Design
for a better
future /

Talis Consultants

Wangara Waste Transfer Station Modification and Addition Works

Geotechnical Investigation

wsp

March 2025

Question today
Imagine tomorrow
Create for the future

Wangara Waste Transfer Station Modification and Addition Works
Geotechnical Investigation

Talis Consultants

WSP
Lvl 3, Mia Yellagonga Tower 2, 5 Spring St
Perth WA 6000
PO Box 7181
Cloisters Square WA 6850

Tel: +61 8 9489 9700
Fax: +61 8 9489 9777
wsp.com

Rev	Date	Details
0	06/03/2025	Issued as final

	Name	Date	Signature
Prepared by:	[redacted]	06/03/2025	[redacted]
Reviewed by:		06/03/2025	
Approved by:		06/03/2025	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

Table of contents

List of tables

List of appendices

1 Introduction

WSP Australia Pty Ltd (WSP) has been engaged by Talis Consultants (Talis) to undertake a geotechnical investigation for the Wangara Waste Transfer Station (WTS) alterations and expansion project, located at 70 Motivation Drive, Wangara, Western Australia. The location of the site is shown in Figure 1, Location Plan.

The Wangara WTS project involves the addition and alteration of an existing waste transfer facility, including:

- the construction of a loadout lane,
- a canopy over the loadout lane,
- modifications to the existing single storey industrial steel frame building, and associated tracks for haulage trailers.

To facilitate excavation and underpinning of the existing foundation, a micro-fine cement grout injection program is proposed.

2 Objectives

The objectives of the geotechnical investigation were to:

- Assess the site conditions, including topography, geomorphology and subsurface profiles, with groundwater observations (if encountered)
- Assess the site classification in accordance with AS 2870, relevant to the proposed structures.
- Provide geotechnical recommendations for bearing capacity and preliminary design parameters for the proposed building modifications and foundation alterations
- Provide geotechnical recommendations for earthworks, including slope stability in cut/fill areas, excavation support and trenching stability to inform loadout lane construction
- Provide geotechnical recommendations for construction considerations, including site preparation, foundation recommendations and ground improvement requirements
- Provide geotechnical recommendations for the utilisation of micro-fine cement permeation grouting.

3 Fieldwork

3.1 Scope of fieldwork

The fieldwork for the investigation was conducted on 18 February 2025 and comprised:

- Cone Penetration Testing (CPT) at 6 no. locations, CPT01, CPT02, CPT02A, CPT02B, CPT03 and CPT04, extending to depths of between 0.44 m and 9.20 m.
- Drilling of hand auger boreholes (HA) at 2 no. locations, HA01 and HA02, extending to depths of 1.2 m and 1.4 m.
- Falling head permeability tests undertaken within each of the hand auger boreholes at a depth of 1.0 m.
- Perth sand penetrometer (PSP) testing adjacent to each hand auger borehole locations, extending to a depth of 1.05 m.
- Collection of samples for geotechnical laboratory testing.

The coordinates for hand auger borehole locations were recorded using a hand-held GPS typically accurate to within about 5 m. Following completion of the CPTs, the test positions were surveyed and recorded by Probedrill, with the positions of all completed locations surveyed with a GPS unit generally accurate to ±50 mm relative to MGA2020 Australian Height Datum (AHD).

The test locations are shown on Figure 2 – Site Plan. A summary of test details is presented in Table 3.1.

Table 3.1 Summary of test details

Location	Coordinates (MGA2020 Zone 50)		Ground Elevation (m AHD)	Termination Depth (m bgl)	Termination Reason	Groundwater Depth (m bgl)	Soil Sample Depth (m bgl)
	Easting	Northing					
HA01 PSP01	390022 [a]	6481944 [a]	-	1.2 1.05	Refusal	GNE	0.3 – 0.5 0.7 – 1.0
HA02 PSP02	390091 [a]	6481958 [a]	-	1.4 1.05	Refusal	GNE	1.0 – 1.3
CPT01	390040.45 [b]	6481950.94 [b]	68.6	8.22	Target Depth	GNE	-
CPT02	390072.92 [b]	6481943.41 [b]	67.1	0.44	Refusal	GNE	-
CPT02A	390071.67 [b]	6481942.86 [b]	67.7	1.84	Refusal	GNE	-
CPT02B	390071.58 [b]	6481938.27 [b]	67.7	8.2	Target Depth	GNE	-
CPT03	390085.77 [b]	6481969.86 [b]	66.1	8.2	Target Depth	GNE	-
CPT04	390056.20 [b]	6481998.30 [b]	67.0	9.2	Target Depth	GNE	-

Notes: GNE = Groundwater not encountered.
bgl = below ground level
[a] Coordinates collected using hand held GPS
[b] Coordinates collected using GPS survey equipment.

The hand auger borehole reports are included in Appendix A, along with a list of notes, abbreviations and the method of soil description used on the reports. All soil materials were logged in accordance with AS 1726 (2017).

The CPTs were performed using a 22-tonne truck rig suppled and operated by Probedrill Geotechnical Survey Pty Ltd. The tests were performed in accordance with Australian Standard AS 1289.6.5.1. The results of the CPT are presented as plots of cone penetration resistance (qc), friction sleeve resistance (fs) and friction ratio (FR) versus depth in Appendix B. A method of soil classification by Robertson et al (1986) based on the values of qc and FR is also included in Appendix B. Groundwater measurements were recorded in the hole remaining after the removal of the CPT rods and are shown on the CPT reports.

Infiltration testing was undertaken within all of the hand auger boreholes using the "inverse auger method" outlined in Cocks (2007). The *in-situ* infiltration tests were advanced using a 75 mm hand auger. Further discussion on the infiltration test results is provided in Section 5.9.

Perth sand penetrometer (PSP) testing was undertaken adjacent to all hand augers and were conducted in accordance with AS 1289.6.3.3. The results of the PSP testing are provided on the relevant hand auger borehole reports in Appendix A.

A Geotechnical Engineer from WSP positioned the test locations, monitored the CPT testing, drilled the hand auger boreholes and logged the materials encountered, conducted the PSP testing and the infiltration testing.

3.2 Laboratory testing

Geotechnical laboratory testing has been conducted within WSP's NATA accredited laboratory and comprised:

— Particle size distributions on three samples.

Laboratory test results are summarised in Table 3.2 and test certificates are provided in Appendix C.

Table 3.2 Laboratory test results

Sample Location	Depth (m)	AS 1726 Soil Description	Particle Size Distribution (% Passing)		
			Fines	Sand	Gravel
HA01	0.3 – 0.5	(SP) SAND, fine to coarse grained, grey, trace fines, trace fine to medium gravel	2.6	95.1	2.3
	0.7 – 1.0	(SP) SAND, fine to coarse grained grey, trace fines, trace fine to medium gravel	2.5	89.3	8.2
HA02	1.0 – 1.3	(SP) SAND, fine to coarse grained, grey, trace fines, trace fine to medium gravel	4.3	90.4	5.3

Note: Gravel – material passing the 63 mm sieve and retained on the 2.36 mm sieve; Sand – material passing the 2.36 mm sieve and retained on the 0.075 mm sieve; Fines – material passing the 0.075 mm sieve.

4 Site conditions

4.1 surface conditions

At the time of the investigation, the central part of the site was occupied by an existing single storey structure with hardstand asphalt covering majority of the perimeter of the site. The asphalt extended to the kerb, which ran along the boundary fence line. Beyond the kerb, a narrow verge area was present, which was sparsely vegetated and appeared to contain a layer of very dense crushed limestone from previous site works or road construction. The site is generally flat, at an elevation of approximately 68 m AHD.

4.2 Regional geology

The Perth sheet of the 1:50,000 Environmental Geology series map indicates that the site is underlain by Sand derived from the Tamala Limestone, which is described as *pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin*. An extract of the geological map is presented in Figure 3.

4.3 Subsurface conditions

Based on the results of the geotechnical investigation, the subsurface conditions at the site can be generalised as comprising:

- **ASPHALT**
- **FILL – SAND to Gravelly SAND**: fine to coarse grained, sub-angular to sub-rounded, pale yellow-brown to brown Sand.Gravel is fine to medium grained, sub-angular. This unit extends to around 0.25 m depth, overlying
- **SAND (SP) – Sand derived from Tamala Limestone**: fine to coarse grained, sub-angular to sub-rounded, pale grey and brown, **becoming** grey with depth, generally
  - Very dense to a depth of about 2.0 m bgl.
  - Medium dense to a depth of about 7.0 m bgl.
  - Dense extending to the maximum depth investigated of 9.2 m bgl (minimum elevation of about RL 57.8 m AHD).

Deviations from the above generalised stratigraphy occur, and the individual CPT and borehole reports should be referred to for further information.

4.4 Groundwater

The Perth Groundwater Atlas (1997) indicates the estimated maximum groundwater level is between RL 39 m AHD and RL 40 m AHD, which is about 28 m below ground level.

Groundwater was not encountered to the maximum depth investigated of 9.2 m.

5 Geotechnical discussion

5.1 Site classification

We have assessed the classification of the site in accordance with AS 2870-2011 "Residential Slabs and Footings – Construction". AS 2870-2011 defines the site on the basis of a characteristic surface movement associated with the seasonal moisture changes in expansive soils. It does not specifically deal with settlement. It should be noted that the AS 2870-2011 site classification is limited to lightly loaded residential and commercial structures. The structural designer should consider this when using the site classification.

We consider that a preliminary site classification of "Class A" is appropriate for the site, providing the site preparation procedures listed within Section 5.2 are performed.

5.2 Site preparation

The following site preparation procedures are recommended for the development:

- Where required, demolish existing buildings and break out hardstand.
- Remove any deleterious materials from the site, including grubbing out roots and removing organic matter. Any buried services, rubble, structural elements and other unsuitable or deleterious material encountered during the excavation should be removed.
- Excavate to footing foundation level where required. The *in situ* sands are likely to be suitable for re-use as structural fill (following the removal of any deleterious material that may be present), and may be stockpiled for later re-use if required.
- Densify the exposed ground beneath floor slabs and footings by compacting to achieve the level of compaction specified in Section 5.3 to a minimum of 0.9 m below the underside of footings or ground slabs. This may require over-excavation and replacement of soil in compacted layers.
- Where required, place approved granular fill to the required levels in layers of no greater than 0.3 m loose thickness and compact each layer to achieve the level of compaction outlined in Section 5.3.
- Confirm that the specified level of compaction, as defined in Section 5.3 has been achieved to a depth of 0.9 m below the base of the footings and slabs by testing:
  - At each spread footing excavation.
  - At 2.5 m centres along strip footing excavations, and
  - On a grid at 5 m centres beneath slab-on-ground floors.

The occurrence of undetected unsuitable fill cannot be dismissed. Any deleterious material must be removed from beneath the building and replaced with approved granular fill. Allowance for such a contingency should be made in earthwork quantities.

5.3 Compaction

In situ sand and approved sand fill should be moisture conditioned and compacted using suitable compaction equipment to achieve a Perth sand penetrometer (PSP) blow count of at least 8 blows per 0.3 m penetration in accordance with AS 1289 6.3.3. If difficulty arises in achieving the specified PSP blow counts, then a calibration should be established

between PSP blow count and the *in situ* density in consultation with a geotechnical engineer. Over-excavation and replacement of loose materials may be required where the minimum density cannot be achieved.

Fill materials should be placed in horizontal layers of not greater than 0.3 m loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

Care will need to be taken when compacting in the vicinity of existing buildings, roads and services. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[1] provides assistance with the selection of compaction equipment for use adjacent to structures. The proximity and structural properties of the structures adjacent to the site should be considered when selecting compaction methods for the site.

5.4 Approved fill

Imported and on-site granular fill must comply with the material requirements as stated in AS 3798-2007 "Guidelines on Earthworks for Commercial and Residential Developments". Granular fill should be free of organic matter, with a fines content (percent finer than 0.075 mm) of less than 5%.

The *in situ* sand at the site is generally considered suitable for re-use as fill, provided that any roots, organic matter, and deleterious materials are removed. Any fill containing deleterious material is not considered suitable for re-use as structural fill.

5.5 Shallow footings

Based on the subsurface conditions encountered, pad and strip footings are considered appropriate to support proposed building modifications and foundation alterations on the site, subject to the proposed design loads and the founding depth of the footings. A footing design involving individual pad and strip footings with a minimum embedment of 0.5 m and 1.0 m below finished surface level has been performed. The footing design assumes that the site preparation measured outlined in Section 5.2 have been undertaken, and that the footings are formed in compacted sand.

Table 5.1 shows the maximum allowable bearing pressures and expected settlements for a range of pad and strip footings sizes with minimum embedment depths of 0.5 m and 1.0 m.

Table 5.1 Allowable working bearing pressures and settlements for pad and strip footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)		Allowable Working Bearing Pressure (kPa)		Expected Settlement at Allowable Bearing Pressure (mm)	
	Pad	Strip	Pad	Strip	Pad	Strip
0.5	1.0	0.5	210	150	<5	<5
	2.0	1.0	250	180	10-15	5-10
	3.0	2.0		220	15-20	15-20
1.0	1.0	0.5	250	250	5-10	5-10
	2.0	1.0			10-15	10-15
	3.0	2.0			15-20	15-20

[1] Tynan (1973) Ground Vibration and Damage Effects on Buildings, Australia Road Research Board, Special Report No. 11.

Allowable bearing pressures for footings of intermediate plan dimensions to those tabulated can be interpolated. Footings that have a plan dimension either smaller or larger than those covered by the table above will need to be considered individually along with other embedment depths. Footings carrying significant eccentric loading, such as below retaining walls, need to be assessed separately. Allowable working bearing pressures of 250 kPa are considered to be an upper limit for shallow footings at this site to limit total and differential settlement.

Settlement of proposed structures will depend upon a number of factors including the applied pressures, footing and base preparation. The estimates of settlements provided in Table 5.1 assume that the site preparation measures detailed in Section 5.2 have been completed. The estimated settlements are for single isolated footings for the working bearing pressure values shown. Differential settlements of up to half the total estimated settlement values are likely between footings of similar size, depth and loadings.

5.6 Excavations

Based on the investigation results, excavations are predominantly expected to occur within sandy soils. It is expected that the sandy soils can be excavated using standard earthmoving equipment (e.g. a 10-tonne or greater mass excavator).

A short-term slope angle of 1V:1.5H is recommended for dry sands with no seepage at the site, provided there are no structures or surcharges located behind the crest. Where this is not possible, the excavation should be supported by appropriately designed sheet piling

Excavations for the construction of footings and the loadout lane must observe the recommendations provided in the "Code of Practice – Excavation, 2005" produced by Worksafe on behalf of the Government of Western Australia.

5.6.1 Excavations adjacent to existing structures

We understand that excavations for the load out lane may be constructed along the western side of the WTS building. The floor level of the loadout lane will be approximately 2 m below the level of the existing building, and approximately 1.2 m below the existing pad footing level. Care during construction and excavation of the loadout lane will be required to minimise potential ground movements that may damage the existing WTS structure. An assessment of the type, condition and depth of the existing footings of adjacent buildings has not been completed as part of this study, but is recommended prior to construction commencing.

Where excavations are proposed below the adjacent footing, and the distance between footings is less than 1.5 times the difference in depth of excavation base level, micro-fine cement grouting is recommended to underpin the adjacent footing.

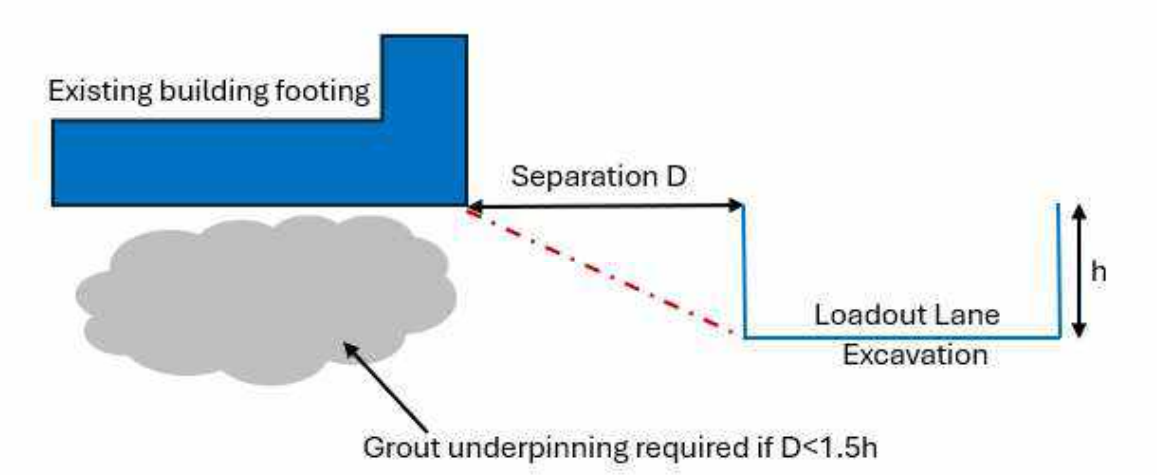


Figure A: Requirement for grout underpinning

Where grout underpinning is required, a specialist grouting contractor should be contacted for further design advice.

5.7 Comments of suitability of permeation grout injection

Based on the geotechnical investigation and laboratory test results presented in Sections 3.2 and 4.3, our comments on feasibility of permeation grout injection are as follows:

- Sand with a fines content of less than 5% is generally considered to be suitable for permeation grout injection. Fines content of the subsurface material encountered during the investigation is between 2.5% and 4.3%. It should be noted that samples were obtained from the upper 1.3 m, and not to the full extent of the proposed excavation. However, based on our experience with Sand derived from the Tamala Limestone, it is WSP's opinion that significant grout injection installation issues are not expected based on our findings in Section 4, provided that the grout is selected appropriately by the grouting contractor.

5.8 Pavements

The subgrade material is likely to comprise engineered fill or *in situ* sand. Where the subgrade materials are compacted to a minimum density level of 96% maximum modified dry density, a subgrade California Bearing Ratio (CBR) of 12% is considered appropriate.

5.9 Stormwater disposal

Falling head permeability tests were undertaken within HA01 and HA02 at a depth of about 1.0 m. The test was carried out using the inverse hand auger hole test method[2]. The results of returned values ranging from 40 m per day to 60 m per day. A design infiltration rate of 5 m per day is considered appropriate for infiltration systems founded at about 1 m below ground level.

The design of any stormwater infiltration system should allow for reductions in the soil permeability arising from:

- Clogging of sands with fine particles through ongoing infiltration.
- Densification of *in situ* sands from compaction during construction.

Proximity to foundations, the load out lane and below ground structures will impede infiltration from adjacent stormwater cells. Design for restricting build-up of water against these items must be considered.

Where shallow footings are adopted and are founded on compacted backfill or sand, stormwater infiltration cells should not be positioned within 3 m of these footings to limit the potential for settlement of the footings caused by localised mounding of infiltration water.

[2] Cocks (2007) Disposal of Stormwater Runoff by Soakage in Perth Western Australia. Journal and News of the Australian Geomechanics Society, Volume 43, pp101 – 114.

6 Limitation statement – Geotechnical site investigation

6.1 Scope of services

This geotechnical site assessment report (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and WSP (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

6.2 Reliance on data

In preparing the report, WSP has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, WSP has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. WSP will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

6.3 Geotechnical investigation

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared to meet the specific needs of individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor or even some other consulting civil engineer. This report was prepared expressly for the client and expressly for purposes indicated by the client or his representative. Use by any other persons for any purpose, or by the client for a different purpose, might result in problems. The client should not use this report for other than its intended purpose without seeking additional geotechnical advice.

6.4 This geotechnical report is based on project-specific factors

This geotechnical engineering report is based on a subsurface investigation which was designed for project-specification factors, including the nature of any development, its size and configuration, the location of any development on the site and its orientation, and the location of access roads and parking areas. Unless further geotechnical advice is obtained this geotechnical engineering report cannot be used:

- when the nature of any proposed development is changed
- when the size, configuration location or orientation of any proposed development is modified.

This geotechnical engineering report cannot be applied to an adjacent site.

6.5 The limitations of site investigation

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between test locations. Site exploration identifies specific subsurface conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency

of test locations; however this often does not result in any overall cost savings for the project. The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The borehole logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and can not always be definitive. For example, inspection of an excavation or test pit allows a greater area of the subsurface profile to be inspected than borehole investigation, however, such methods are limited by depth and site disturbance restrictions. In borehole investigation, the actual interface between materials may be more gradual or abrupt than a report indicates.

6.6 Subsurface conditions are time dependent

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical engineering report is based on conditions which existed at the time of subsurface exploration. Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept appraised of any such events, and should be consulted to determine if additional tests are necessary.

6.7 Avoid misinterpretation

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

6.8 Bore/Profile logs should not be separated from the engineering report

Final bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems. For further information on this matter reference should be made to ‘Guidelines for the Provision of Geotechnical Information in Construction Contracts’ published by the Institution of Engineers Australia, National Headquarters, Canberra 1987.

6.9 Geotechnical involvement during CONSTRUCTION

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

6.10 Report for benefit of client

The report has been prepared for the benefit of the client and no other party. WSP assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of WSP or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

6.11 Other limitations

WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Figures

LEGEND

- SITE BOUNDARY
- CADASTRE

0 125 250

1:5,000 METRES

NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

REFERENCES:
1. AERIAL IMAGE SOURCED FROM LANDGATE (SEP 2024)

CLIENT
TALIS CONSULTANTS

PROJECT
WANGARA WASTE TRANSFER STATION GEOTECHNICAL INVESTIGATION

TITLE
SITE LOCATION

CONSULTANT
wsp

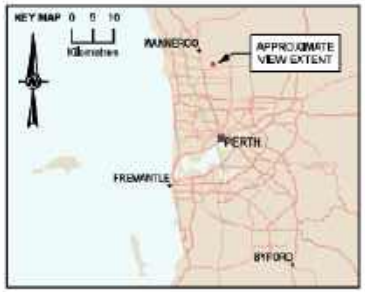
YYYY-MM-DD	2026-02-26
DESIGNED	
PREPARED	
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
PS221993	WSP-PER-GEC-REP-00001	0	1

LEGEND

SITE INVESTIGATION

- CONE PENETRATION TEST
- HAND AUGER
- SITE BOUNDARY



0 10 20

1:500 METRES

NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

REFERENCES:
1. AERIAL IMAGE SOURCED FROM LANDGATE (SEP 2024)

CLIENT
TALIS CONSULTANTS

PROJECT
WANGARA WASTE TRANSFER STATION GEOTECHNICAL INVESTIGATION

TITLE
SITE PLAN

CONSULTANT
wsp

YYYY-MM-DD	2026-02-26
DESIGNED	
PREPARED	
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
PS221993	WSP-PER-GEO-REP-00001	0	2

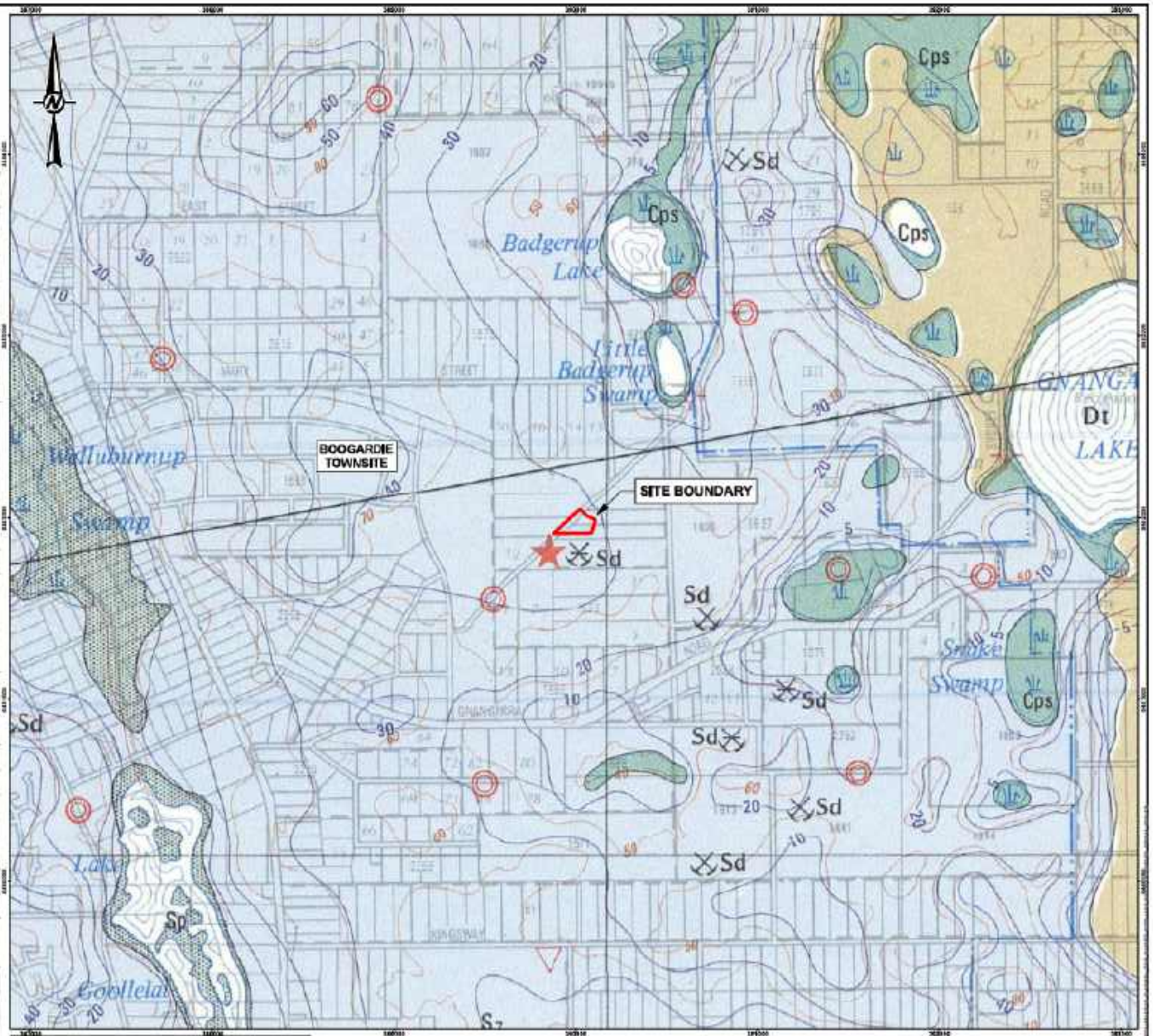
LEGEND

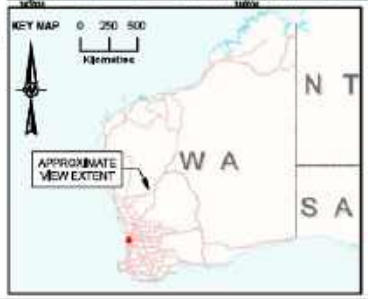
SITE BOUNDARY

GENERAL FEATURES

GENERAL FEATURES

Map Unit (Unconsolidated Material)	Map Unit (Rock)	Description
		PEATY CLAY – dark grey and black, soft with variable sand content of lacustrine origin
		SILT – grey mottled yellowish brown, blocky, firm, variable clay content
		PEAT – black, clayey in part, saturated fibrous organic soil
		PEATY SAND – greyish brown, medium-grained quartz, moderately well sorted, variable organic content, of lacustrine origin
		PEATY SAND – dark grey and black quartz sand with variable organic content and common root voids, variable clay content
		CALCAREOUS SAND – white, fine to medium-grained, well-rounded quartz and shell debris, of eolian origin
		CALCAREOUS SAND – as s_1
		LIMESTONE – pale yellowish brown, weakly cemented, friable, medium-grained, well-rounded quartz and shell debris, of eolian origin
		CLAY – mid to dark grey, soft, saturated, prominent 0.2 m thick oyster shell bed near surface of alluvial origin
		CLAY – dark strong brown, hard when dry, saturated moist, variable silt content, as sand, of alluvial origin
		CLAYEY SILT – yellow brown to strong brown, blocky, mottled, soft, with variable clay content, dispersive in part, of alluvial origin
		SANDY SILT – light yellow brown, blocky, mottled, loose fine to medium-grained sand, soft when moist, variable clay content
		SAND – pale grey to white, medium-grained sub-angular, quartz and feldspar, well sorted, abundant shells and broken bivalves and gastropod shells, of alluvial origin
		SILTY SAND – strong brown, mottled at surface, fine to medium-grained, quartz, variable silt content
		SILT – strong brown, tough, hard, variable fine-grained quartz sand in matrix
		GRAVELLY SILT – strong brown, tough with common pebbles of fine to coarse-grained, sub-rounded granite, some siltstone and iron sandstone (SS) rounded sand content
		SANDY SILT – strong brown, firm, friable, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, tourmaline, of colluvial origin
		SANDY SILT – yellowish brown, rough, with variable sand content of fine to medium-grained quartz sand, some gravel in places
		SILTY SAND – dark yellowish brown, tough silty, medium to coarse quartz sand, in places a dominant medium to coarse-grained pisolitic laterite (D_{cp}) pebble
		SAND – pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin
Ls_1		LIMESTONE – light, yellowish brown, fine to coarse-grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, eolian barrier of eolian origin
Ls_2		LIMESTONE – as Ls_1, but more coarse grained and containing coral, coral reef, eolian
		SAND – very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin
		SAND – as s_3
		HIGHLY SILT – strong brown silt with common, fine to occasionally coarse-grained, sub-rounded eolian quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin
		SANDY SILT – strong brown to mid grey, mottled, blocky, disseminated fine sand, hard when dry, variable clay content of alluvial origin
		SAND – light grey, medium grained, sub-angular to rounded quartz and feldspar, moderately sorted of alluvial origin
		SAND – yellow, fine to medium-grained, sub-angular to rounded quartz, with some feldspar, well sorted, variable silt content, of colluvial origin
Ss		SANDSTONE – light grey, hard, compact, moderately weathered, fine-grained silty sandstone, interbedded fine siltstone layers
La_1		LATERITE – massive and cemented, occasionally vesicular, up to c. 4 m in thickness, overlies a zone of mottled mottled pallid clay and sporadic
Cg		GRAVEL – strong brown, coarse, sub-rounded to rounded laterised quartz pebbles in clay silt matrix, moderately sorted, of colluvial origin
		GALLERITE – quartz rich, fine-grained, indurated, 2 to 20 m wide styles
Sc_2		SILT – yellowish brown mottled, overlying bauxitic horizon, firm and tough when dry, soft when wet, very variable sand content
		GRANITE – monzonite, fine to coarse grained, ranges in composition from pro-dominantly to granite, altered to being contaminated variably
		GRANITIC and GNEISSIC – intimate association of coarse grained granites (GG) and gneissic and fine grained materials (GG)





NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 50

REFERENCE:
1. GOZZARD JR., 1986. PERTH, SHEET 2034 II AND PART 2034 III AND 2134 III, PERTH METROPOLITAN REGION ENVIRONMENTAL GEOLOGY SERIES, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

0 625 1,250
1:25,000 METRES

CLIENT: TALIS CONSULTANTS

CONSULTANT: wsp

YYYY/MM/DD	2025-02-25
DESIGNED	
PREPARED	
REVIEWED	
APPROVED	

PROJECT: WANGARA WASTE TRANSFER STATION GEOTECHNICAL INVESTIGATION

TITLE: **GEOLOGICAL MAP**

PROJECT NO.	CONTROL	REV.	FIGURE
PS221993	WSP-PER-GEO-REP-00001	0	3

Appendix A

Hand Auger borehole reports

HAND AUGER: HA01

Sheet 1 of 1

Project: WTS Modification and Addition Works
Location: Wangara
Client: Tallis Consulting
Job No.: PS221993

Coords: 390022 m E 6481944 m N MGA2020-50
Contractor: Drill Rig:
Inclination: -90°

Date Started: 18/2/2025
Date Completed: 18/2/2025
Logged: AT

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY
HA		Not Encountered	0.0						TOPSOIL - SAND: fine to coarse, sub-angular to sub-rounded, pale yellow-brown to brown, with gravel; trace fines; trace rootlets.		
			0.2	0.20				SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale orange-brown to brown, trace gravel; trace fines.		L - MD
			0.4		D 0.30-0.50 m						
			0.6	0.70					Pale grey and brown, trace fines.	D	
			0.8		D 0.70-1.00 m				Dark grey, with fine gravel.		D
			1.0								VD
			1.2	1.20					Hole Terminated at 1.20 m Refusal Backfilled with spoil		

PERTH PENETROMETER TEST (AS 1289.6.3.3-1997) Blows per 150 mm
0 5 10 15 20 25

Comments

Checked
Date

HAND AUGER: HA02

Sheet 1 of 1

Project: WTS Modification and Addition Works
Location: Wangara
Client: Tallis Consulting
Job No.: PS221993

Coords: 390091 m E 6481958 m N MGA2020-50
Contractor: Drill Rig:
Inclination: -90°

Date Started: 18/2/2025
Date Completed: 18/2/2025
Logged: AT

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY
HA		Not Encountered	0.0	0.07					TOPSOIL - SAND: fine to coarse, sub-angular to sub-rounded, pale brown, trace fines; trace gravel.		
			0.2	0.25					FILL - GRAVELLY SAND: fine to medium, sub-angular to sub-rounded, pale yellow brown, fine to medium grained, sub-angular; with fines.		
			0.4					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey and brown, trace gravel; trace fines.		L - MD
			0.6	0.70					Pale grey, trace fines.		
			0.8						Dark grey, trace gravel.	D	D
			1.0		D 1.00-1.30 m						VD
			1.2								
			1.4	1.40					Hole Terminated at 1.40 m Refusal Backfilled with spoil		

PERTH PENETROMETER TEST (AS 1289.6.3.3-1997) Blows per 150 mm
0 5 10 15 20 25

Comments

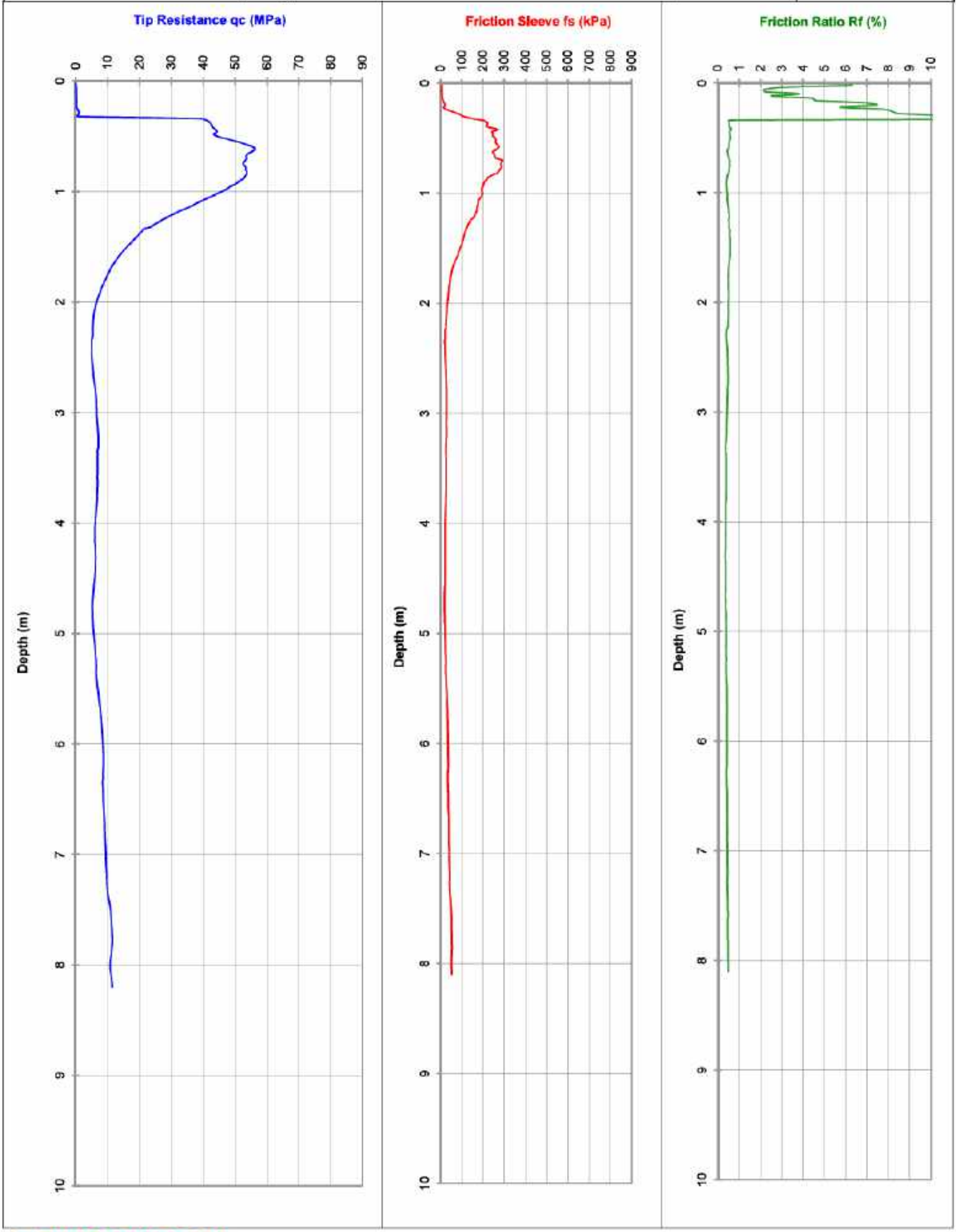
Checked
Date

Appendix B

Cone penetration test reports

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D: **CPT 01**
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 68.59	
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390040.45mE, 6481950.94mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 7.9

Dummy probe to (m): 0.36

Refusal:

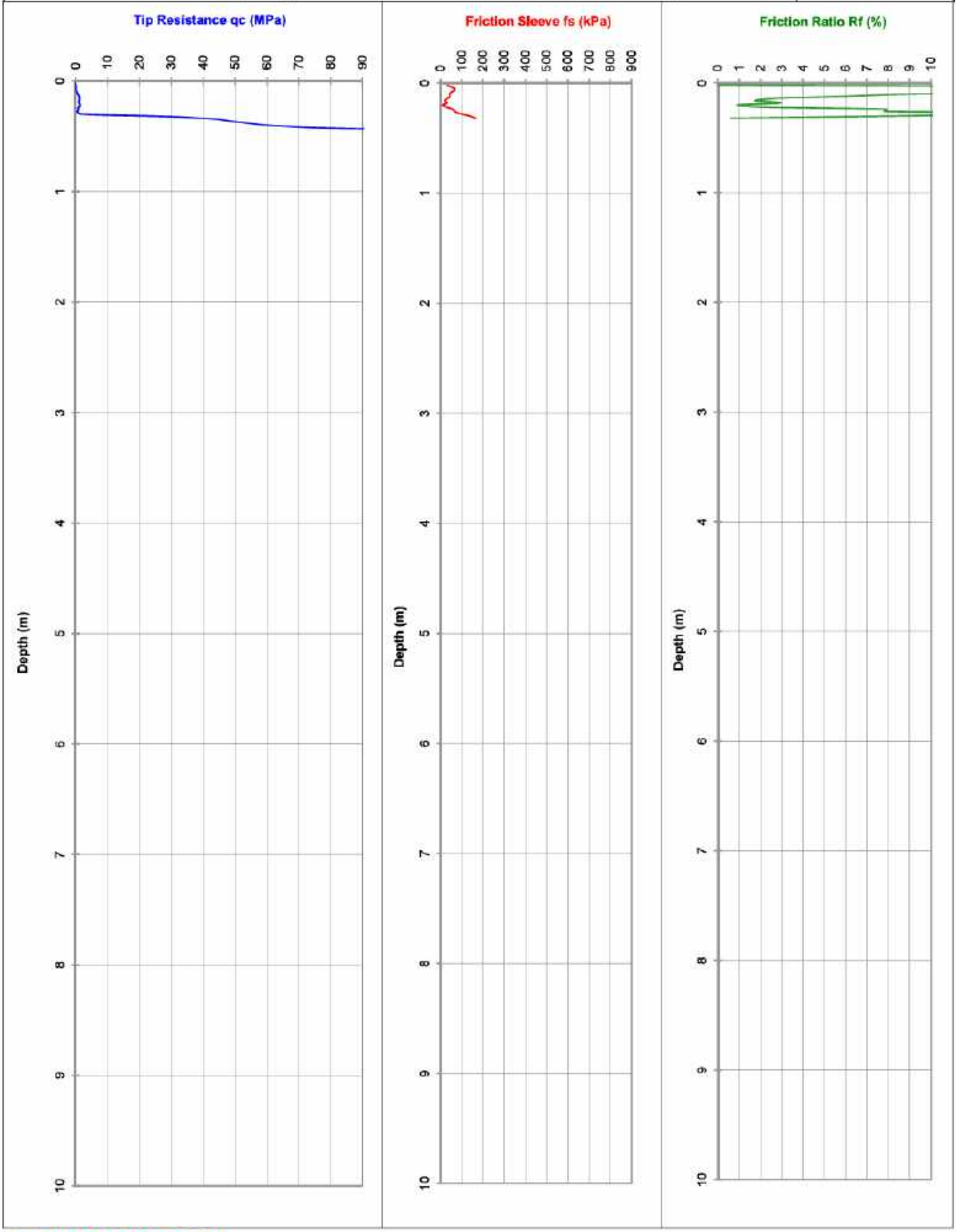
Cone I.D.: EC46

File: WS0248G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D: **CPT 02**
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 67.06	
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390072.92mE, 6481943.41mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 0.49

Dummy probe to (m): 0.36

Refusal: 102 MPa

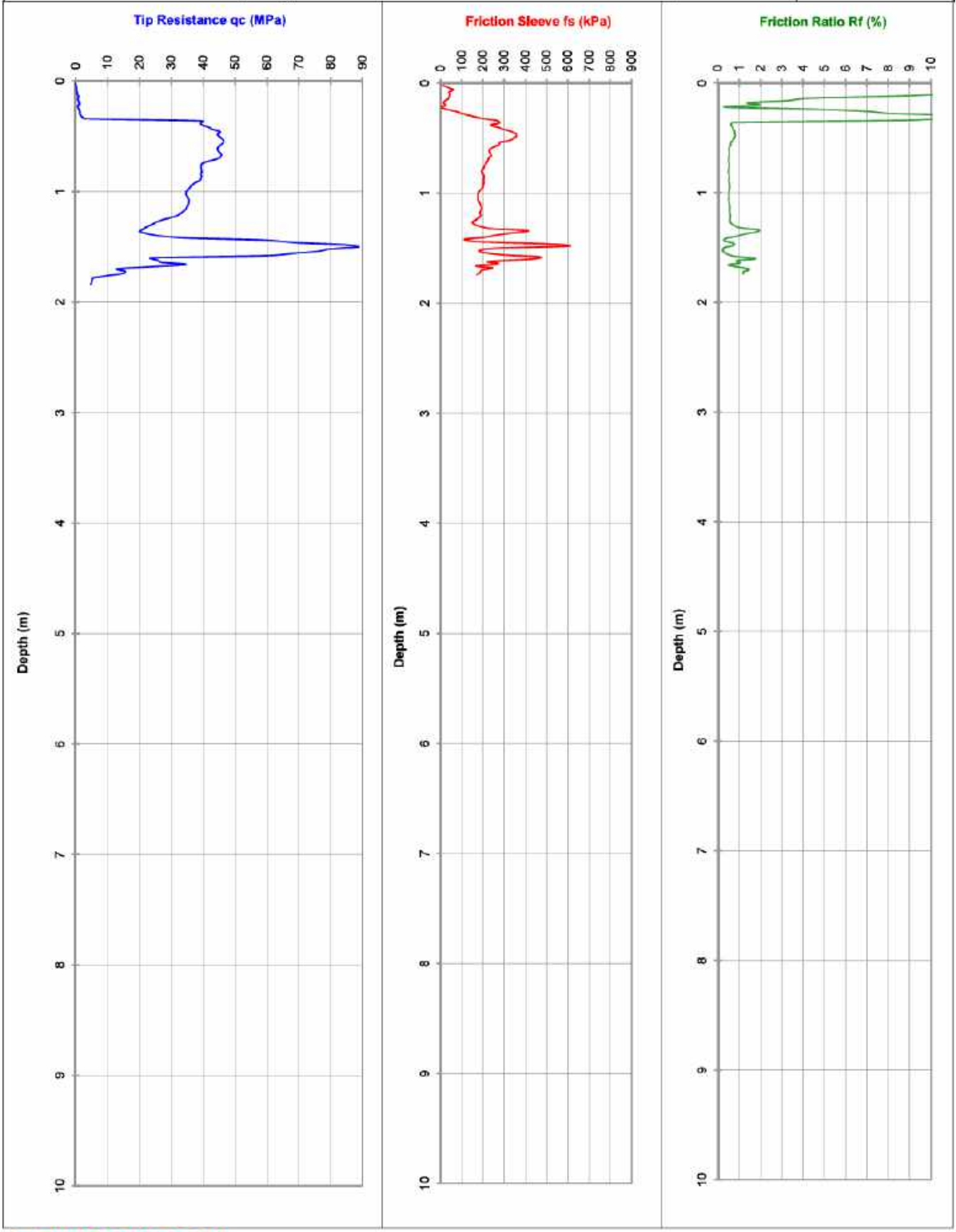
Cone I.D.: EC46

File: WS0249G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 67.75	**CPT 02A**
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390071.67mE, 6481942.86mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 1.84

Dummy probe to (m): 0.36

Refusal: Inclination

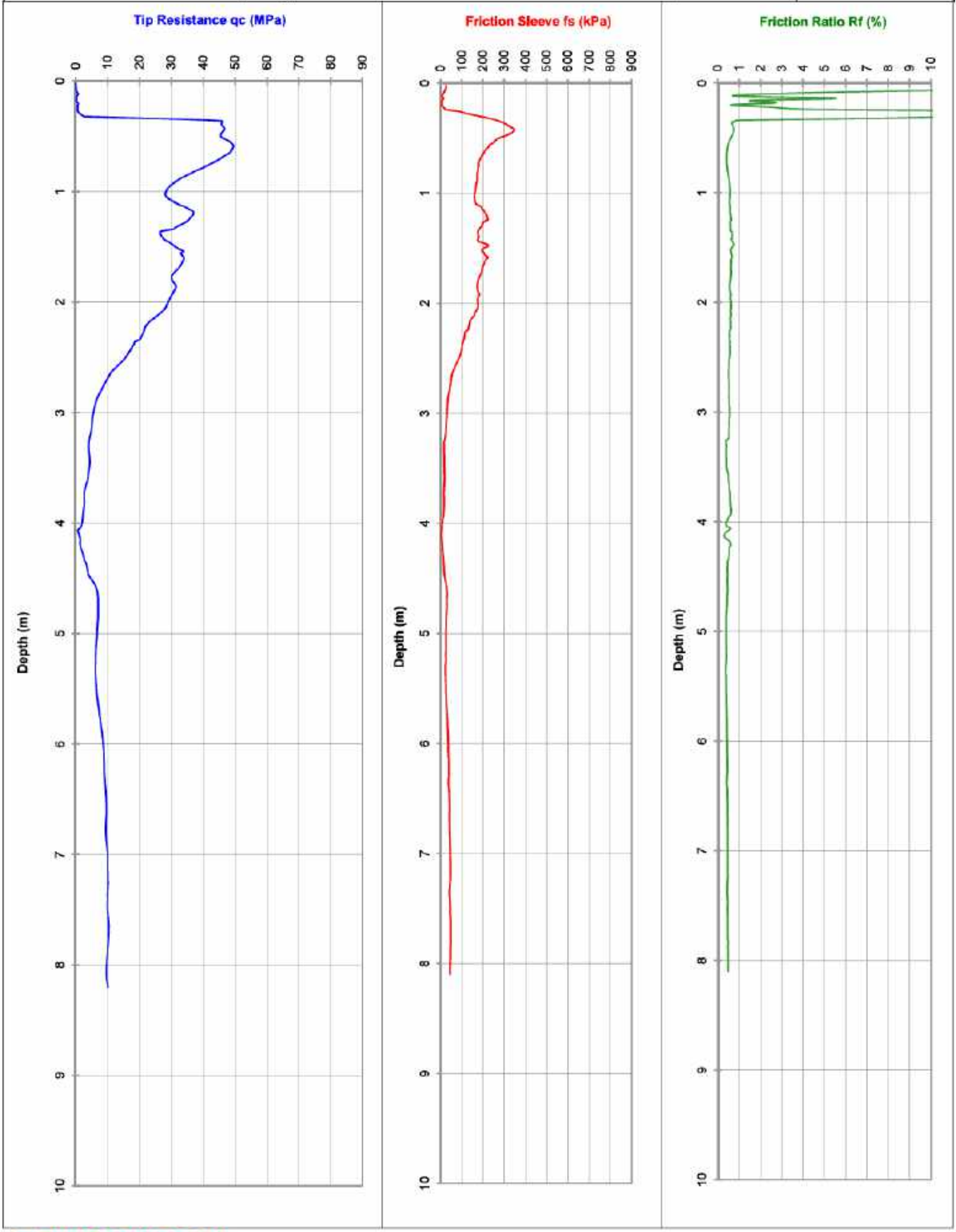
Cone I.D.: EC46

File: WS0250G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 67.66	CPT 02B
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390071.58mE, 6481938.27mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 7.8

Dummy probe to (m): 0.36

Refusal:

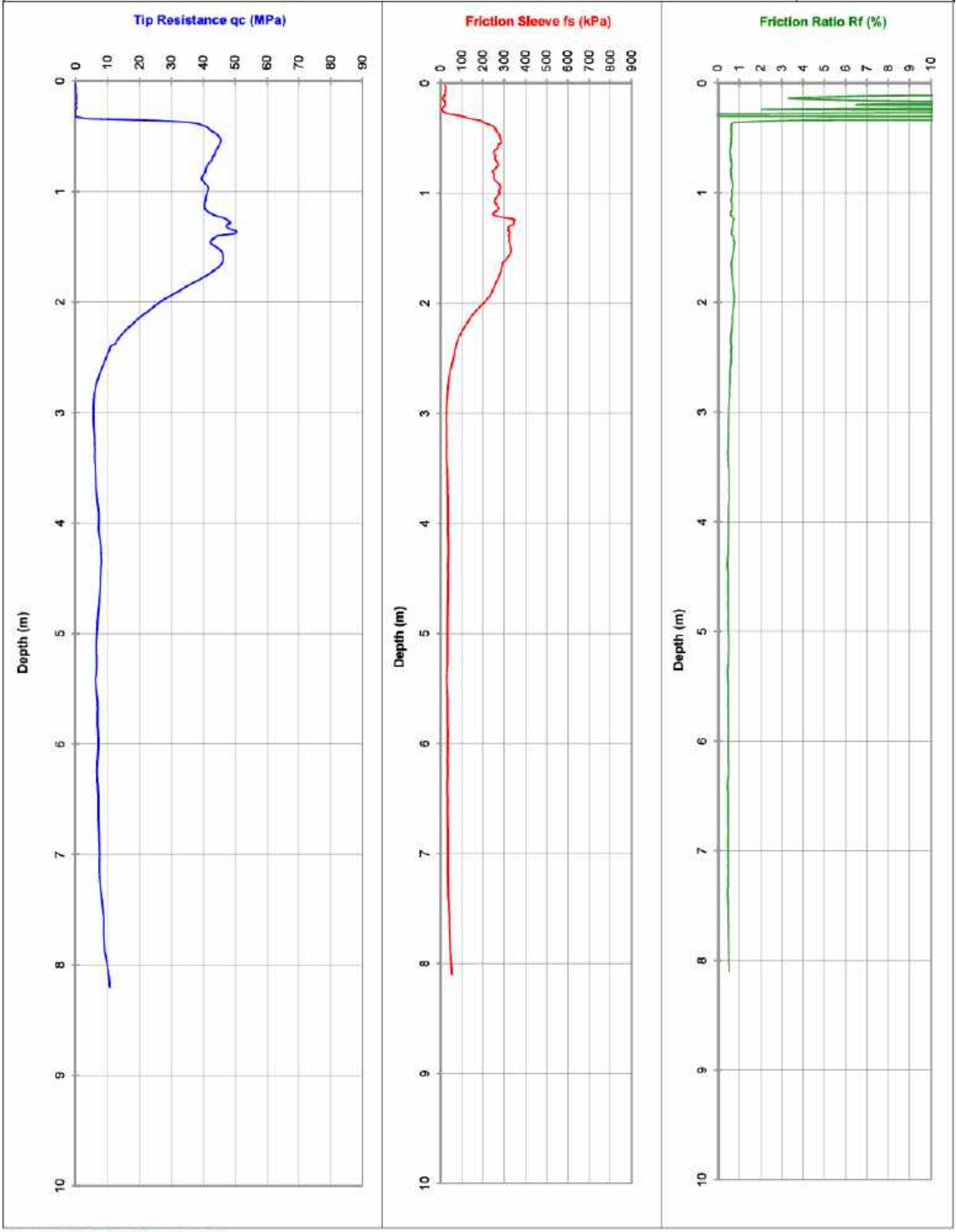
Cone I.D.: EC46

File: WS0251G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D: **CPT 03**
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 66.09	
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390085.77mE, 6481969.86mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 7.6

Dummy probe to (m): 0.36

Refusal:

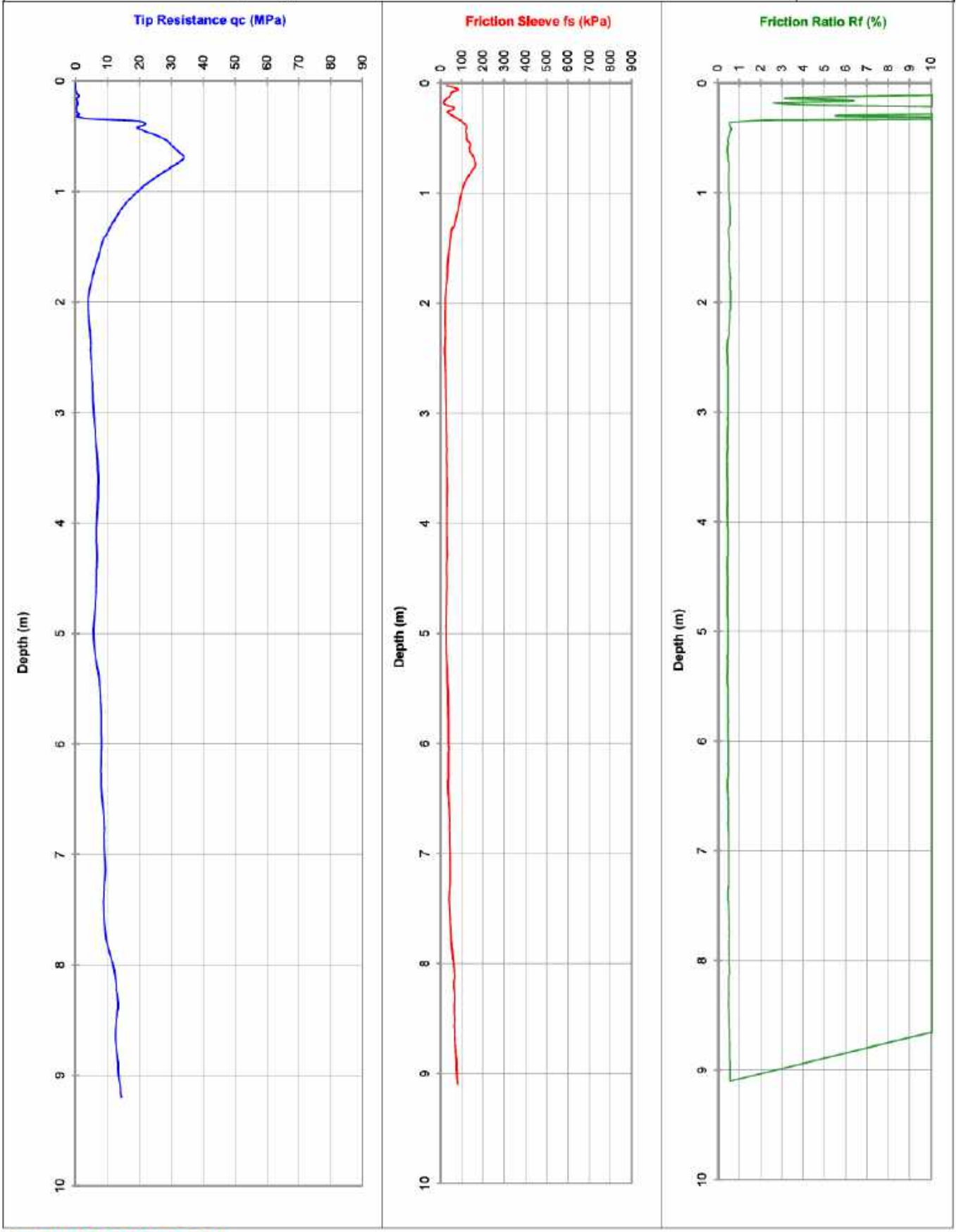
Cone I.D.: EC46

File: WS0252G

Rig Type: 22t truck (Merc)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Talis Consultants	Job No.: PS2251993	Probe I.D
PROJECT: Wangara Waste Transfer Station Geotechnical Inv	RL (m): 66.99	**CPT 04**
LOCATION: 70 Motivation Drive, Wangara	Co-ords: 390056.2mE, 6481998.3mN	18-Feb-25



PROBEDRILL GEOTECHNICAL SURVEY

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

Approx. water (m): Dry to 7.8

Dummy probe to (m): 0.36

Refusal:

Cone I.D.: EC46

File: WS0253G

Rig Type: 22t truck (Merc)

Appendix C

Laboratory test reports

Soils testing - Particle size distribution & consistency limits test report

Standard method (by sieving)

AS 1289.3.6.1 & 2.1.1

Test request #:	STRP25-0021	**Specimen ID:**	LPER202502209	**WSP Australia Pty Ltd**	
Client:	Talis Consultants			**PERTH GEOTECHNICAL LABORATORY**	
Client address:				780 Marshall Road, Malaga, Western Australia 6090	
Project ID:	PS221993		Location ID: HA01	**Sample depth (m):**	0.30 - 0.50
Project name:	Wangara Waste Transfer Station GI			**Client sample ref:**	
Project reference:				**Loc. ref.:**	-

Specimen description: (Based on visual and tactile assessment) (SP) SAND, fine to coarse grained, grey, trace of fines, trace of fine to medium gravel.

Sampling: Tested as received

Easting (m)	Northing (m)	Level (m)

PARTICLE SIZE DISTRIBUTION AS 1289.3.6.1

Sieve Size	Passing	LB S	UB S
125 mm	100%		
75 mm	100%		
63 mm	100%		
53 mm	100%		
37.5 mm	100%		
26.5 mm	100%		
19 mm	100%		
13.2 mm	100%		
9.5 mm	99%		
6.7 mm	99%		
4.75 mm	98%		
2.36 mm	98%		
1.18 mm	97%		
600 µm	85%		
425 µm	54%		
300 µm	24%		
212 µm	11%		
150 µm	5%		
75 µm	3%		

Method:	AS 1289.2.1.1	AS 1289.3.1.2	AS 1289.3.2.1	AS 1289.3.3.1	AS 1289.3.4.1	
	Moisture content	1 point Liquid limit	Plastic limit	Plasticity index	Linear shrinkage	Curling/ Crumbling/ Cracking
Result:	12.4% As Rcvd.	-	-	-	-	
LB S:						-
UB S:						-

Att. preparation method: | **LSM length (mm):**

Specimen history/notes: Compliance check AS 1289.1.1 - Clause 5.7 - Table 1 - OK

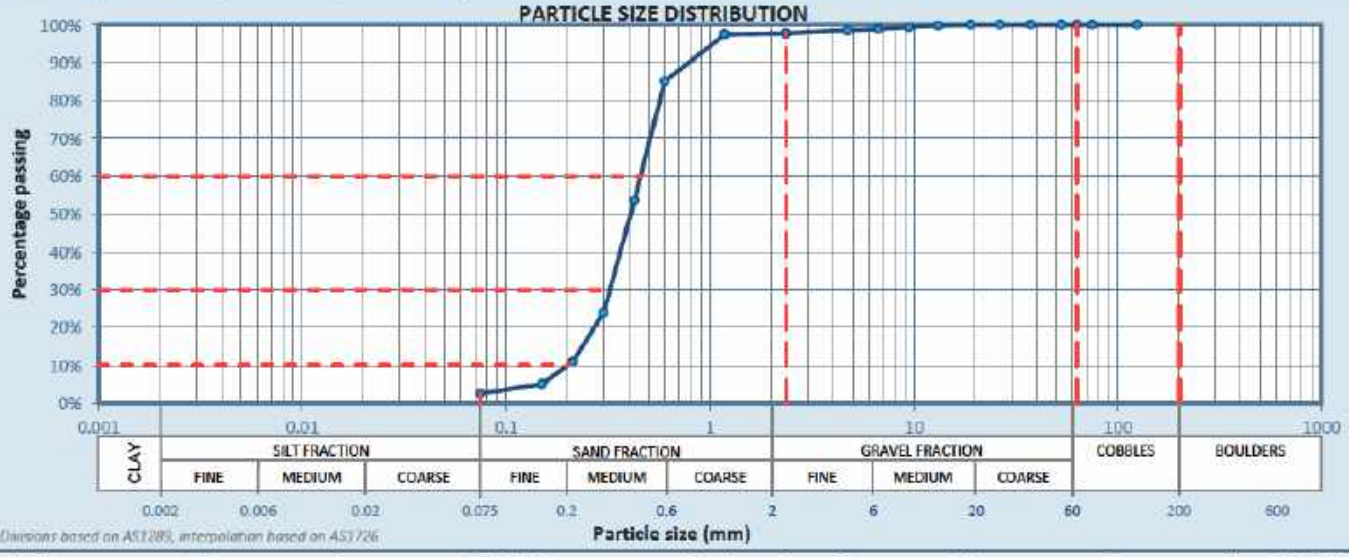
Definitions:
LB S = Lower bound specification
LSM = Linear shrinkage mould
UB S = Upper bound specification
N/A = Not applicable
ND = Not determined; SIB = Slip in bowl
NC = Not obtainable; NP = Non plastic

GRADING SUMMARY

Fines (<75 µm)	Sand* (>75 µm - <2.36 mm)	Gravel* (>2.36 mm - <63 mm)	Cobbles* (>63mm - <200 mm)
2.6%	95.1%	2.3%	0.0%

*Proportions based on guidance in AS1726-2017 Section 6.1.4.2

PARTICLE SIZE DISTRIBUTION



Divisions based on AS1289, interpolation based on AS1726

Testing by: BC **Date:** 04/03/25 **Results reviewed by:** PKent **Date reported:** 04/03/2025

Cert. ref.: PS221993_HA01_STRP25-0021_PSD_2502209_Rep25120249

Approved signatory: [redacted]

NATA accreditation number: 1961 - Site:1598 - Perth

Accredited for compliance with ISO/IEC 17025 - Testing

Phone: +61 (0)8 9441 0700 **Fax:** +61 (0)8 9441 0701 **E-mail:** pergeolab@wsp.com **Web:** www.wsp.com

These tests were carried out in accordance with the Australian standards identified in this certificate.
Test results relate only to the specimens tested.

Soils testing - Particle size distribution & consistency limits test report

Standard method (by sieving)

AS 1289.3.6.1 & 2.1.1

Test request #:	STRP25-0021	**Specimen ID:**	LPER2025022010
Client:	Talis Consultants		
Client address:			
Project ID:	PS221993		
Project name:	Wangara Waste Transfer Station GI		
Project reference:			

WSP Australia Pty Ltd
PERTH GEOTECHNICAL LABORATORY
780 Marshall Road,
Malaga,
Western Australia 6090

Location ID	Sample depth (m)	Client sample ref:	Loc. ref.:
HA01	0.70 - 1.00	-	-

Specimen description: (Based on visual and tactile assessment) (SP) SAND, fine to coarse grained grey, trace of fines, trace of fine to medium gravel.

Sampling: Tested as received

Easting (m)	Northing (m)	Level (m)

PARTICLE SIZE DISTRIBUTION AS 1289.3.6.1

Sieve Size	Passing	LB S	UB S
125 mm	100%		
75 mm	100%		
63 mm	100%		
53 mm	100%		
37.5 mm	100%		
26.5 mm	100%		
19 mm	100%		
13.2 mm	97%		
9.5 mm	96%		
6.7 mm	95%		
4.75 mm	93%		
2.36 mm	92%		
1.18 mm	90%		
600 µm	74%		
425 µm	42%		
300 µm	18%		
212 µm	9%		
150 µm	4%		
75 µm	2%		

Method:	AS 1289.2.1.1	AS 1289.3.1.2	AS 1289.3.2.1	AS 1289.3.3.1	AS 1289.3.4.1	
	Moisture content	1 point Liquid limit	Plastic limit	Plasticity index	Linear shrinkage	Curling/ Crumbling/ Cracking
Result:	14.5% As Rcvd.	-	-	-	-	
LB S:						-
UB S:						-

Att. preparation method: | **LSM length (mm):**

Specimen history/notes: Compliance check AS 1289.1.1 - Clause 5.7 - Table 1 - OK

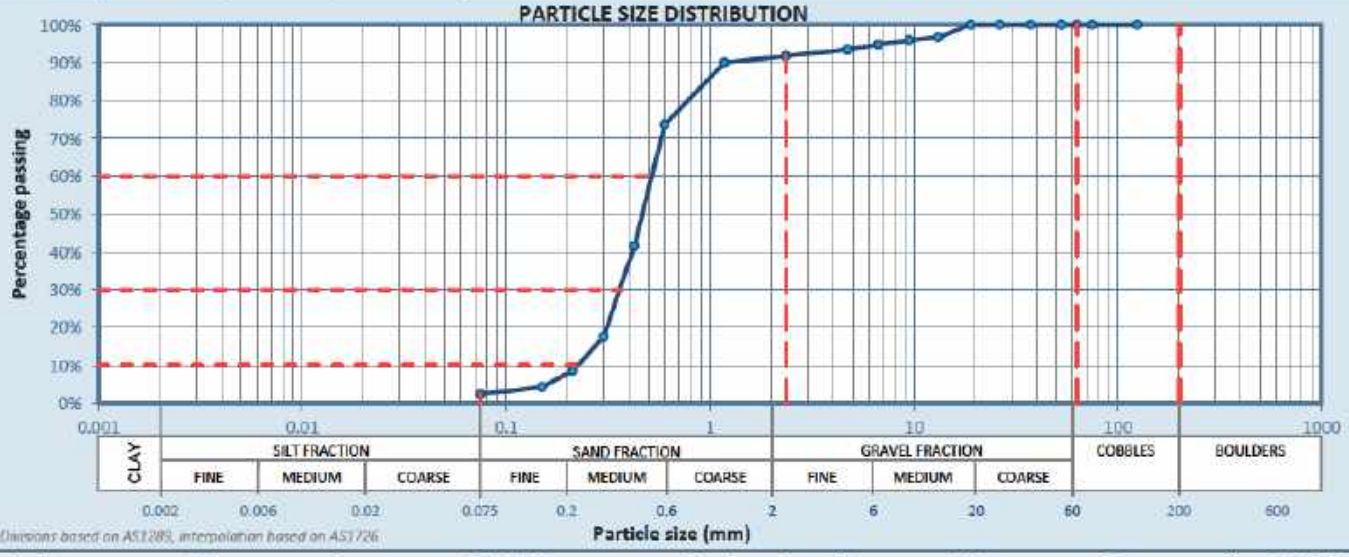
Definitions:
LB S = Lower bound specification
LSM = Linear shrinkage mould
UB S = Upper bound specification
N/A = Not applicable
ND = Not determined; SIB = Slip in bowl
NC = Not obtainable; NP = Non plastic

GRADING SUMMARY

Fines (<75 µm)	Sand* (>75 µm - <2.36 mm)	Gravel* (>2.36 mm - <63 mm)	Cobbles* (>63mm - <200 mm)
2.5%	89.3%	8.2%	0.0%

*Proportions based on guidance in AS1726-2017 Section 6.1.4.2

PARTICLE SIZE DISTRIBUTION



Divisions based on AS1289, interpolation based on AS1726

Testing by: BC **Date:** 04/03/25 **Results reviewed by:** PKent **Date reported:** 04/03/2025

Cert. ref.: PS221993_HA01_STRP25-0021_PSD_25022010_Rep25120250

Approved signatory: [redacted]

NATA accreditation number: 1961 - Site:1598 - Perth
Accredited for compliance with ISO/IEC 17025 - Testing

Phone: +61 (0)8 9441 0700 Fax: +61 (0)8 9441 0701 E-mail: pergeolab@wsp.com Web: www.wsp.com

These tests were carried out in accordance with the Australian standards identified in this certificate.
Test results relate only to the specimens tested.

Soils testing - Particle size distribution & consistency limits test report

Standard method (by sieving)

AS 1289.3.6.1 & 2.1.1

Test request #:	STRP25-0021	**Specimen ID:**	LPER2025022011	**WSP Australia Pty Ltd**	
Client:	Talis Consultants			**PERTH GEOTECHNICAL LABORATORY**	
Client address:				780 Marshall Road, Malaga, Western Australia 6090	
Project ID:	PS221993		Location ID: HA02	**Sample depth (m):**	1.00 - 1.30
Project name:	Wangara Waste Transfer Station GI			**Client sample ref:**	
Project reference:				**Loc. ref.:**	-

Specimen description: (Based on visual and tactile assessment) (SP) SAND, fine to coarse grained, grey, trace of fines, trace of fine to medium gravel.

Sampling: Tested as received

Easting (m)	Northing (m)	Level (m)

PARTICLE SIZE DISTRIBUTION AS 1289.3.6.1

Sieve Size	Passing	LB S	UB S
125 mm	100%		
75 mm	100%		
63 mm	100%		
53 mm	100%		
37.5 mm	100%		
26.5 mm	100%		
19 mm	100%		
13.2 mm	98%		
9.5 mm	98%		
6.7 mm	96%		
4.75 mm	96%		
2.36 mm	95%		
1.18 mm	94%		
600 µm	84%		
425 µm	57%		
300 µm	28%		
212 µm	14%		
150 µm	7%		
75 µm	4%		

Method:	AS 1289.2.1.1	AS 1289.3.1.2	AS 1289.3.2.1	AS 1289.3.3.1	AS 1289.3.4.1	
	Moisture content	1 point Liquid limit	Plastic limit	Plasticity index	Linear shrinkage	Curling/ Crumbling/ Cracking
Result:	10.7% As Rcvd.	-	-	-	-	
LB S:						-
UB S:						-

Att. preparation method: | **LSM length (mm):**

Specimen history/notes: Compliance check AS 1289.1.1 - Clause 5.7 - Table 1 - OK

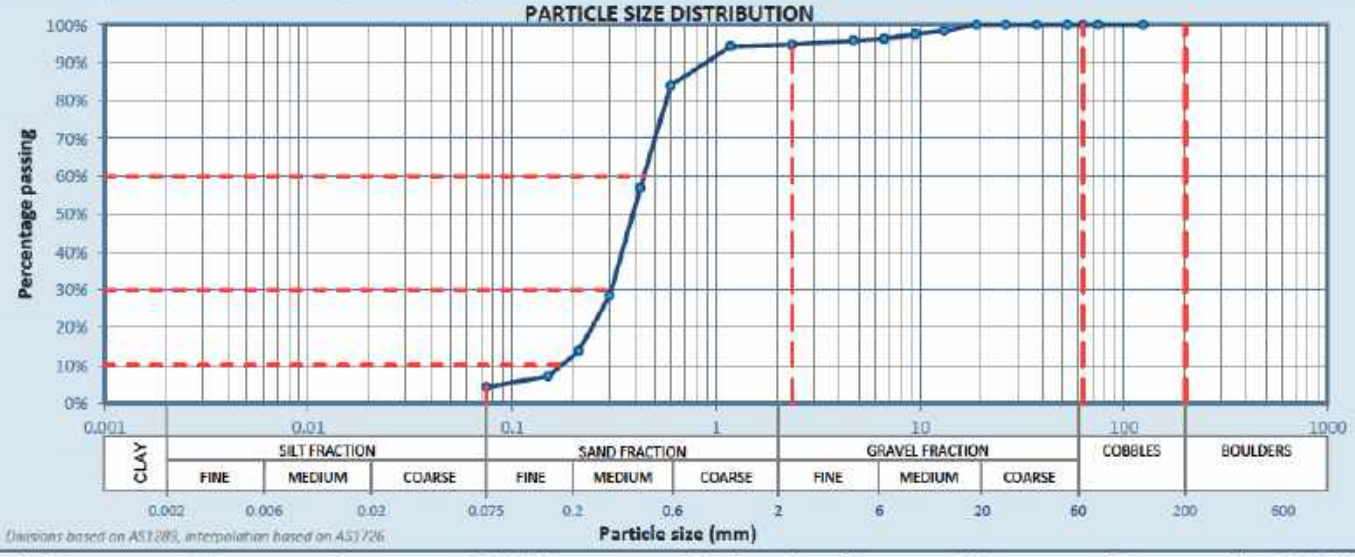
Definitions:
LB S = Lower bound specification
LSM = Linear shrinkage mould
UB S = Upper bound specification
N/A = Not applicable
ND = Not determined; SIB = Slip in bowl
NC = Not obtainable; NP = Non plastic

GRADING SUMMARY

Fines (<75 µm)	Sand* (>75 µm - <2.36 mm)	Gravel* (>2.36 mm - <63 mm)	Cobbles* (>63mm - <200 mm)
4.3%	90.4%	5.3%	0.0%

*Proportions based on guidance in AS1726-2017 Section 6.1.4.2

PARTICLE SIZE DISTRIBUTION



Divisions based on AS1289, interpolation based on AS1726

Testing by: BC **Date:** 04/03/25 **Results reviewed by:** PKent **Date reported:** 04/03/2025

Cert. ref.: PS221993_HA02_STRP25-0021_PSD_25022011_Rep25120251

Approved signatory: [redacted]

NATA accreditation number: 1961 - Site:1598 - Perth

Accredited for compliance with ISO/IEC 17025 - Testing

Phone: +61 (0)8 9441 0700 **Fax:** +61 (0)8 9441 0701 **E-mail:** pergeolab@wsp.com **Web:** www.wsp.com

These tests were carried out in accordance with the Australian standards identified in this certificate.
Test results relate only to the specimens tested.