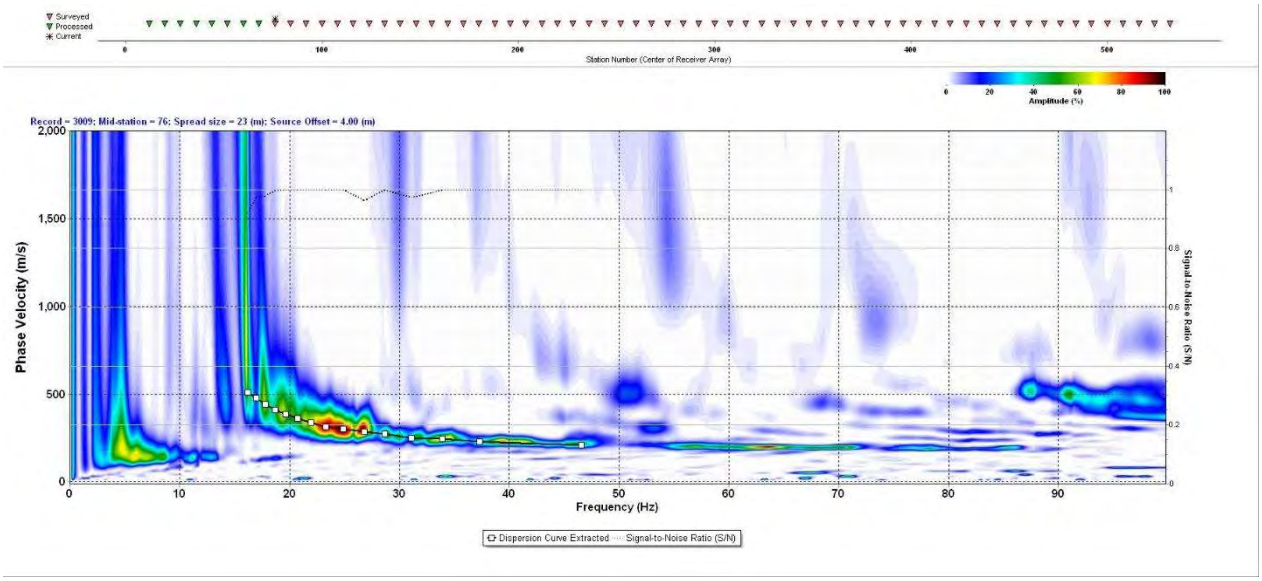

Figure 5: MASW overtone image with high signal to noise ratio and picked dispersion curve.

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 Whitby 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	WHIY00AUS0
Latitude	S 32° 17' 51.07968"
Longitude	E 116° 1' 41.07335"
Ellipsoidal height (m)	200.358

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 Kwinana Beach, City of Kwinana are presented in Appendices B and C of this report as follows:

Appendix B – Geophysical and Interpreted Sections

- **3142G-02.** Transect 01 and 02 seismic S-wave velocity model and interpreted geological section.
- **3142G-03.** Transect 03 seismic S-wave velocity model and interpreted geological section.
- **3142G-04.** Transect 04 and 05 seismic S-wave velocity model and interpreted geological section.
- **3142G-05.** Transect 06, 07 and 08 seismic S-wave velocity model and interpreted geological section.

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

- **3142G-06.** Contoured surface level models derived from aerial photogrammetry.
- **3142G -07.** Contoured level to modelled top of rock.
- **3142G -08.** Class post map level to modelled top of rock.
- **3142G -09.** Contoured modelled sand thickness over rock / Depth to top of rock.
- **3142G -10.** 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 250-400m/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 400-550m/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 >550m/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.

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 / 06** – no refusal to 12.2m depth.
- **CPT-02 on Transect 02** – no refusal to 12.2m depth.
- **CPT-03 on Transect 03** – no refusal to 12.2m depth.
- **CPT-04** – no refusal to 12.2m depth. (offset from Transects too great for calibration)
- **CPT-05 on Transect 05 / 08** – no refusal to 12.2m depth.
- **CPT-06 on Transect 05** – no refusal to 12.2m depth.
- **CPT-07 on Transect 03** – no refusal to 12.2m depth.

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.

No outcropping rock was observed on the Kwinana Beach site.

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 has 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 elevation. 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 3142G-06) – generated from the aerial photogrammetry, this presents the level to ground surface ranging from 0mAHD to 5mAHD. Note: vegetation height has not been removed from these models.
- **Contoured Level to Top of Rock Substrate** (drawings 3142G-07) – this presents the level to the top of rock substrate ranging from <-13mAHD to 0mAHD.
- **Classed Post Map Level to Top of Rock Substrate** (drawings 3142G-08) – this presents the level to the top of rock substrate along the acquired transects at 2m level increments from <-6mAHD to >6mAHD.
- **Contoured Sand Thickness / Depth to Top of Rock** (drawings 3142G-09) – this presents the thickness of sand overlying the rock substrate ranging from 5mBGL to >18mBGL.
- **Classed Post Map Sand Thickness / Depth to Top of Rock** (drawings 3142G-10) – 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 to the accuracy of the GNSS receivers using 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 Kwinana Beach in the City of Kwinana, Western Australia. During the investigation ground geophysical and intrusive geotechnical testing was conducted within an 800m corridor of coastal beach and dune formation adjacent to the Kwinana Beach settlement which has been identified as an at risk site as part Hotspot # 31.

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 KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

INVESTIGATION SITE MAP

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

N

Date	11 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-01	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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

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APPENDIX B – GEOPHYSICAL AND INTERPRETED SECTIONS

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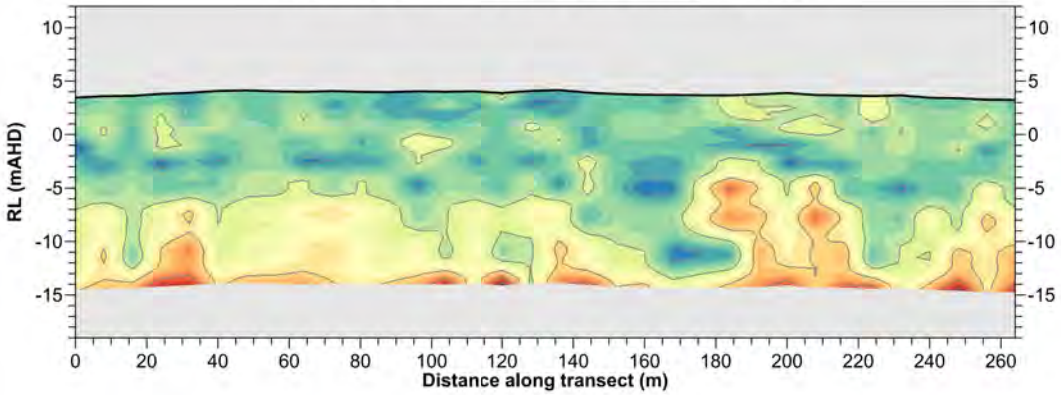
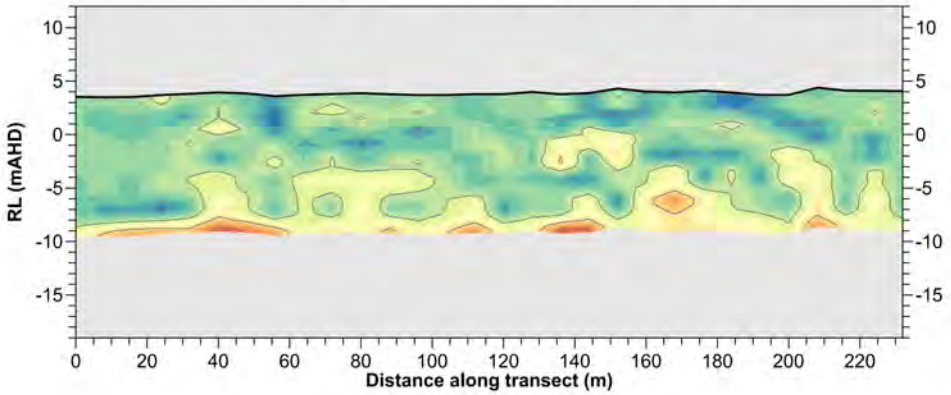
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

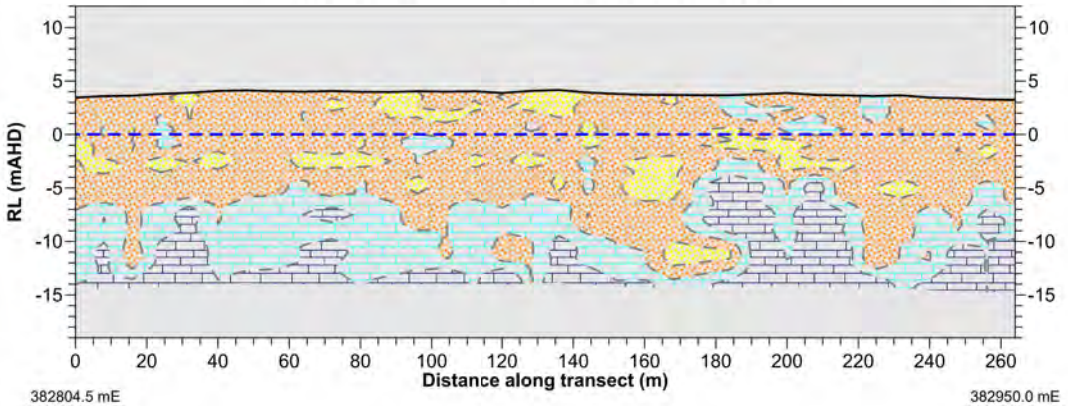
TRANSECT 01 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 02 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 01 - INTERPRETED GEOLOGICAL SECTION



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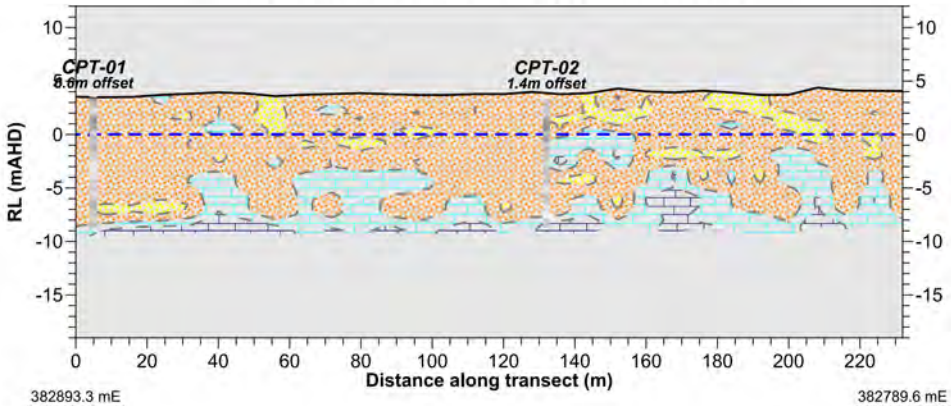
6430983.1 mN

382950.0 mE
6431201.9 mN

TRANSECT 02 - INTERPRETED GEOLOGICAL SECTION



382893.3 mE
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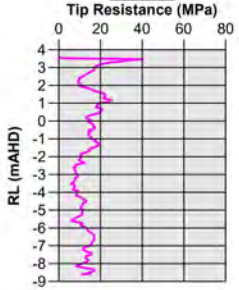
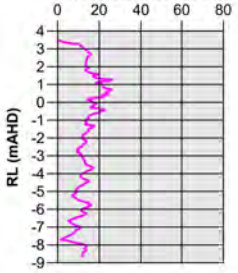
382789.6 mE
6430991.8 mN

CPT-01



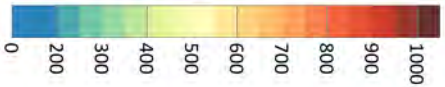
Target Depth
No Refusal

CPT-02



Target Depth
No Refusal

SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-400 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 400-550 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 550 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 3142G.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	18 December 2024	Paper Size	A3
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. KWINANA, CITY OF KWINANA WA		Scale	1:1500H, 1:500V	Drawn	PJE
		Drawing	3142G-02	Revision	0

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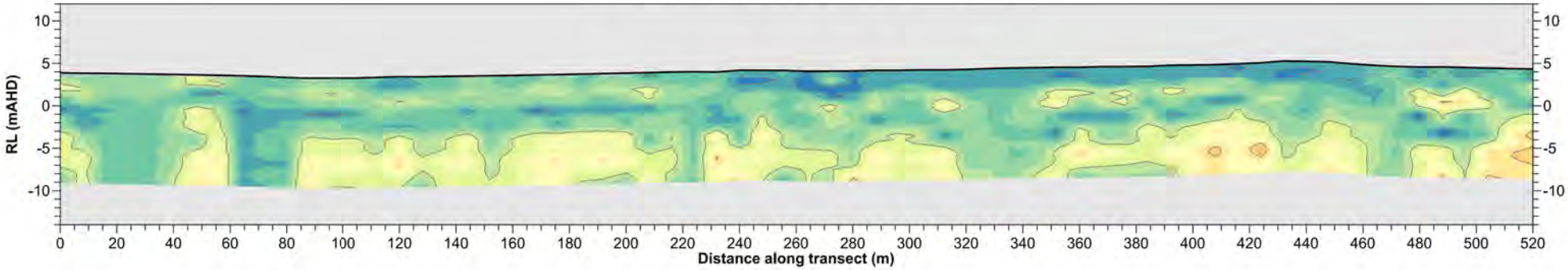
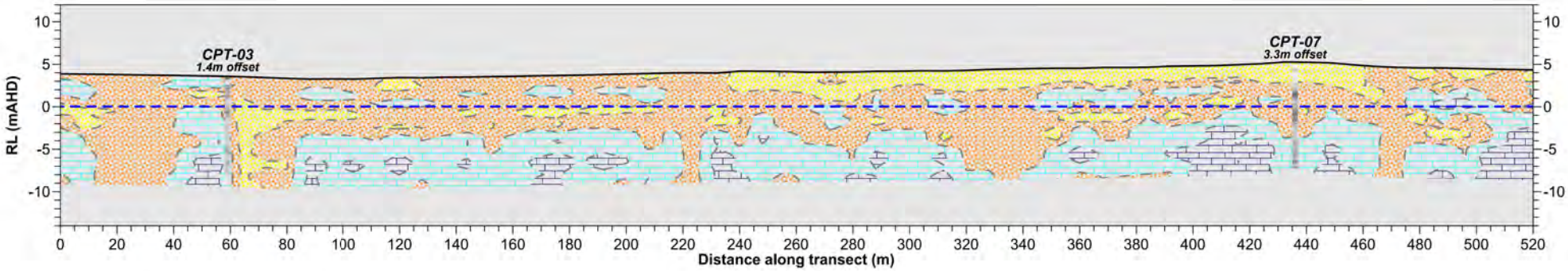
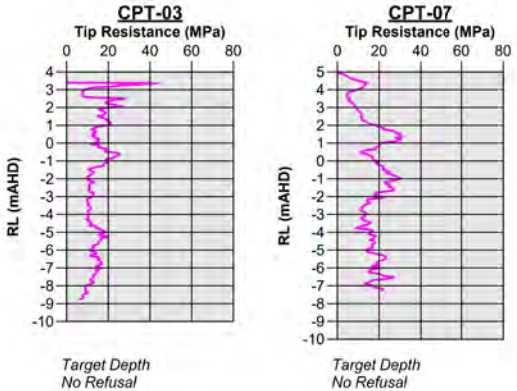
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

TRANSECT 03 - SEISMIC SHEAR WAVE VELOCITY MODEL

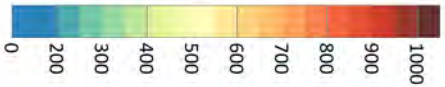


TRANSECT 03 - INTERPRETED GEOLOGICAL SECTION





SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-400 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 400-550 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 550 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 3142G.
Positioning is given in GDA2020 zone 50.
Levels are given in Australian Height Datum (AHD).

CLIENT	DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA	Date	18 December 2024	Paper Size	A3
	GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT. KWINANA, CITY OF KWINANA WA	Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142G-03	Revision	0

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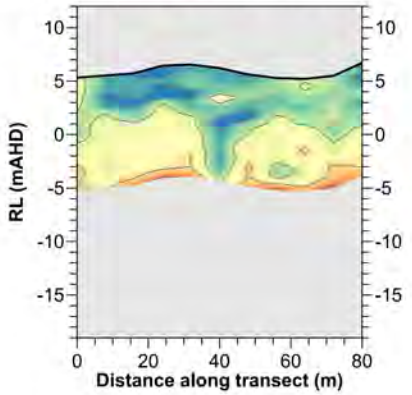
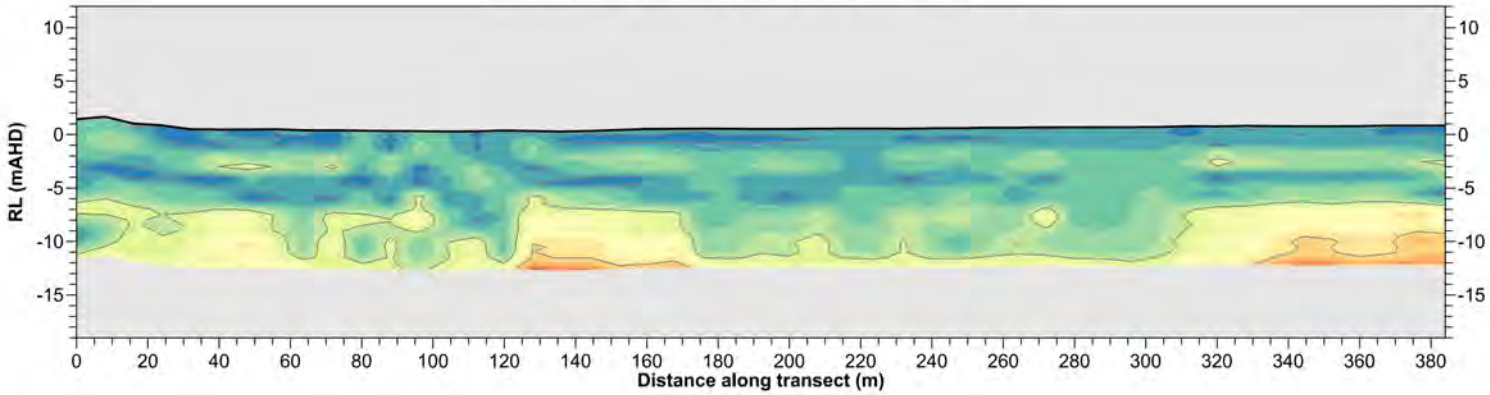
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

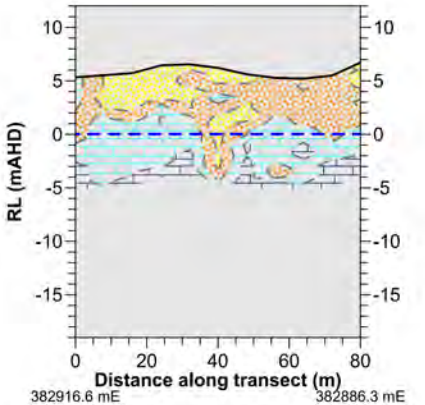
TRANSECT 04 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 05 - SEISMIC SHEAR WAVE VELOCITY MODEL



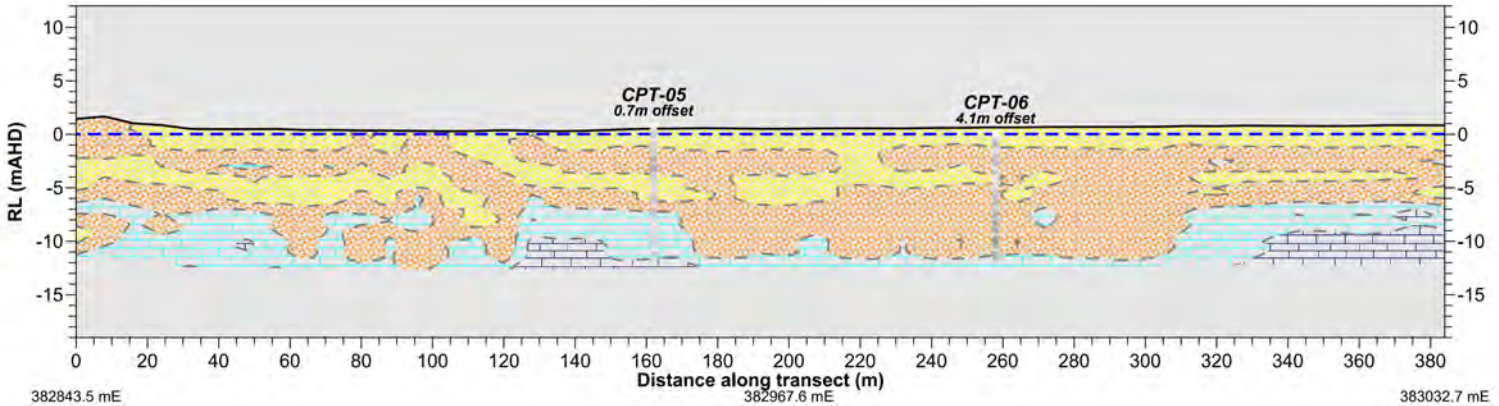
TRANSECT 04 - INTERPRETED GEOLOGICAL SECTION



382916.6 mE
6431301.7 mN

382886.3 mE
6431232.7 mN

TRANSECT 05 - INTERPRETED GEOLOGICAL SECTION

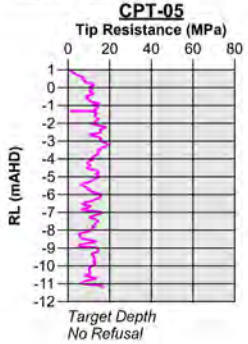


382843.5 mE
6431425.6 mN

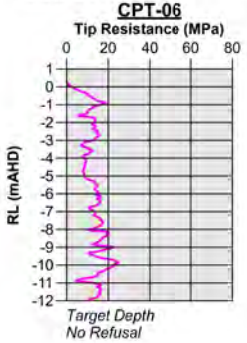
382967.6 mE
6431556.2 mN

383032.7 mE
6431718.7 mN

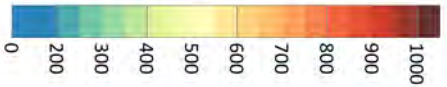
CPT-05



CPT-06



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

- SAND - LOW COMPACTION
  S-WAVE VELOCITY < 250 m/s
- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-400 m/s
- LOW STRENGTH WEATHERED ROCK
  S-WAVE VELOCITY 400-550 m/s
- MODERATE STRENGTH COMPETENT ROCK
  S-WAVE VELOCITY > 550 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 3142G.
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. KWINANA, CITY OF KWINANA WA		Scale	1:1500H, 1:500V	Drawn	PJE
		Drawing	3142G-04	Revision	0

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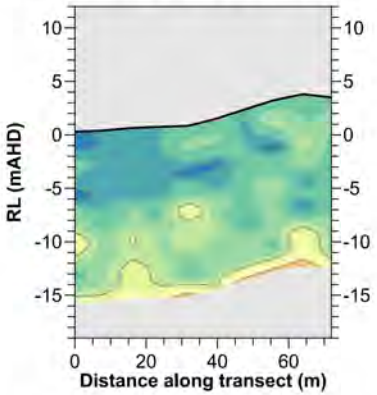
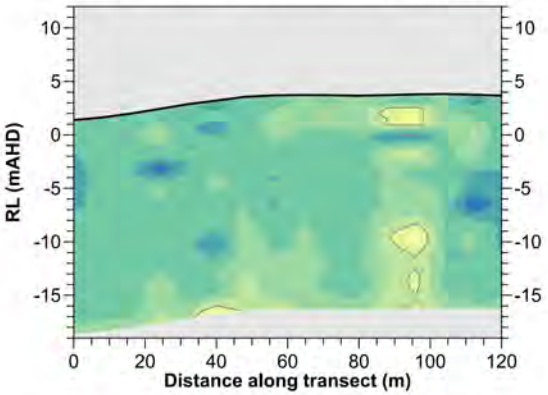
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT
KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

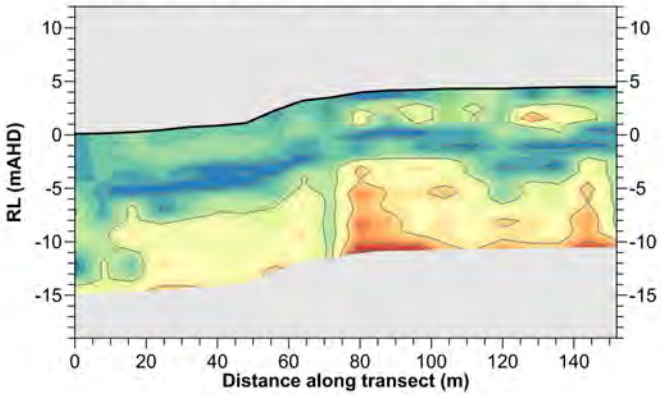
TRANSECT 06 - SEISMIC SHEAR WAVE VELOCITY MODEL



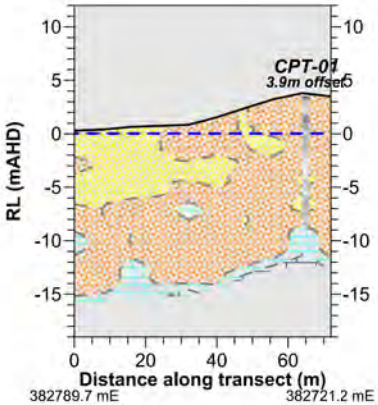
TRANSECT 07 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 08 - SEISMIC SHEAR WAVE VELOCITY MODEL



TRANSECT 06 - INTERPRETED GEOLOGICAL SECTION



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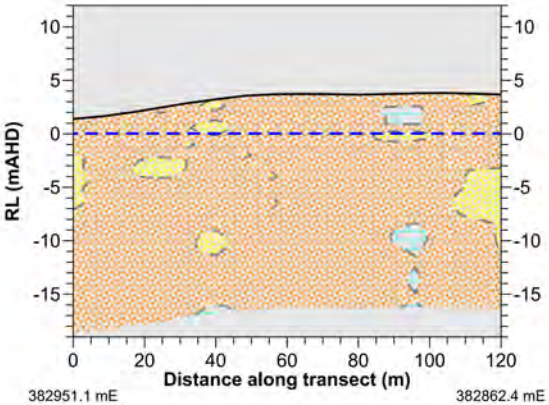
6431000.6 mN

382721.2 mE
6431011.3 mN

TRANSECT 07 - INTERPRETED GEOLOGICAL SECTION



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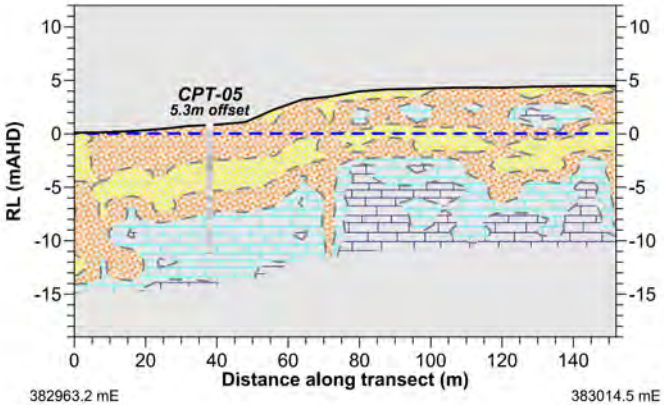
6431331.9 mN

382862.4 mE
6431398.4 mN

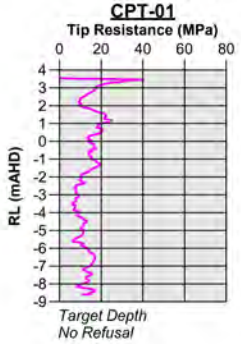
TRANSECT 08 - INTERPRETED GEOLOGICAL SECTION



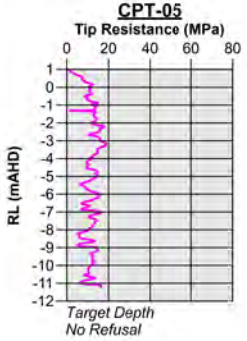
382963.2 mE
6431558.9 mN

383014.5 mE
6431450.9 mN

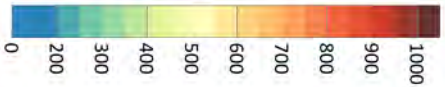
CPT-01



CPT-05



SEISMIC S-WAVE VELOCITY (m/s)



INTERPRETED MATERIAL TYPE

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- SAND - MODERATE COMPACTION
  S-WAVE VELOCITY 250-400 m/s
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- 0m AUSTRALIAN HEIGHT DATUM

CONE PENETRATION TEST

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- 0 to <5
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- 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. KWINANA, CITY OF KWINANA WA		Scale	1:3000H, 1:500V	Drawn	PJE
		Drawing	3142G-05	Revision	0

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APPENDIX C – MODELLED LEVELTO TOP OF ROCK AND SAND THICKNESS

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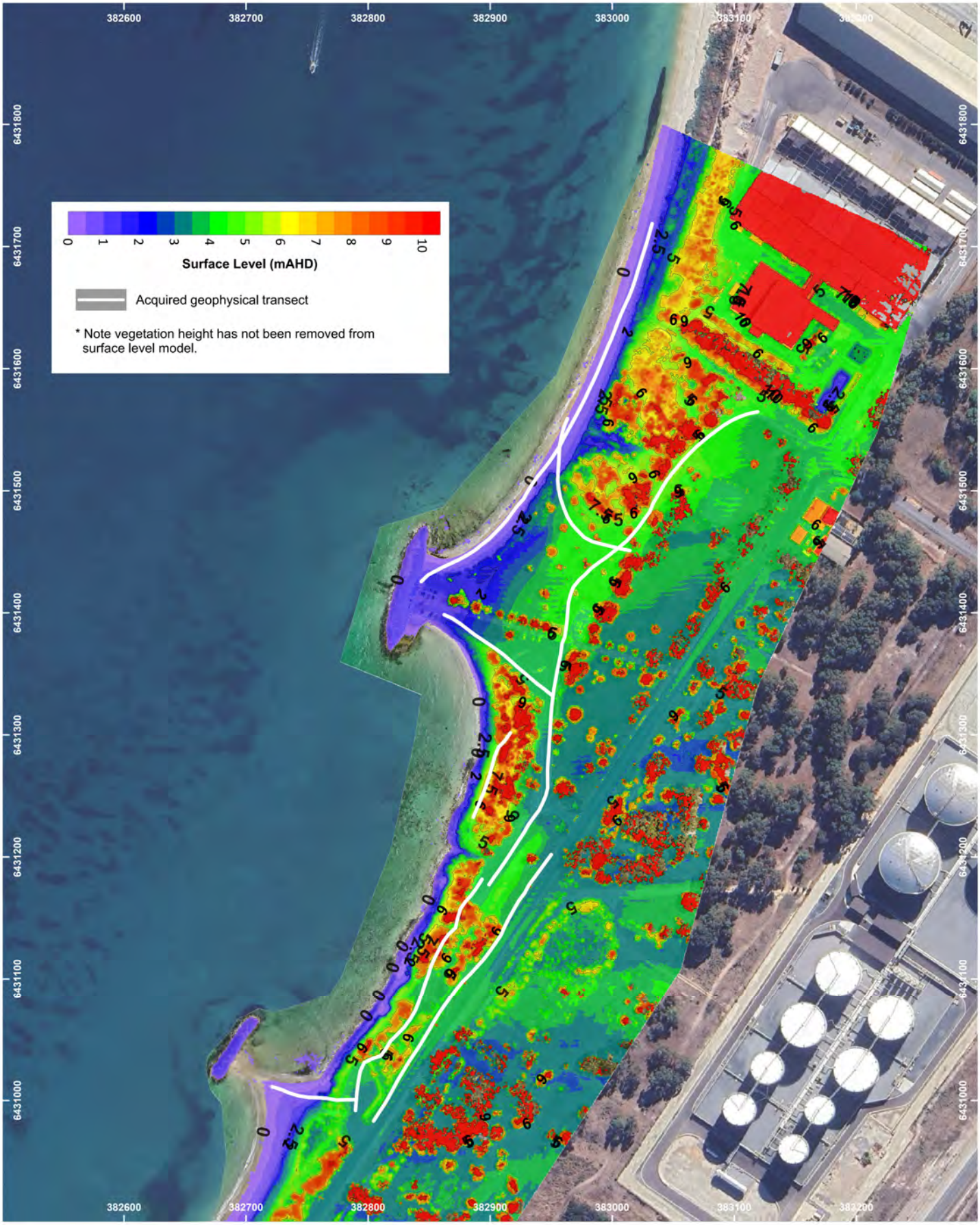
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

SURFACE LEVEL MODEL



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

N

Date	11 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-06	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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

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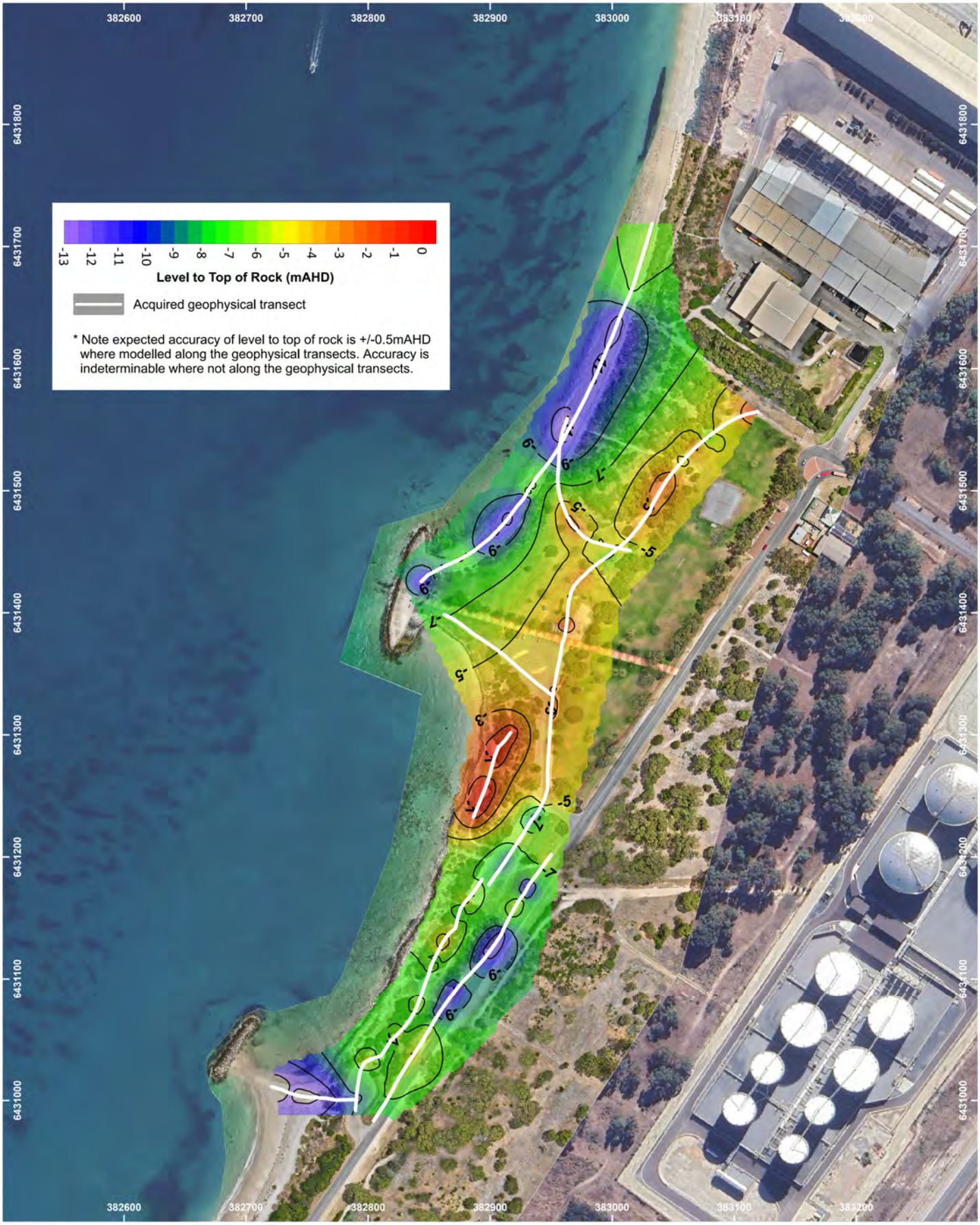
GEOTECHNICAL INVESTIGATION FOR COASTAL EROSION VULNERABILITY ASSESSMENT KWINANA, CITY OF KWINANA WESTERN AUSTRALIA

CONTOURED LEVEL TO TOP OF ROCK



NOTES

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

N

Date	11 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-07	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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

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

CLASSED POST MAP LEVEL TO TOP OF ROCK

NOTES

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

N

Date	18 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-08	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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

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

CONTOURED SAND THICKNESS OVER ROCK

NOTES

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

N

Date	18 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-09	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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GBGGROUP

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

CLASSED POST MAP SAND THICKNESS OVER ROCK

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

N

Date	18 December 2024	Paper Size	A3
Scale	1:3000	Drawn	PJE
Drawing	3142G-10	Revision	0

DEPARTMENT OF TRANSPORT, WESTERN AUSTRALIA

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

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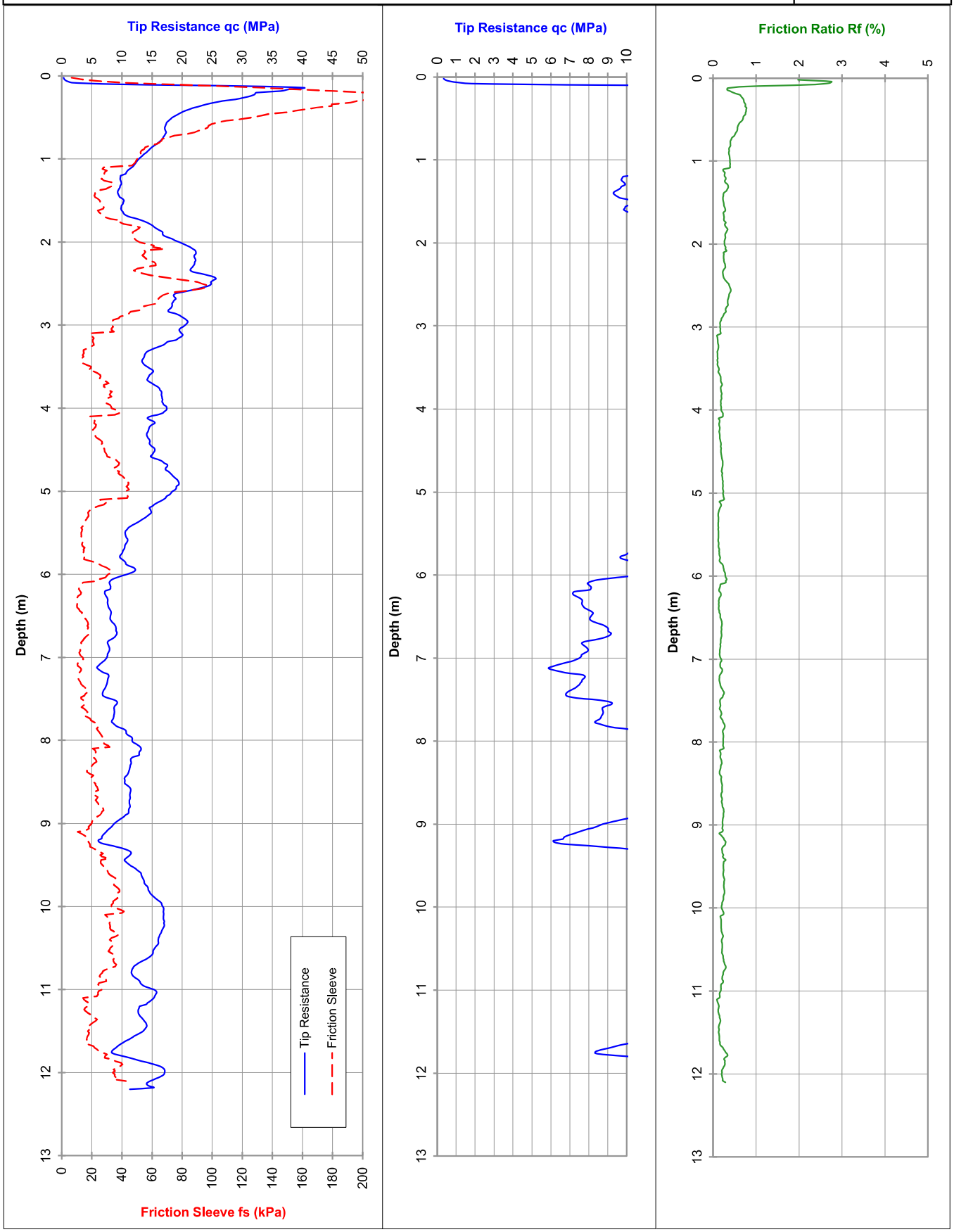
APPENDIX D – CONE PENETRATION TEST PLOTS

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 3.7	**CPT 01**
LOCATION: Kwinana	Co-ords: 382783.79mE, 6430996.44mN	16-Dec-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 5.2

Dummy probe to (m): 0.12

Refusal:

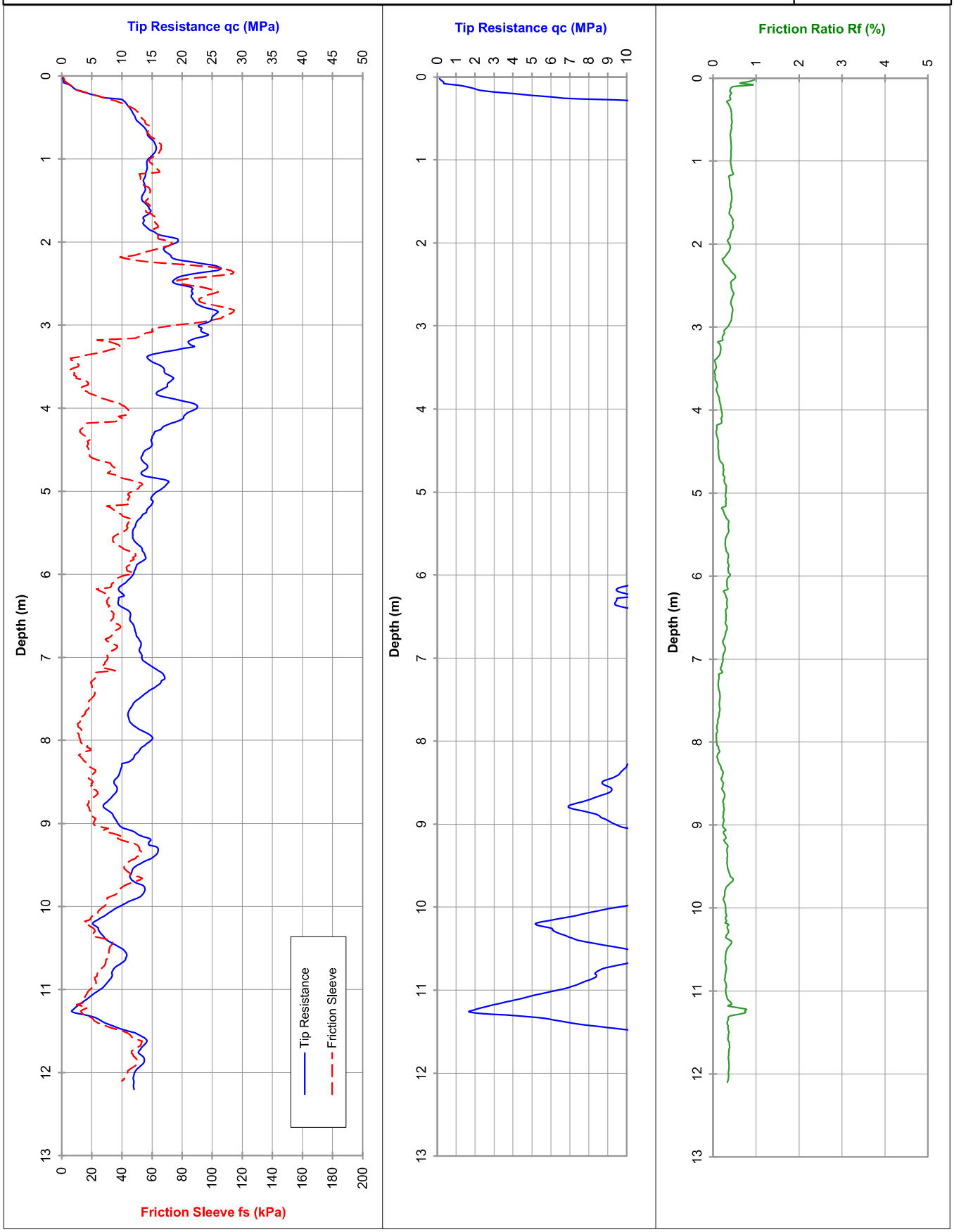
Cone I.D.: EC05

File: GB0020G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 5.36	**CPT 02**
LOCATION: Kwinana	Co-ords: 382849.91mE, 6431100.48mN	16-Dec-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 4.5

Dummy probe to (m):

Refusal:

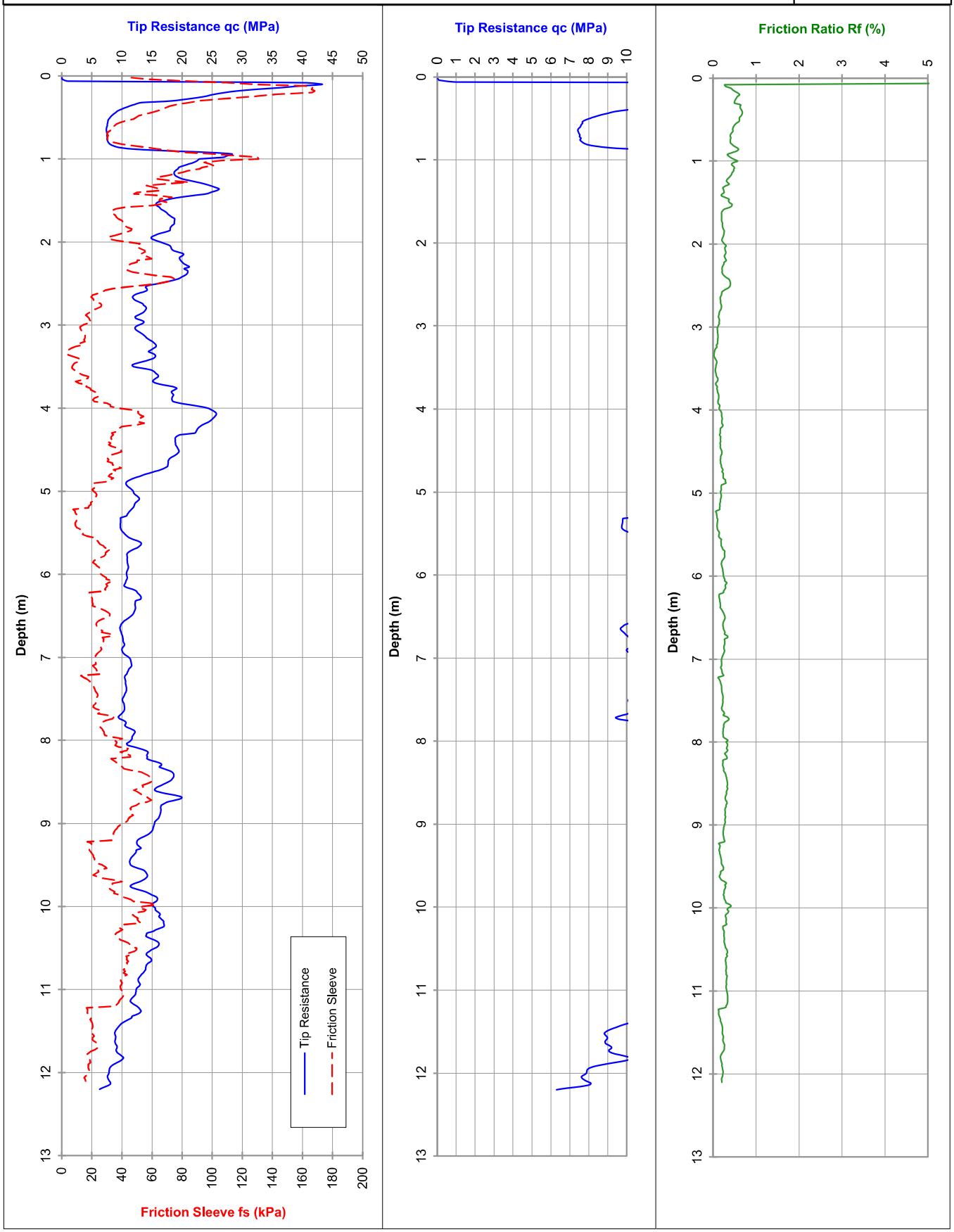
Cone I.D.: EC16

File: GB0021G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 3.61	**CPT 03**
LOCATION: Kwinana	Co-ords: 382929.28mE, 6431221.65mN	16-Dec-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 4.9

Dummy probe to (m): 0.1

Refusal:

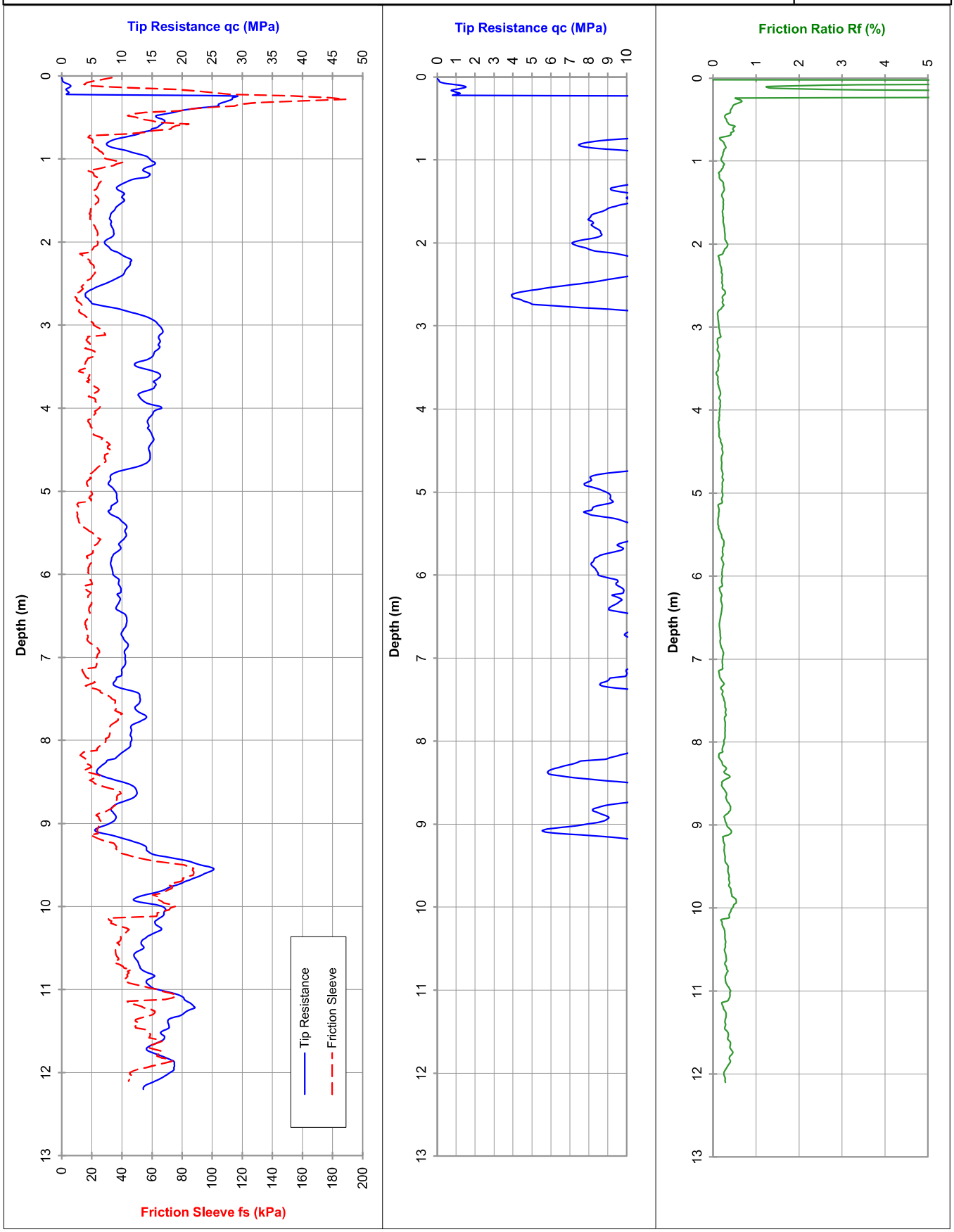
Cone I.D.: EC16

File: GB0022G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 1.21	**CPT 04**
LOCATION: Kwinana	Co-ords: 382850.77mE, 6431401.48mN	16-Dec-24



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): 1.0

Dummy probe to (m): 0.2

Refusal:

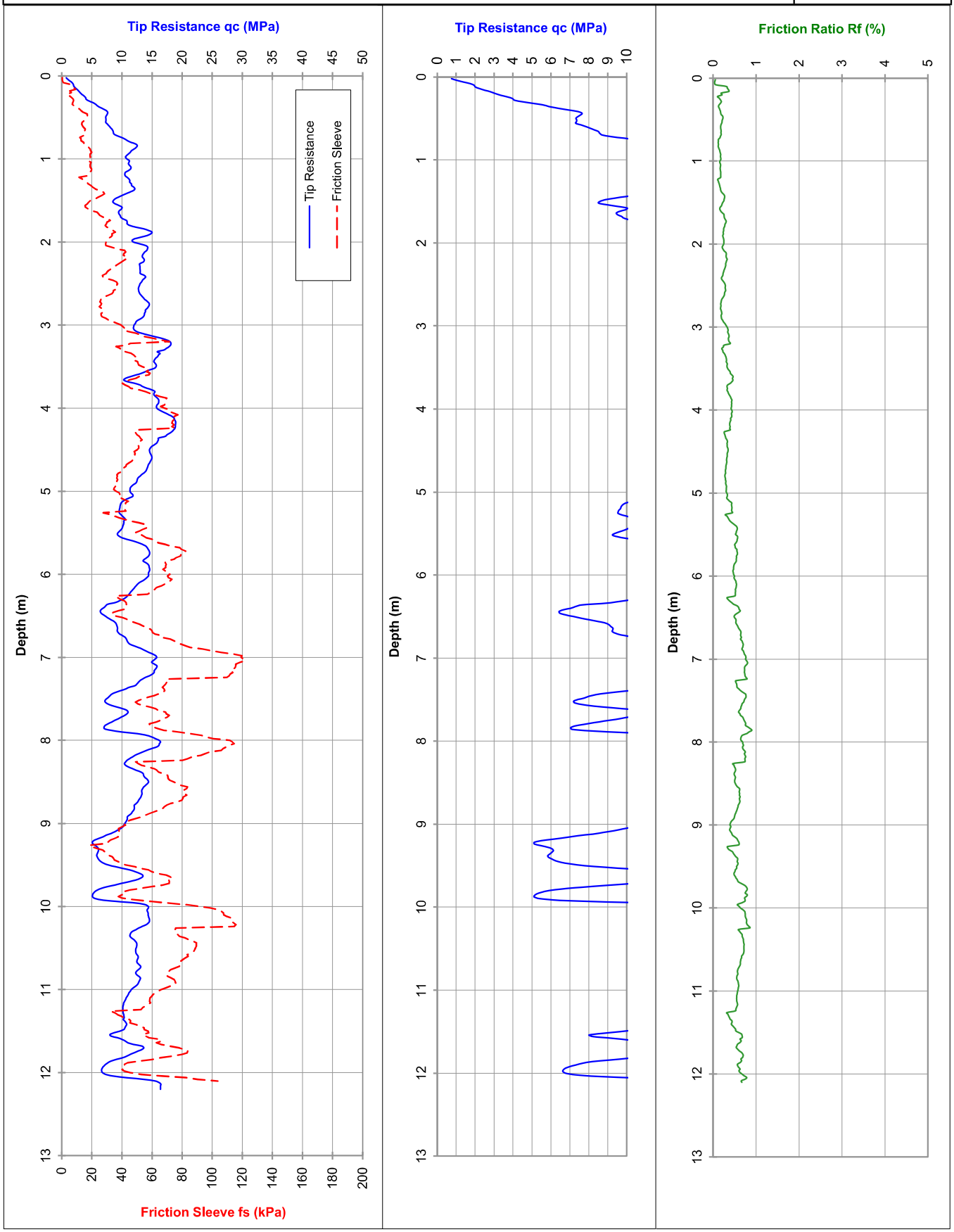
Cone I.D.: EC05

File: GB0019G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 1	**CPT 05**
LOCATION: Kwinana	Co-ords: 382950.64mE, 6431525.2mN	11-Dec-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 0.0

Dummy probe to (m):

Refusal:

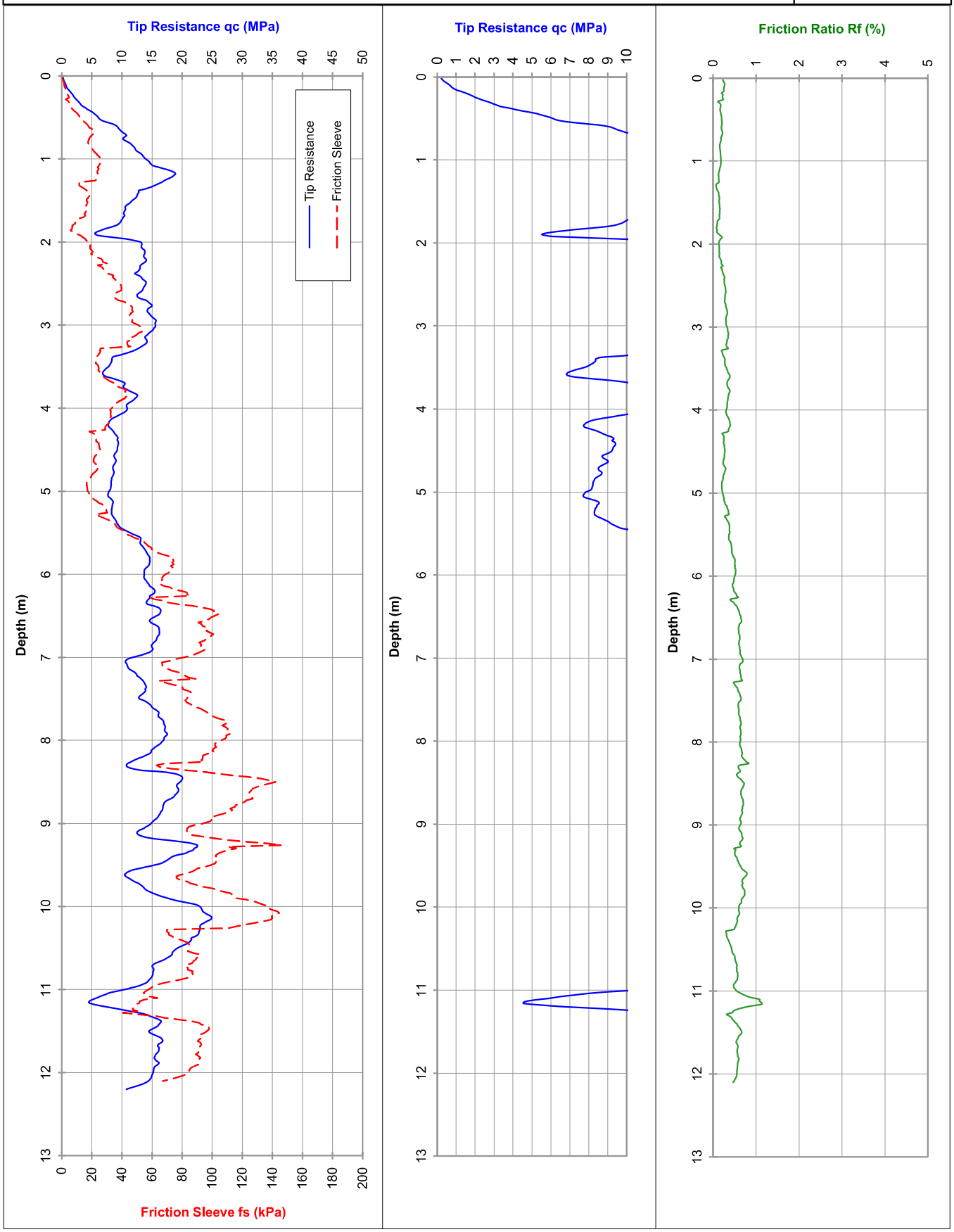
Cone I.D.: EC47

File: GB0063T

Rig Type: 7t track

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 0.28	**CPT 06**
LOCATION: Kwinana	Co-ords: 382995.12mE, 6431604.05mN	11-Dec-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 0.0

Dummy probe to (m):

Refusal:

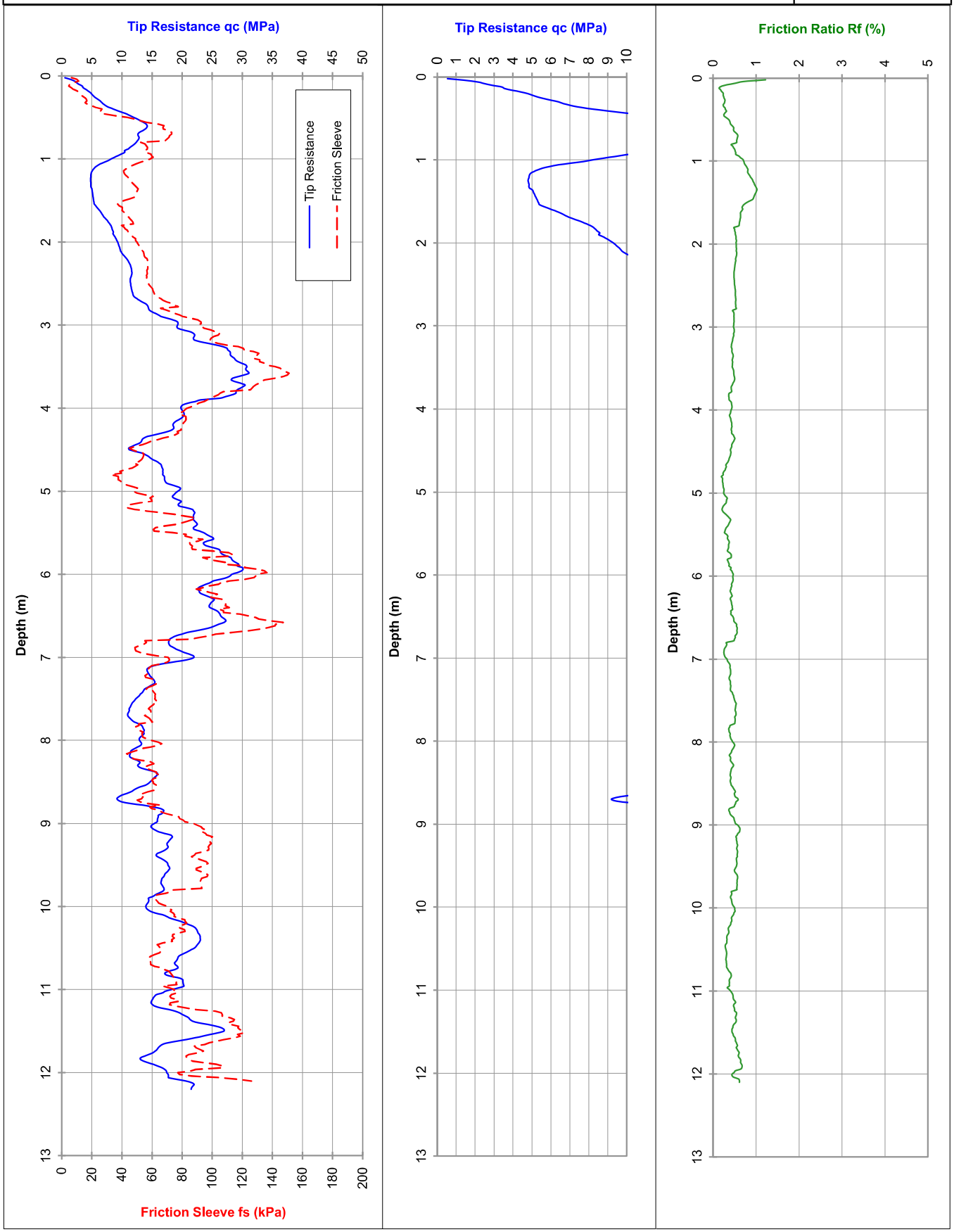
Cone I.D.: EC47

File: GB0064T

Rig Type: 7t track

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: GBG Group	Job No.: 3142	Probe I.D
PROJECT: Southern and Southwest Coastal	RL (m): 5.15	**CPT 07**
LOCATION: Kwinana	Co-ords: 383056.62mE, 6431522.04mN	11-Dec-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 4.3

Dummy probe to (m):

Refusal:

Cone I.D.: EC39

File: GB0061TT

Rig Type: 22t truck (Track-Truck)

PROBEDRILL
GEOTECHNICAL SURVEY

CALIBRATION CERTIFICATE

CONE ID: EC05

Cone Type:	Compression
Calibration Date (qc/fs):	25 October 2024
Calibration Date (u):	25 October 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	0.796
20	20	1.597
30	30	2.398
40	40	3.199
50	50	4.003
60	60	4.811
70	70	5.617
80	80	6.428
90	90	7.245
100	100	8.062
90	90	7.274
80	80	6.477
70	70	5.672
60	60	4.865
50	50	4.058
40	40	3.251
30	30	2.440
20	20	1.632
10	10	0.821
0	0	0.003
R^2 Value =	1.000	

Zero Load Error: 0.04%
Max. Linearity 0.32%
Max. Hysteris 0.69%

MPa/Volt: 12.401

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	0.753
6	400	1.514
9	600	2.270
12	800	3.026
15	1000	3.783
18	1200	4.539
21	1400	5.299
24	1600	6.057
27	1800	6.817
30	2000	7.578
27	1800	6.832
24	1600	6.078
21	1400	5.325
18	1200	4.568
15	1000	3.813
12	800	3.057
9	600	2.298
6	400	1.540
3	200	0.773
0	0	0.000
R^2 Value =	1.000	

Zero Load Error: 0.00%
Max. Linearity 0.34%
Max. Hysteris 0.41%

kPa/Volt: 263.97

u (pore pressure):

Capacity: 3500 (kPa)
Position u2

Applied Pressure bar	Eqv. Pressure kPa	Mean Observed Reading Volts
0	0	0.000
3	300	0.431
6	600	0.857
9	900	1.283
12	1200	1.707
15	1500	2.134
18	1800	2.558
21	2100	2.981
25	2500	3.546
30	3000	4.250
35	3500	4.952
30	3000	4.254
25	2500	3.549
21	2100	2.985
18	1800	2.561
15	1500	2.136
12	1200	1.711
9	900	1.285
6	600	0.858
3	300	0.431
0	0	0.000
R^2 Value =	1.000	

Zero Load Error: 0.01%
Max. Linearity 0.27%
Max. Hysteris 0.10%

kPa/Volt: 706.42
Net Area (calibrated): 0.83

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

Calibration Checked & Authorised: Nicole London

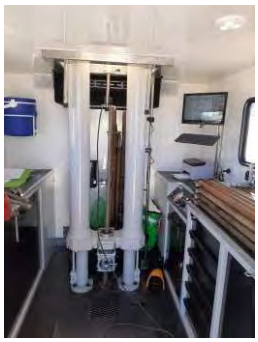
Job Details

Client:	GBG	**Date of Job:**	16/12/24
Rep:	Oscar Leon Estacio	**Tip Diameter:**	35.86
Location:	Kwinana	**Sleeve Diameter:**	36.06

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)