GeoSolve Ref: 220556.03
26 November 2025

RCL Homestead Bay Ltd
[redacted]

Attention: Dan Wells

# Request for Further Information - Homestead Bay
# Lot 12 DP 364700

Dear Dan,

## 1 General

In accordance with your request I have reviewed the request for further information (RFI) received with respect to development in Lot 12. The required information is outlined in the Fast Track Panel document 'Request for Further Information Homestead Bay [FTAA-2506-1071]. The geotechnical aspects of the RFI are concerned with the liquefaction risk in Lot 12.

It is understand the developer (RCL Homestead Bay Ltd) is proposing infrastructure (Reservoir and water treatment structures) at the eastern end of Lot 12 only, as shown on Figure 1.1 below. Development is not proposed in other areas of Lot 12.

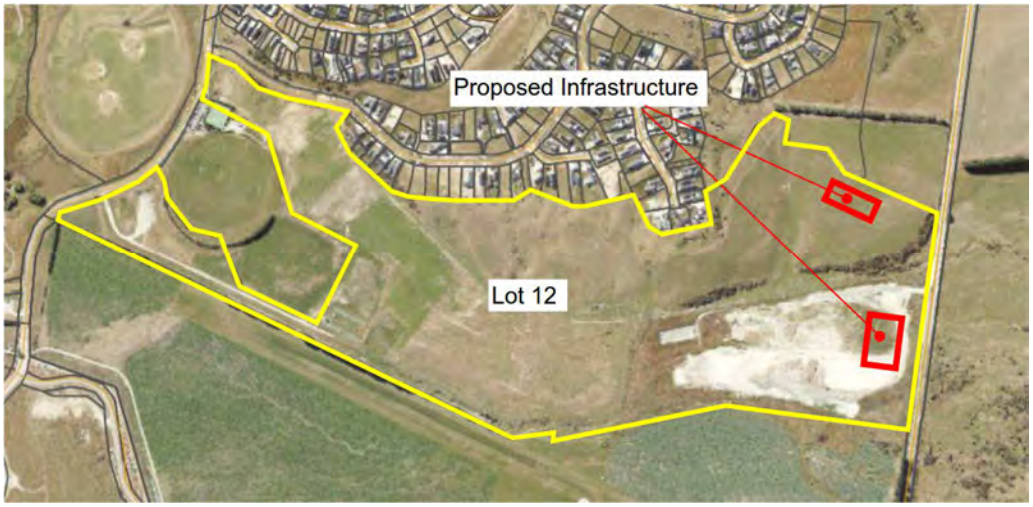



Figure 1.1: Lot 12 proposed infrastructure location.

To provide context with respect to the RFI a review of the geological model at the eastern end of Lot of Lot 12 is relevant and a summary is provided in Section 2 below.


GeoSolve Queenstown Office:
829 Frankton Road, Frankton Marina
PO Box 1780, Queenstown 9300
queenstown@geosolve.co.nz

## 2 Geological Model for the eastern area of Lot 12

Investigations have been undertaken across the eastern end of Lot 12 and the wider areas to the north and south. The investigations comprise test pits, cone penetrometer tests, boreholes and mapping of surface exposures. The investigations immediately to the south form part of the recent Lot 8 Homestead Bay development proposal.

Figure 1, Appendix A, shows the extent of investigations undertaken and notes have been added to provide further guidance.

From the investigations a ground model has been determined and a sketch geological cross-section through the eastern end of Lot 12 is provided as Figure 2, Appendix A.

The ground model in the proposed reservoir structure location (noted on the RFI as Lot 12 - north), is shown to comprise:

- ~ 0.2 m of Topsoil, overlying;
- 0 – 1.3 m of Colluvium (in very localised areas), overlying;
- 0 – 0. 9 m of Outwash Gravel (in very localised areas), overlying;
- Glacial Till (base at depth, not confirmed).

The site investigation data, test pits and surface mapping, for the reservoir location are provided in Appendix B.

The ground model in the proposed water treatment plant location (noted on the RFI as Lot 12 – south), is shown to comprise.

- ~ 0.2 m of Topsoil, overlying;
- Fill, varying depths from 0 to approximately 3 m (estimated),
- 6.0 to 10.0 m of Alluvial Fan deposits, overlying;
- Glacial Till (base at depth, not confirmed).

Borehole BH-P8 and CPT 2, 3 and 4 located immediately adjacent to the proposed water treatment plant are provided in Appendix C.

## 3 Relevant Points from the Ground Model.

The proposed water and wastewater treatment plant and reservoirs are at RL's of approximately 390 m and 405 m which is significantly above historic lake levels and associated deposits of fine grained sediments. The sites are located in a historic glacial environment with more recent alluvial deposition overlying the glacial deposits in some areas. This general ground model is observed in the investigations undertaken.

Investigation data shows Glacial Till is present close to the surface in the reservoir location and at depths of up to approximately 10 m below the treatment plant. This ground model can also be seen in the investigations completed a short distance to the south in the north eastern corner of Lot 8, and to the north in the Jacks Point residential area. Glacial till is also exposed at the surface adjacent to the reservoir and less than 100 m north of the proposed treatment plant.

The glacial till is typically dense with SPT N values of 50+ where tested and as described in the log of BH-P8 and test pits. Glacial till will not liquefy and the top surface of the till therefore provides a lower limit on the depth of liquefaction.

Groundwater shows some variation across the area, being preferentially present in more permeable layers in the alluvial fan material and at shallower depths around flow paths and lower lying areas.

## 4 CPT4 Liquefaction Assessment

CPT4 is considered to be the only CP test that penetrated the alluvial fan material and reached the upper surface of the glacial till.

The liquefaction assessment results for CPT 4 are provided in Appendix D, and are summarised in Table 1 below. The assessment has been undertaken using a groundwater depth of 6 m, a 50 year design life and an Importance Level of 4.

Table 1. Liquefaction Results for CPT4.

| Case | Return Period | PGA | Settlements (mm) |
|---|---|---|---|
| SLS1 | 1/25 | 0.1 | 0 |
| - | 1/100 | 0.2 | 6 |
| SLS2 | 1/500 | 0.41 | 50 |
| ULS | 1/2500 | 0.74 | 60 |

The liquefaction assessment shows there is a risk of settlement during a seismic event, however for a large low probability event (1/2500 year) a relatively minor incremental increase over the 1/500 year is predicted. This suggests the site is not highly sensitive to worsening land damage for larger events.

## 5 Future Investigation and Assessment.

Based on the above geological summary and assessment I consider the ground model is sufficiently understood with respect to resource consent and the feasibility of the development proposal.

I expect future geotechnical investigation and geotechnical engineering assessment will be undertaken as part of the detailed design process for future structures. Additional assessment will be required to finalise detailed design aspects of the infrastructure e.g. foundation design. The liquefaction assessment will be refined as part of this process as is standard in the building consent process.

# 6 Responses to the Further Information Request

Responses to the specific requests for information are provided below.

QLDC RFI:

**Reservoir Site (Lot 12 - north)**

16. The applicant says that the site is glacial till and is therefore a low risk to liquefaction. As part of the TTSC, QLDC geotechnical consultant undertook a liquefaction hazard assessment as per the MBIE (2017) 'Planning and engineering guidance for potentially liquefaction-prone land' guidance. The TTSC report is **attached** to this response.

17. For the reservoir area the assessment level of detail is in accordance with 'Level A' basic desktop assessment. No physical investigations were undertaken as part of the TTSC study, but that area near the reservoir was also mapped as Glacial Till. It is agreed that glacial till is unlikely to result in liquefaction, however, the Applicant references test pits that were done near the site. These referenced test pit logs or physical investigation that confirm it is glacial till cannot be seen in the initial application nor the additional information provided. As part of this consent, physical investigation should support geotechnical assessment.

Geosolve Response to 16 and 17:

See the geotechnical investigation data provided in Appendix B which confirms Glacial till is present in the proposed reservoir area.

QLDC RFI:

**WWTP / WTP Site (Lot 12 - south)**

18. The data provided for each of the four Cone Penetration Test (**CPT**) varies in the Appendix H:
    - (a) Depth of CPT 4 is not provided. Ideally CPT would extend to a 20-30m depth. The depth needs to be confirmed to understand whether the data is reliable.
    - (b) For CPT 4 ground water level of 6m was used, corresponding to the water depth encountered at the borehole adjacent which is reasonable.
    - (c) For CPT 1 the water depth is not stated. Confirmation of the water depth or if it was dry is requested. This will allow for this CPT to be compared to the CPTs QLDC consultants undertook nearby at Tewa Park, where further investigations were recommended (as discussed in #172)

(d) It is unclear if SPT (Standard Penetration Test) testing was undertaken at the bore hole that was drilled to 30m, or if this was just to inform the water depth. Confirmation and justification (if required) as to why no SPT was undertaken in the borehole, given refusal was met in CPT2 & 3, is needed to understand whether the data is reliable.

Geosolve Response to 18:

a) The log for CPT4 is provided in Appendix C. Due to presence of dense glacial till at relatively shallow depths extending cone penetrometer testing to depths of 20-30 m is not

considered practical. The log for Borehole BH-P8 provides a summary of the ground model to 30 m.

b) Agreed.

c) CPT 1 is located over 1 km to the west of the proposed infrastructure and therefore the ground conditions and liquefaction hazard in this area is not considered to be relevant to the proposal.

d) The drill hole was undertaken for water monitoring purposes and SPT testing was not undertaken. The core was made available to Geosolve and a geotechnical log and core photographs are provided in Appendix C. Refusal of the CPTs on dense glacial till or coarse granular layers in the overlying alluvial deposit is indicated by the drill core.

QLDC RFI:

| | |
|---|---|
| 19. | Geotechnical investigations suitable for the liquefaction assessment are defined by MBIE (2017) as machine boreholes with Standard Penetration Testing (SPT) or Cone Penetration Tests (CPT) that characterise the ground to at least 10–15 m depth for residential or light commercial development, or at least 20–25 m depth for heavier structures or critical facilities. The recommended densities of subsurface investigations required for each assessment detailed by MBIE (2017) are outlined below. |

Geosolve Response to 19:

CPT investigation to depths of 20-25 m is not considered practical as glacial till is present at relatively shallow depths. Glacial Till is dense and is expected to restrict CPT depths.

The borehole allows the soil profile to be determined to a depth of 30 m in the water treatment facility location. No SPTs are available, however Glacial Till has been identified. Based on the borehole Geosolve consider that CPT4, which reached 11 m, is highly likely to have refused on the top surface of the till. This behaviour was also observed in the north eastern area of Lot 8. Liquefaction analysis of CPT4 therefore provides a reasonable representation of the liquefaction risk with glacial till below acting as a lower limit.

Deep investigations in the reservoir location are not considered to be required due to the shallow depth to glacial till.

QLDC RFI:

| | |
|---|---|
| 20. | The applicant needs to confirm the level of detail of the liquefaction assessments for both the reservoir site and the WTP/WWTP site in accordance with MBIE (2017) and demonstrate that it is suitable level for this stage of the consent. |

Geosolve Response to 20:

Geosolve have undertaken 4 specific deep investigations and multiple test pits across the infrastructure area in various stages. Wider data and surface mapping has also been

utilised to determine the geological model, see Figures 1 and 2, Appendix A, which shows the nearby investigation locations, mapped exposures and interpretation. Based on this data adequate characterisation of the ground conditions is considered to have been presented, as discussed above. Geosolve consider the assessment to be equivalent to a Level C detailed area wide assessment with respect to the eastern area of Lot 12 and the proposed infrastructure locations.

QLDC RFI:

| | |
|---|---|
| 21. | The liquefaction analysis undertaken for CPT 4 was for both IL3 and IL4 – QLDC requires reservoirs and WTP to be designed for IL4, so the results for IL4 have been considered. The liquefaction analysis undertaken from CPT 4 shows settlements for IL4 SLS2 (1 in 500) and ULS (1 in 1000) of 50mm and 60mm respectively. Appendix H does not conclude the classification of the liquefaction risk, but it does refer that "the liquefaction risk to be similar to eastern areas of the wider Homestead Bay site to the south" which stated: medium vulnerability, the initial report states it can be mitigated with robust foundation slabs similar to MBIE TC2 slabs (pg 511 of Eng Report Part 2). This mitigation was provided for residential buildings. |

Geosolve Response to 21:

Based on the liquefaction assessment Geosolve consider the liquefaction vulnerability to be Medium. This is based on the following:

- Liquefaction settlements of 50 mm have been calculated for a 1/500 year event.
- Differential settlements are expected to be Less than 50 mm, but may be 25 mm;
- No lateral spread is expected.
- The calculated liquefaction for a 100 year event is <10 mm, which is considered to be none to minor.
- Larger seismic events (1/2500 yr) result in relatively minor incremental settlement.

QLDC RFI:

| | |
|---|---|
| 22. | Confirmation of the classification of the liquefaction risk for the WTP/WWTP is required along with suitable mitigations for the intended use of the site, being for heavier structures which are also critical facilities in accordance with MBIE (2017). |

Geosolve Response to 22

The site is assessed to have a medium liquefaction vulnerability.

Suitable mitigations for an Importance Level 4 structures include:

- Pile foundations that bear on the Glacial Till at depth.
- Stone columns.
- Geogrid reinforced engineered fill rafts.
- Structural engineered considerations
- A combination of the above measures.

The above mitigations will be considered at detailed design and will be address through the building consent process.

QLDC RFI:

| | |
|---|---|
| 23. | In response to paragraph 172 of the applicant's response:<br><br>(a) CPTs were undertaken by the applicant across the entire site, however, only the CPTs in the upper platform were undertaken for liquefaction analysis, as stated in the Geosolve Liquefaction Assessment provided in the initial application: *"As discussed above only the CPTs in the upper platform where shallow groundwater is present have been analysed which include CPT8, 12-16, 20-24 and 26, which achieved variable depths of between 2.3 and 13.9 m. The deeper CPTs are considered more representative."*<br><br>(b) This is what is written in the QLDC response: "Only the CPTs in the upper platform where shallow groundwater is present were analysed as part of the liquefaction assessment" |

| | |
|---|---|
| 24. | QLDC geotechnical consultant for the TTSC recommended further investigation is undertaken in this area to confirm the liquefaction risk. This differs from the applicant's assessment. Access to the land was not granted to QLDC to undertake physical investigation in this area. The location of CPT 1 is where further investigations were recommended. |

Geosolve Response to 23 and 24:

Development is currently not proposed in the western area of Lot 12, where CPT 1 has been undertaken. The location of CPT 1 is > 1 km from the proposed infrastructure in the eastern area of the site and Geosolve therefore consider the liquefaction risk in the area of CPT 1 is not directly relevant to the current development proposal.

# 7 Conclusion

In conclusion I consider the levels of investigation and assessment undertaken with respect to the liquefaction risk, and the proposed infrastructure in Lot 12, is appropriate for a resource consent, and the ground model is sufficiently well understood. I am confident there is a feasible and practical engineering design that will satisfactorily manage the liquefaction risk. Finalisation of the design can be determined as part of the detailed assessment associated with the building consent process.

# 8 Applicability

This document has been prepared for the use of our client, RCL Homestead Bay Limited, with respect to a particular brief and on the terms and conditions agreed with our client. It may not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

Yours faithfully,

Paul Faulkner
Principal Engineering Geologist
GeoSolve Limited

# Appendix A:

- Figure 1: Site Investigation Summary
- Figure 2: Sketch Geological Cross Section

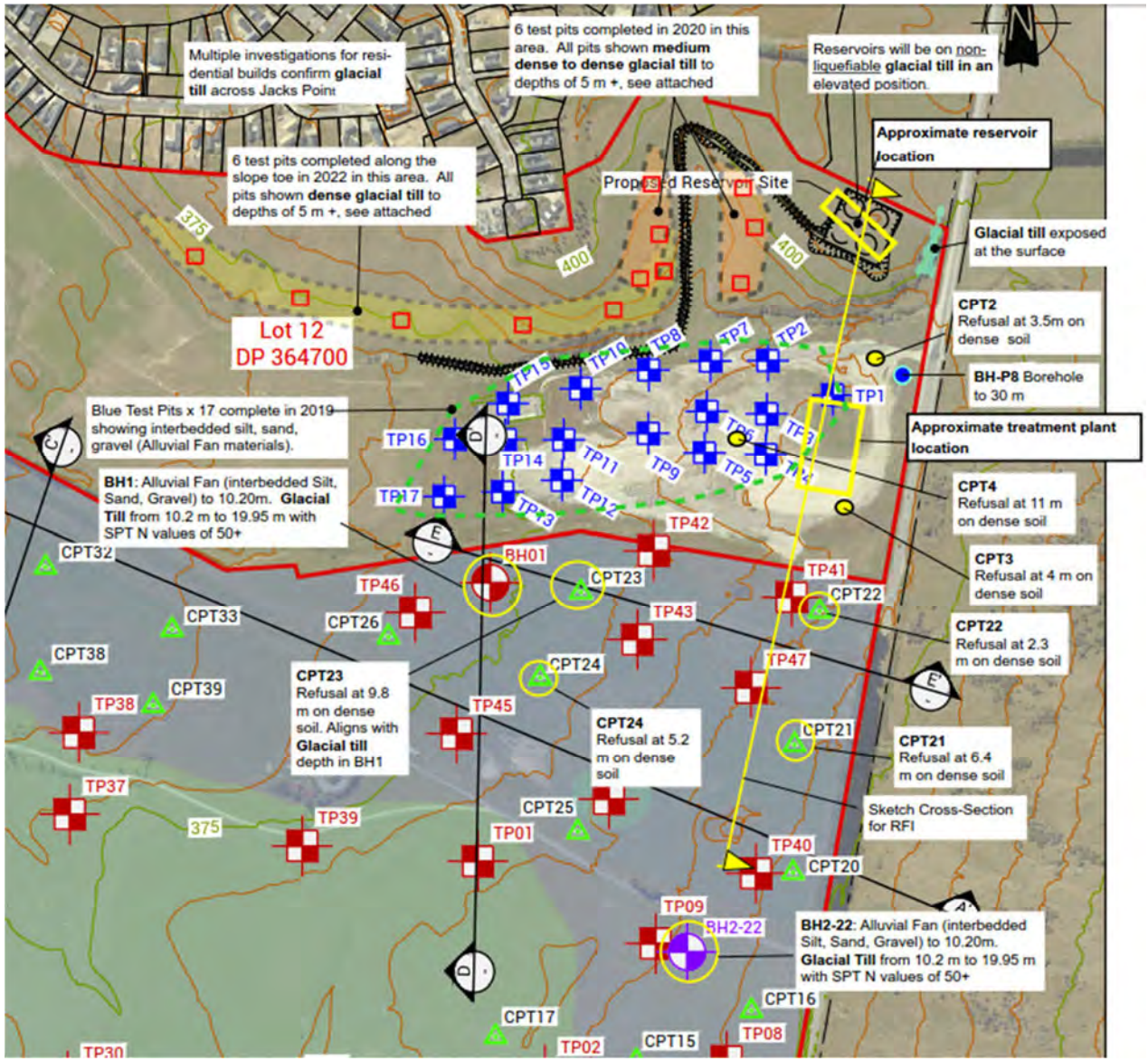
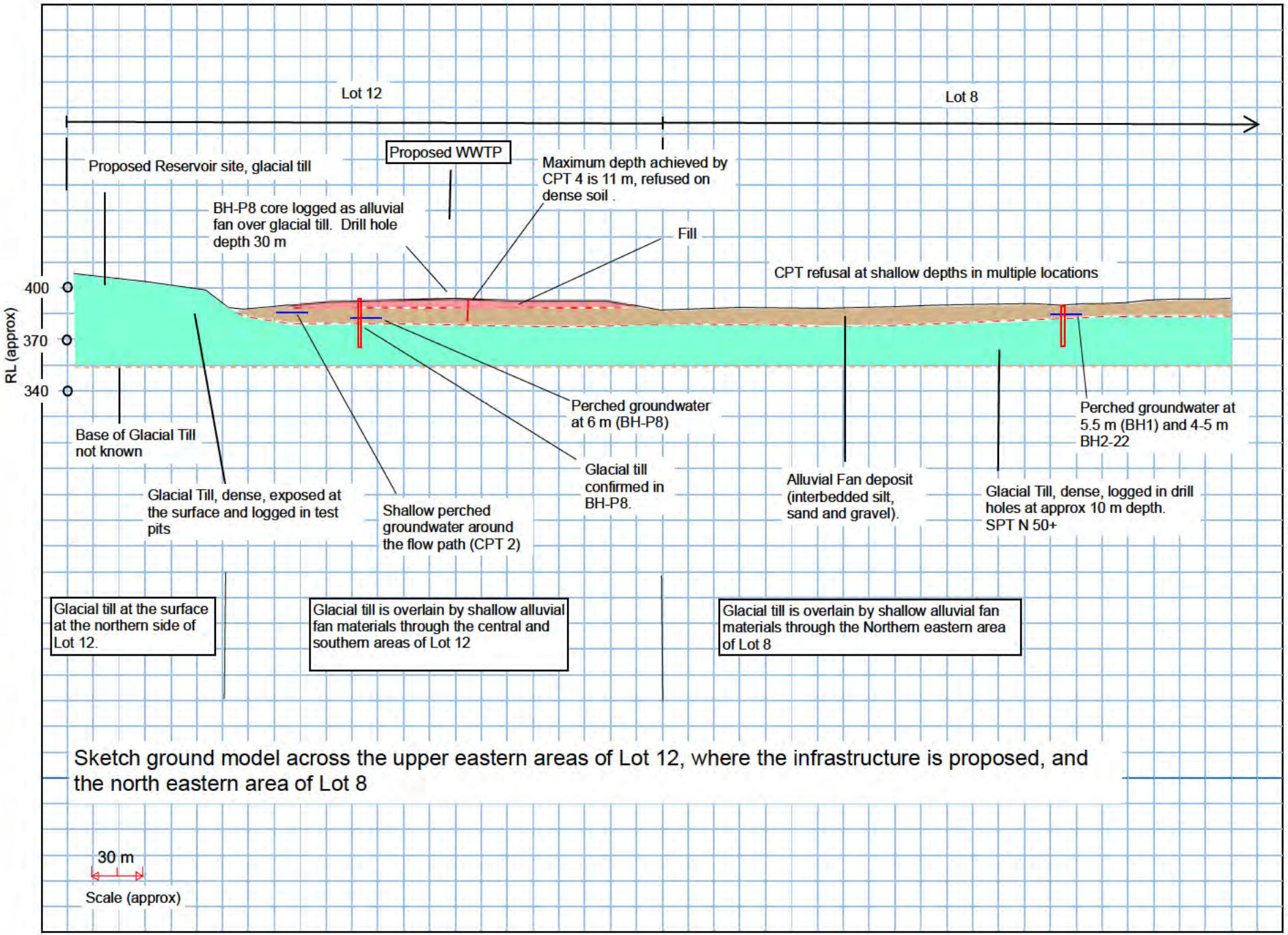



Figure 1. Site investigation Plan for the eastern area of Lot 12, and the north eastern corner of Lot 8.

Geosolve Reference 220556.03. November 2025.

Not to scale




Sketch ground model across the upper eastern areas of Lot 12, where the infrastructure is proposed, and the north eastern area of Lot 8

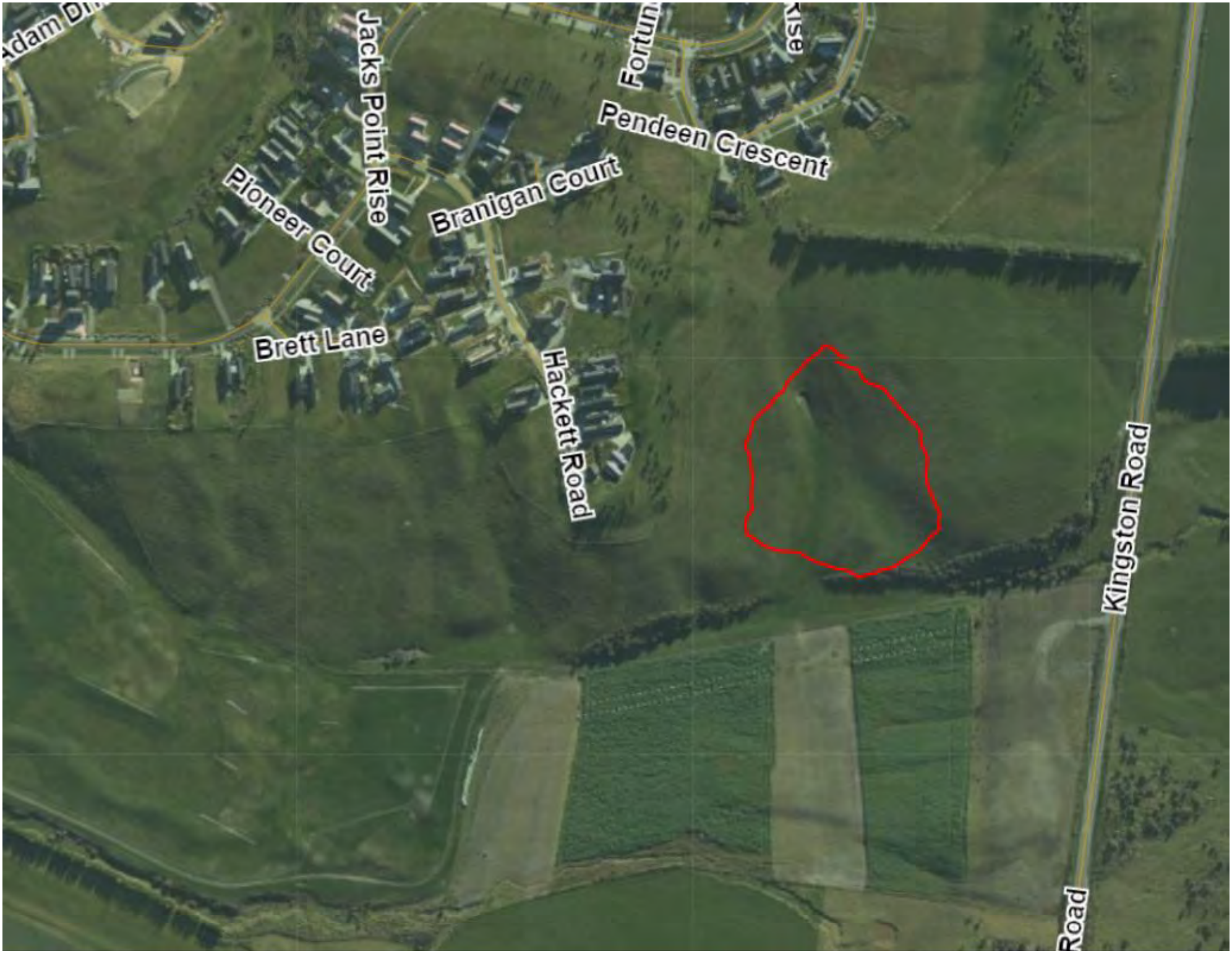
GEOSOLVE
ENGINEERING CONSULTANTS
www.geosolve.co.nz

| | |
|---|---|
| Project | Lot 12 Infrastructure |
| Part | Sketch Geological Section |
| Drawing Ref | Figure 2 |
| Calc by | PF |
| Date | 25/11/25 |
| Check by | |
| Page | 1 / 1 |
| Job Number | 220556.03 |
| Revision | |
| Date | |

# Appendix B:

Proposed Reservoir Location Investigation data

- 2020 Test Pit Plan and test pit logs
- 2022 Test Pit Plan and test pit logs
- Mapped soil exposure.


Jacks Point Rise
Pioneer Court
Branigan Court
Pendeen Crescent
Brett Lane
Hackett Road
Kingston Road

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 1**

| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |
|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL | | Dark brown, organic SILT. Soft. Moist. | | | |
| 0.8 | OUTWASH GRAVEL | | Orangey brown, silty GRAVEL with minor sand. Sand is fine to medium. Gravel is fine to coarse; subrounded. Medium dense. Massive. Moist. | | | |
| 2.5 | GLACIAL TILL | | Light grey, SAND with some gravel and minor silt and cobbles. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | | |
| 4.0 | GLACIAL TILL | | Light grey, gravelly SAND with trace silt and cobbles. Sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

COMMENT: Test pit dry.

Logged By: JM

Checked Date:

Sheet: 1 of 1


TEST PIT 1

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 2**

| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |
|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL | | Dark brown, organic SILT. Soft. Moist. | | | |
| 1.1 | OUTWASH GRAVEL | | Greyish brown, gravelly SILT with minor sand. Sand is fine. Gravel is fine to coarse; subrounded to rounded. Firm to stiff. Massive. Moist. | | | |
| 2.1 | GLACIAL TILL | | Light grey, SAND with some gravel and minor silt and cobbles. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | | |
| 4.0 | GLACIAL TILL | | Light grey, gravelly SAND with trace silt and cobbles. Sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

COMMENT: Test pit dry.

Logged By: JM

Checked Date:


TEST PIT 2

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 3**

| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |
|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL | | Dark brown, organic SILT. Soft. Moist. | | | |
| 1.3 | GLACIAL TILL | | Light grey, gravelly SAND with trace silt and cobbles. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | | |
| 4.0 | GLACIAL TILL | | Light grey, SAND with minor gravel and trace silt and cobbles. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

COMMENT: Test pit dry.

Logged By: JM

Checked Date:


TEST PIT 3

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 4**

| | | | |
|---|---|---|---|
| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |

| | | | | | | |
|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL | | Dark brown, organic SILT. Soft. Moist. | | | |
| 4.0 | GLACIAL TILL | | Light grey, gravelly SAND with trace silt and cobbles. Occasional 50 mm thick lenses of fine sand. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

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|---|---|
| COMMENT: Test pit dry. | Logged By: JM |
| | Checked Date: |
| | Sheet: 1 of 1 |


TEST PIT 4

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 5**

| | | | |
|---|---|---|---|
| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL |  | Dark brown, organic SILT. Soft. Moist. | | | |
| 0.5 | OUTWASH GRAVEL |  | Orangey brown, silty GRAVEL with some sand. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | | |
| 4.0 | GLACIAL TILL |  | Light grey, sandy GRAVEL with trace silt and cobbles and boulders. Occasional 50 mm thick lenses of fine sand. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Boulders up to 400 mm. Dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

| | |
|---|---|
| COMMENT: Test pit dry. | Logged By: JM |
| | Checked Date: |
| | Sheet: 1 of 1 |


TEST PIT 5

GEOSOLVE

# EXCAVATION LOG

EXCAVATION NUMBER: **TP 6**

| PROJECT: | Hanley's Farm Lot 12 DP 364700 | JOB NUMBER: | |
|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EASTING: | | mE | EQUIPMENT: | 20T Excavator | OPERATOR: | Stephen |
| NORTHING: | | mN | INFOMAP NO. | | COMPANY: | Base Contracting |
| ELEVATION: | | m | DIMENSIONS: | | HOLE STARTED: | 23-Oct-20 |
| METHOD: | | | EXCAV. DATUM: | | HOLE FINISHED: | 23-Oct-20 |

| DEPTH (m) | SOIL / ROCK TYPE | GRAPHIC LOG | DESCRIPTION | USCS GROUP | GROUNDWATER / SEEPAGE | SCALA PENETROMETER |
|---|---|---|---|---|---|---|
| 0.2 | TOPSOIL | | Dark brown, organic SILT. Soft. Moist. | | | |
| 0.5 | OUTWASH GRAVEL | | Orangey brown, silty GRAVEL with some sand. Sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. Medium dense. Massive. Moist. | | | |
| 4.0 | GLACIAL TILL | | Grey, sandy GRAVEL with trace silt and cobbles. Sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. Dense. Massive. Moist. | | NO SEEPAGE | |

Total Depth = 4 m

COMMENT: Test pit dry.

Logged By: JM

Checked Date:

Sheet: 1 of 1


TEST PIT 6

GeoSolve Ref: 190214
25 March 2022

RCL Queenstown PTY Ltd
[redacted]

Attention: Dan Wells

# Geotechnical Investigation and Reporting
# Lot 12 DP 364700, Hanleys Farm Borrow Area

Dear Dan,

## 1 Introduction

This geotechnical assessment for the proposed earthworks located at Lot 12 DP 364700 has been completed as ongoing work and a variation for RCL Queenstown PTY Ltd, GeoSolve reference 190214, dated 5 June 2019.

It is understood that earthworks are proposed to extract granular material for the purpose of constructing approved stages of the Hanley's Farm residential subdivision development.

## 2 Site Description

The site is located immediately south of the Jacks Point subdivision and is accessed from the east via State Highway (SH6) and Maori Jack Road to the west. The proposed borrow area is located in the north-eastern portion of the site on the grassed slopes below Jacks Point. The south facing slope is approximately 20 m high and slopes at angles between 10 and 20 degrees. The area of assessment is shown on the attached site plan.

## 3 Subsurface Conditions

An engineering geological site appraisal has been undertaken with confirmatory subsurface investigations. GeoSolve Ltd visited the subject property on 18 March 2022, undertaking geotechnical investigations comprising six test pits which were advanced to a maximum depth of 5.3 m.

The test pit investigation revealed the ground conditions consist of surficial topsoil and localised colluvium soils overlying dense, SAND with some gravel (glacial till) to at least the base of the 4.7 to 5.3 m deep test pits. The thickness of the glacial till is unknown and is expected to be underlain by schist bedrock.

The regional groundwater table was not encountered in the test pits and is expected to lie below the proposed excavation levels. No groundwater seepages were observed in the test pits.

Full detailed test pit logs and their locations are attached.

# 4 Proposed Earthworks

**General**

Proposed earthworks plans have been provided by Patterson Pitts Group and have been reviewed as part of this assessment. Cut volumes to extract site won fill material are 84,948 $m^3$ with a maximum cut depth of 8.3 m, however, most of the excavation area will have cut depths between 4 and 6 m. The earthworks will remove material from the toe of the south facing slope and form cut batters at 2H:1V (26°).

The excavation will be backfilled with cut to waste material sourced from future stages (DP2, 7, 10 and 11) of the Hanley's Farm subdivision. The total replacement fill volume is 75,748 $m^3$ and is proposed to be placed at a maximum batter angle of 5H:1V (11°) . The cut to waste material will be primarily silt and sand in composition .

# 5 Conclusions

In summary, review of the ground conditions and earthworks plans indicate that:

- Short term construction stability will be acceptable in glacial till constructed at temporary batters of 2H:1V, and there is no identified risk to the surrounding areas.
- Long-term stability will be achieved under both static and seismic conditions for the re-instated 5H:1V batters.

It is recommended that earthwork methodologies and procedures are supervised by a suitably qualified Geotechnical Engineer or Engineering Geologist to confirm ground conditions are consistent with the test pit investigation findings, temporary stability of cuts and quality control of replacement fill compaction.

A geotechnical practitioner should also be contacted to inspect any seepage, spring flow or under-runners if encountered during cut earthworks.

# 6 Applicability

This report has been prepared for the benefit of RCL Queenstown PTY Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Report prepared by:

[redacted]

.....

Josh Moir

Engineering Geologist

Reviewed for GeoSolve Ltd by:

[redacted]

.....

Paul Faulkner

Senior Engineering Geologist

**Attachments** – Site Plan and Test Pit Logs

# GeoSolve Test Pit Location Plan

0m 20m 40m 60m

SCALE BAR 1:1000

SITE 01
- AREA = 32,760m²
- ASSUMED TOPSOIL DEPTH 0.2m
- STRIPPED TOP SOIL VOLUME = 6,552m³
- TOTAL CUT VOLUME 91,500m³
- CUT VOLUME MINUS TOPSOIL = 84,948m³

REPLACEMENT FILL
- AREA = 32,760m²
- ASSUMED TOPSOIL DEPTH 0.2m
- REPLACED TOP SOIL VOLUME = 6,552m³
- TOTAL CUT VOLUME 82,300m³
- FILL VOLUME MINUS TOPSOIL = 75,748m³

ALL FILL TO BE PLACED AT MAX 1:5 GRADE UNLESS STATED OTHERWISE.

Depth ranges

| Lower_value | | Upper_value | | Colour |
|---|---|---|---|---|
| -11.5 | to | -10.5 | m | |
| -10.5 | to | -9.5 | m | |
| -9.5 | to | -8.5 | m | |
| -8.5 | to | -7.5 | m | |
| -7.5 | to | -6.5 | m | |
| -6.5 | to | -5.5 | m | |
| -5.5 | to | -4.5 | m | |
| -4.5 | to | -3.5 | m | |
| -3.5 | to | -2.5 | m | |
| -2.5 | to | -1.5 | m | |
| -1.5 | to | -0.5 | m | |
| -0.5 | to | 0.5 | m | |
| 0.5 | to | 1.5 | m | |
| 1.5 | to | 2.5 | m | |
| 2.5 | to | 3.5 | m | |
| 3.5 | to | 4.5 | m | |
| 4.5 | to | 5.5 | m | |
| 5.5 | to | 6.5 | m | |
| 6.5 | to | 7.5 | m | |
| 7.5 | to | 8.5 | m | |
| 8.5 | to | 9.5 | m | |
| 9.5 | to | 10.5 | m | |
| 10.5 | to | 11.5 | m | |

TP1 TP2 TP3 TP4 TP5 TP6

CUT BATTER 1:2

CUT BATTER 1:2

MAX CUT = 8.3m

-2.75 -3.70 -3.99 -5.78 -4.12 -4.53 -2.20 -5.94 -6.21 -4.38 -4.16

PROFILE 01 PROFILE 02 PROFILE 03 PROFILE 04 PROFILE 05

A-0 B-0 C-0 D-0 E-0

BATTER 1:4

MAX FILL = 2.9m

+1.94 +2.23 +2.68 +2.67 +2.01 +2.04 +1.58 +1.62 +1.79 +1.89 +1.38 +1.70 +1.43 +1.19 +0.88 +0.50 +1.06 +1.10 +1.02 +0.89 +0.79 +0.13 +1.07

SITE 02
- AREA = 44,000m²
- TOTAL FILL VOLUME 54,000m³

BATTER 1:4


PATERSONPITTSGROUP
Surveying • Planning • Engineering
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz


Client/Location:

RCL Henley Downs Ltd
Kingston Road
Lot 12 DP 364700

Purpose/Drawing Title:

Possible earthwork areas
Depth range, ground level vs excavation levels, showing final contours



| | | | |
|---|---|---|---|
| Surveyed by: | | Original Size: | Scale: |
| Designed by: | | A3 | 1:1000 |
| Drawn by: | AH, SR | | DO NOT SCALE |
| Checked by: | MA | | |
| Approved by: | | | |
| Job Ref: Q6205 - 05 | | Sheet No: 03 | Revision No: G |
| | | | Date Created: 08/03/2022 |

PLOT DATE: 09 March, 2022 - 10:50 AM BY: Ma

C:\12DS\DATA\QTSVR01\Q6205 - LOT 12_483\5 - DRAWINGS\1 - DWG\PPQ6205-05-1G-7G LOT 12 DP 364700 EXCAVATIONS.DWG

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 1**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

| Soil / Rock Type | Description | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|
| TOPSOIL | 0m Organic SILT with minor gravel; dark brown. Firm; dry; gravel is fine to coarse. | | 0.0 | | |
| GLACIAL TILL | 0.2m SAND with some gravel and trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. | | 0.1 … 4.7 | NO SEEPAGE | |
| | 4.7m | | | | |

Total Excavation Depth = 4.7 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 1

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 2**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

| Soil / Rock Type | Description | | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|---|
| TOPSOIL | Organic SILT; dark brown. Firm; dry. | 0m<br>0.2m | | 0.0 | | |
| GLACIAL TILL | SAND with some gravel and trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. | 4.8m | | 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 | NO SEEPAGE | |

Total Excavation Depth = 4.8 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 2

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 3**

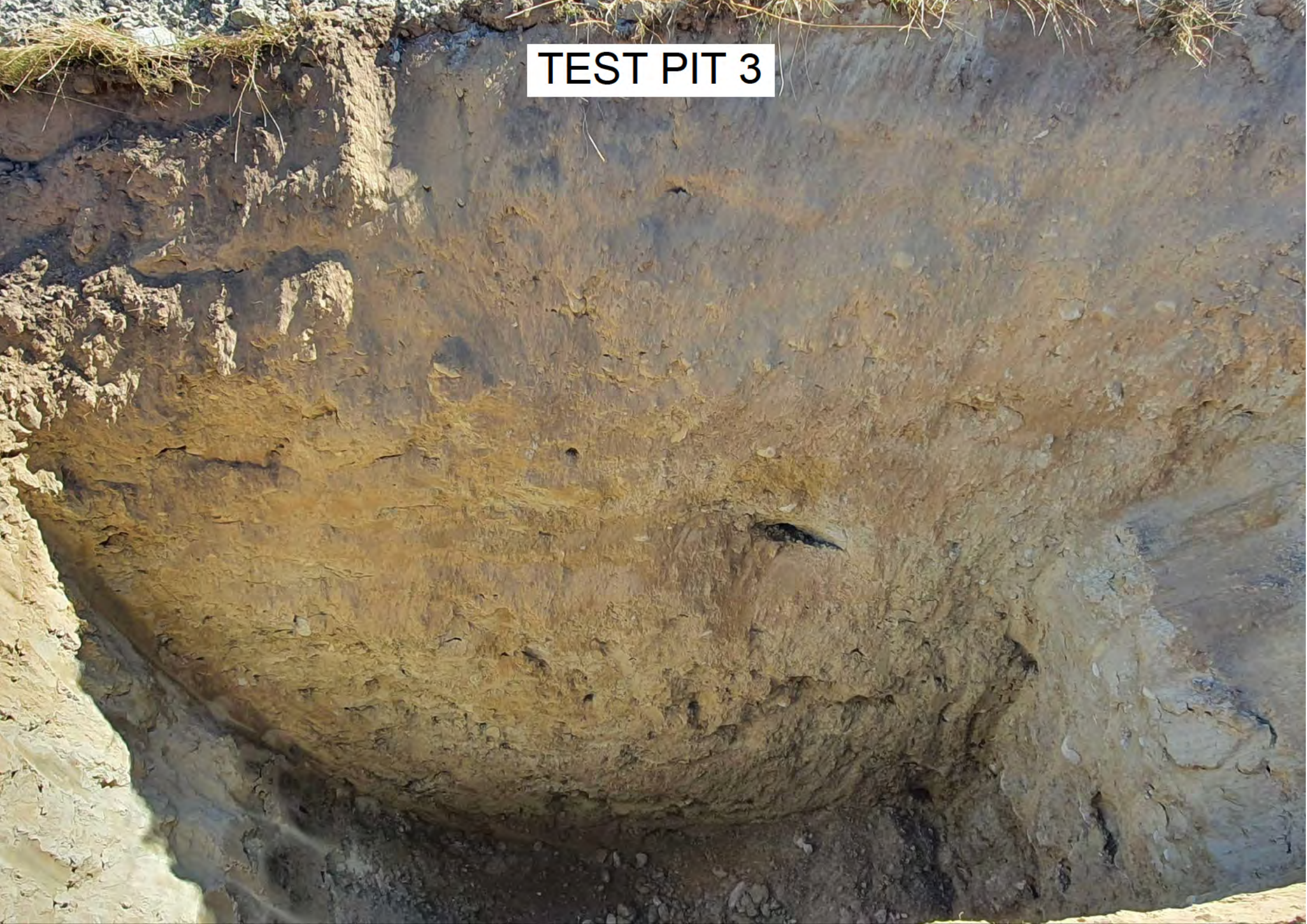
| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

| Soil / Rock Type | Description | | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|---|
| TOPSOIL | Organic SILT; dark brown. Firm; dry. | 0m<br>0.2m | | 0.0 0.1 0.2 | | |
| COLLUVIUM | Gravelly SAND with trace silt; yellow brown, bedded. Medium dense; moist; sand is fine to coarse. Gravel is medium to coarse; subrounded to rounded. | 0.7m | | 0.3 0.4 0.5 0.6 | | |
| GLACIAL TILL | SAND with some gravel and trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. | 4.9m | | 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 | NO SEEPAGE | |

Total Excavation Depth = 4.9 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 3

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 4**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

| Soil / Rock Type | Description | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|
| TOPSOIL | 0m Organic SILT with trace gravel; dark brown. Firm; dry; gravel is fine to coarse. | | 0.0 | | |
| COLLUVIUM | 0.2m Sandy GRAVEL with trace silt; yellow brown, bedded. Medium dense; moist; sand is fine to coarse. Gravel is medium to coarse; subrounded to rounded. | | 0.2 | | |
| GLACIAL TILL | 1.5m SAND with minor gravel and trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to medium. Gravel is fine to coarse; subrounded to rounded. | | 1.5 | NO SEEPAGE | |
| | 4.8m | | 4.8 | | |

Total Excavation Depth = 4.8 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 4

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 5**

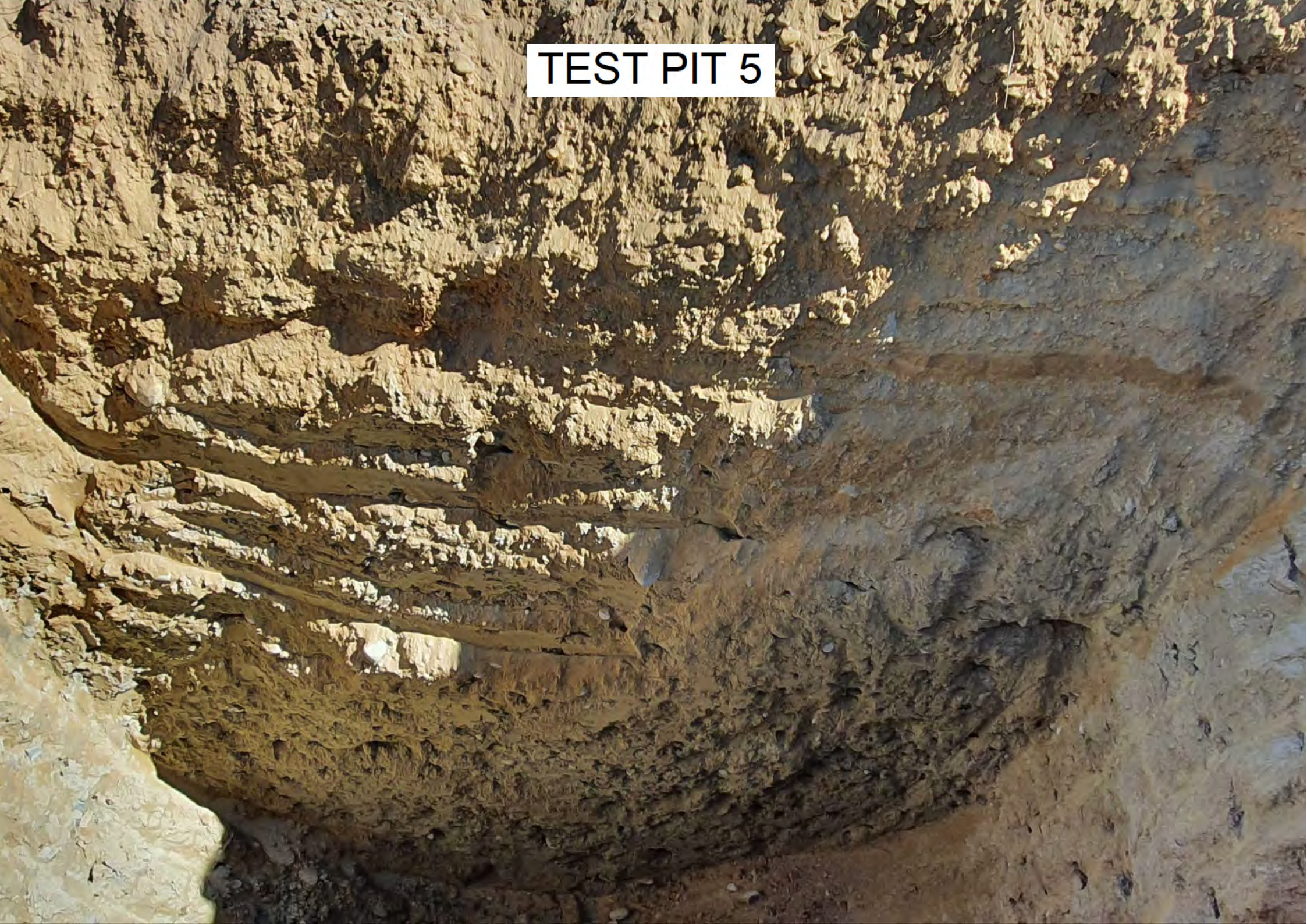
| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

| Soil / Rock Type | Description | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|
| TOPSOIL | 0m Organic SILT with trace gravel; dark brown. Firm; dry; gravel is fine to coarse. | | 0.0 | | |
| COLLUVIUM | 0.2m Sandy GRAVEL with minor silt; yellow brown, bedded. Loose; moist; sand is medium to coarse. Gravel is fine to coarse; subrounded to rounded. | | 0.2 – 1.2 | | |
| GLACIAL TILL | 1.2m SAND with some gravel and trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. | | 1.2 – 5.2 | NO SEEPAGE | |
| | 5.2m | | | | |

Total Excavation Depth = 5.2 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 5

GEOSOLVE
ENGINEERING CONSULTANTS

# TEST PIT LOG

EXCAVATION NUMBER: **TP 6**

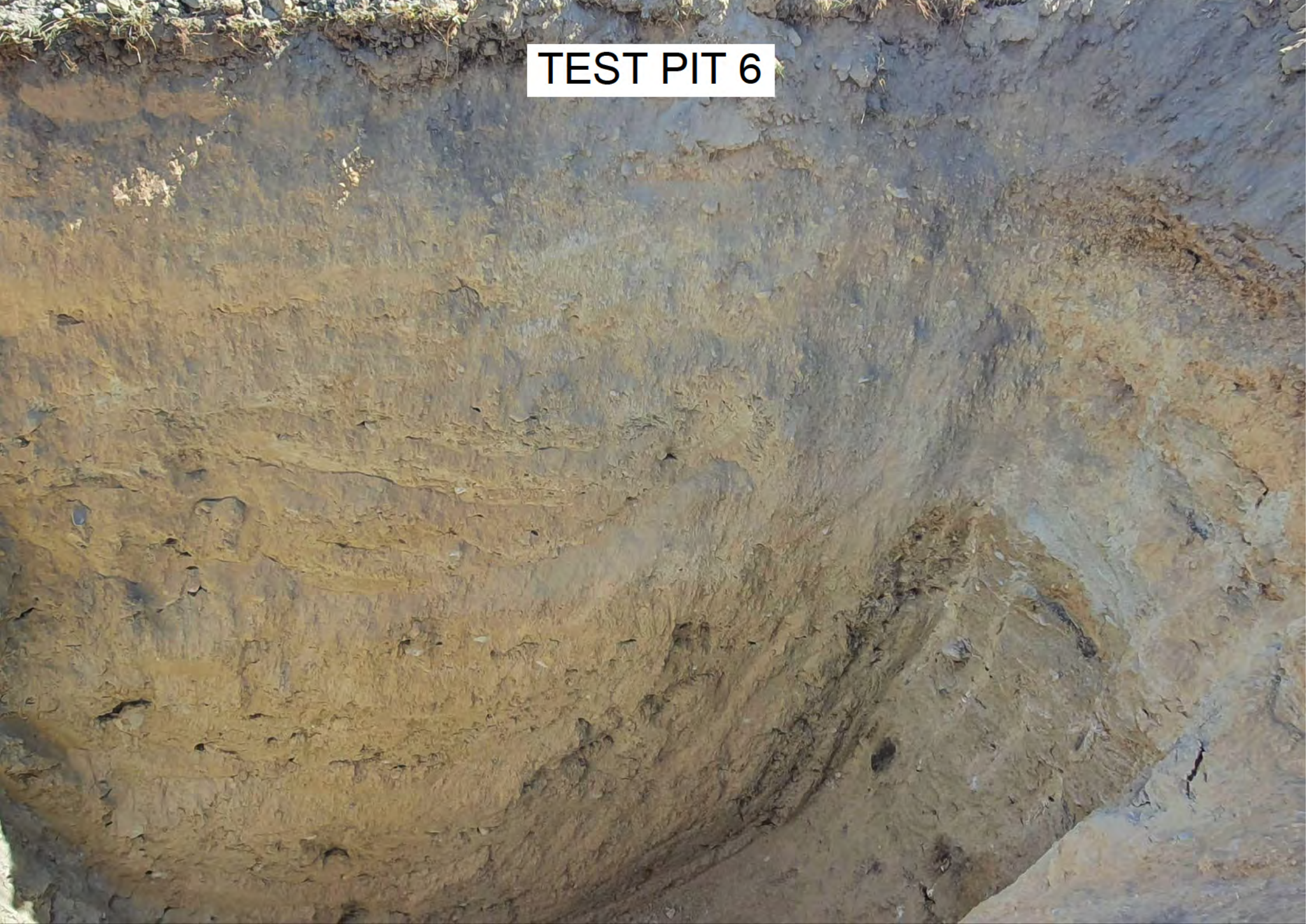
| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Lot 12 Borrow Site | | | JOB NUMBER: | 190214 |
| LOCATION: | See Site Plan | INCLINATION: | Vertical | | |

| | | | | | |
|---|---|---|---|---|---|
| EASTING: | | EQUIPMENT: | 20T Excavator | OPERATOR: | Kane |
| NORTHING: | | COORD. SYSTEM: | | COMPANY: | Base Contracting |
| ELEVATION: | | EXCAV. DATUM: | | HOLE STARTED: | 18/03/2022 |
| METHOD: | Aerial Photography | ACCURACY: | | HOLE FINISHED: | 18/03/2022 |

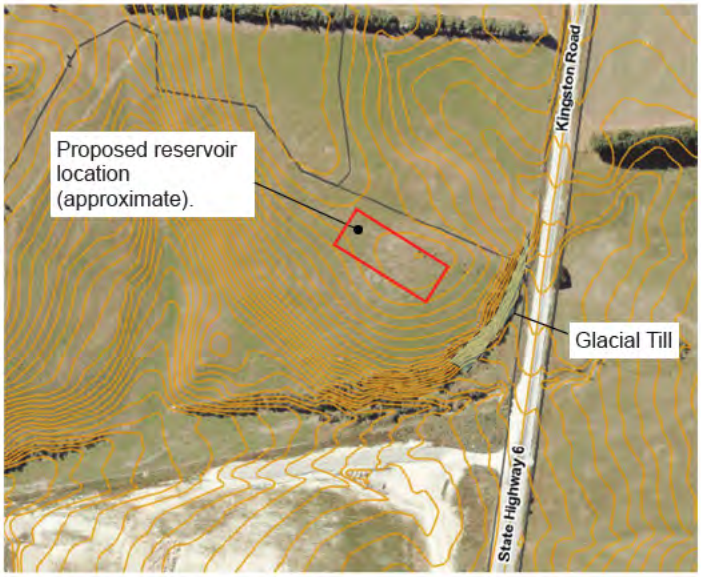
| Soil / Rock Type | Description | | Graphic Log | Depth (m) | Groundwater / Seepage | Scala Penetrometer (Blows per 100mm) 0 5 10 15 |
|---|---|---|---|---|---|---|
| TOPSOIL | Organic SILT with trace gravel; dark brown. Firm; dry; gravel is fine to coarse. | 0m | | 0.0 | | |
| | | 0.2m | | 0.1 0.2 | | |
| GLACIAL TILL | SAND with some gravel amd trace silt and cobbles; light grey, massive. Dense; moist; sand is fine to coarse. Gravel is fine to coarse; subrounded to rounded. | | | 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5.0 5.1 5.2 | NO SEEPAGE | |
| | | 5.3m | | 5.3 | | |

Total Excavation Depth = 5.3 m

| | | | |
|---|---|---|---|
| COMMENT: | TP dry. | LOGGED BY: | JM |
| | | CHECKED DATE: | 21/03/2022 |
| | | SHEET: | 1 of 1 |


TEST PIT 6

Glacial Till is exposed along the eastern side of the low hill present in the northern part of Lot 12, and directly to the east of and below the reservoir location, as shown on Figure 1, appendix A, and on the image below.




Photographs 1B and 2B below show close up images of the glacial till.

Photograph 1B: Glacial Till

Photograph 2B: Glacial Till

# Appendix C:

Proposed Reservoir Location Investigation data

- Borehole BH-P8 log and photographs
- Logs for CPT 2, 3 and 4.

GEOSOLVE

DRILLHOLE No: BH P8

# DRILLHOLE LOG

SHEET ..... OF .....

| | | | |
|---|---|---|---|
| PROJECT: Lot 12 Homestead Bay | JOB No: 220556.03 | LOCATION: Queenstown | HOLE LOCATION: eastern area adj. Kingston Rd |
| CO-ORDINATES mN<br>mE | | DRILL TYPE: HD900 Sonic<br>DATUM: | HOLE STARTED: 18/10/25<br>HOLE FINISHED: 20/10/25 |
| DIRECTION: ° | | R.L. GROUND: m | DRILLED BY: Kyle / Matt |
| ANGLE FROM HORIZ.: 90 ° | | R.L. COLLAR: m | LOGGED BY: HN 22/10/25 CHECKED: PF 24/10/25 |

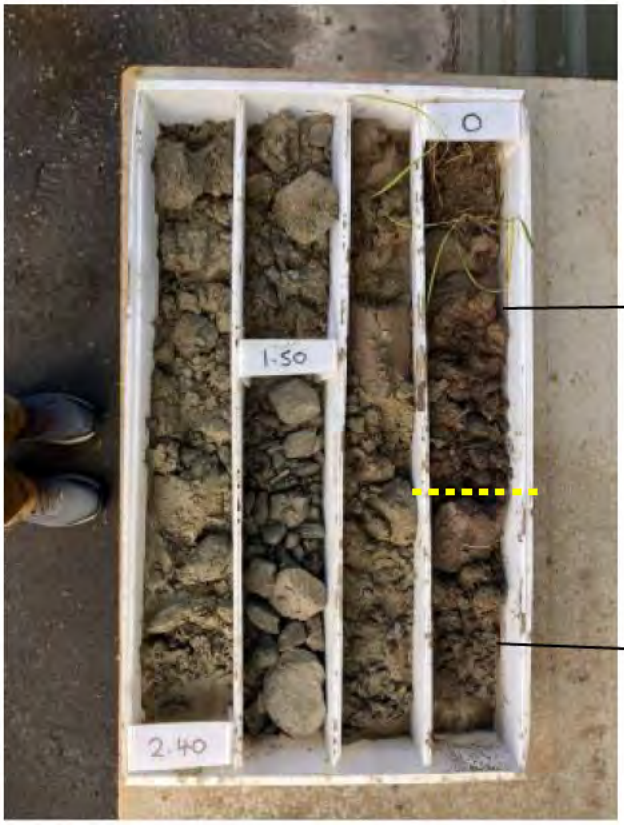
| GEOLOGICAL UNIT | DESCRIPTION OF CORE<br>SOIL: Classification, colour, consistency / density, moisture, plasticity | Sampling Method | Core Recovery (%) | Moisture Condition | Strength/Density Classification | RL (m) Depth (m) | Graphic Log | Drillers Notes | TESTING<br>Hammer Efficiency:<br>Borehole Diameter:<br>Liner: | Water Loss (%) 25 50 75 | Water Level | Casing | Installation | Core Box |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topsoil | **0-0.5 m**<br>Dark brown, organic SILT with trace fine to medium sand, trace fine to coarse angular gravel, trace clay, roots, low plasticity. | | | | | | | | | | | | | |
| Alluvial Fan | **0.5 - 1.0 m**<br>light greyish brown, SILT with trace fine to coarse sand, trace fine to coarse angular gravels, trace clay, low plasticity | | | | | | | | | | | | | |
| | **1.0 to 4.8 m**<br>Light greyish brown, bedded, fine to coarse subangular to subrounded GRAVEL, well graded, with occasional interbeds of silt and fine sand with minor fine to coarse gravel | | | | | | | | | | | | | |
| Alluvial Fan/Glacial Transition | **4.8 to 9.4 m**<br>Light brownish grey fine to coarse SAND with some fine to coarse subangular to rounded gravel, well graded | | | | | | | | | | 6 m | | | |
| Glacial Till | **9.4 to 21.3 m**<br>Light greyish brown to orange brown, homogenous fine sandy SILT with minor fine to coarse subangular gravel and trace cobbles.<br>Consistency of the silt is generally assessed to be stiff to very stiff<br>16 to 16.3 m boulder<br>18 to 18.4 m boulder | | | | | | | | | | | | | |
| | **21.3 to 30 m**<br>Light grey, bedded, fine to coarse subangular to subrounded GRAVEL with trace cobbles, well graded, with occasional bands of silt and fine to coarse sand with some gravel | | | | | | | | | | | | | |
| | End of Hole 30 m | | | | | | | | | | | | | |

COMMENTS:

Survey Method: GPS

Log Scale 1:50

Borehole BH-P8 Photographs




Topsoil

Alluvial Fan

0 to 2.4 m


Alluvial fan

From 4.8 m top of transitional deposits of alluvial fan, glacial outwash and glacial till.

2.4 to 5.1 m


Glacial till like deposit
See Photograph 3B
for detail

5.1 to 8.2 m

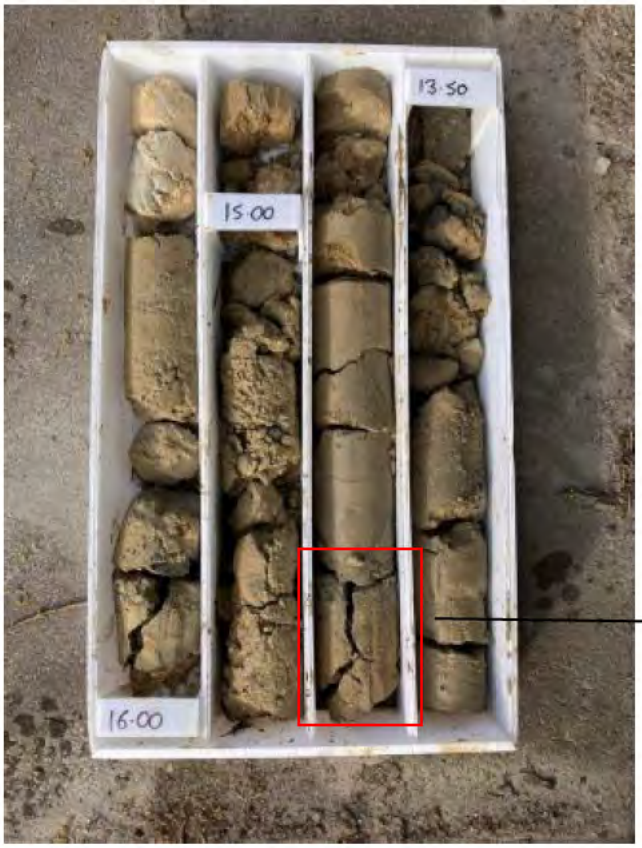

Clear change to stiff to very stiff grey brown silt at 9.4 m. Glacial till.

Glacial Till, see Photograph 4B below for detail.

8.2 to 11.1 m

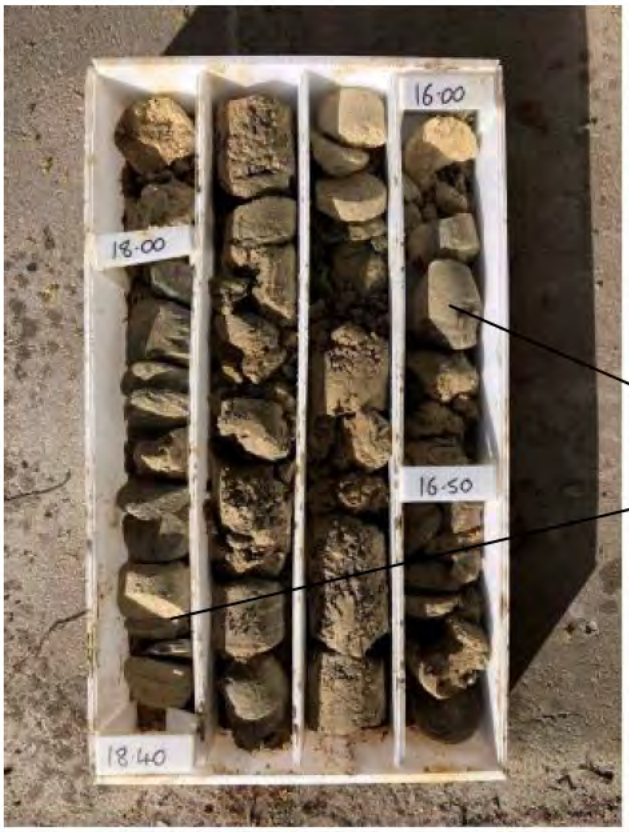

Glacial till

11.1 to 13.5 m




Glacial Till, see photograph 5B below for detail

13.5 to 16 m




Glacial till

Boulders

16 to 18.4 m


Glacial till

18.4 to 21 m


Glacial till of silt composition transitions to well graded granular deposit with silt bands

21 to 27 m

Silt bands

27 to 30 m

Key Photographs BH P8

Photograph 3B - Drill core at 6.0 m depth, Glacial Till like, suggesting transitional depositional process of alluvial fan, glacial outwash and re-working glacial till and reworked deposits.


Photograph 4B - Drill core at 10.8 m depth, Glacial Till


Photograph 5B: Drill core at approximately 14 m depth, Glacial Till.

# Measured CPT Log

**Client:** Geosolve Ltd
**Project:** Jacks Point
**Remarks:** Field water measurement: Measured after testing, depth: 1.25 m

**Depth (m):** 3.48
**Termination:** High cone end resistance

**Standard:** ISO 22476-1:2012 CETANZ TG6
**Date:** 7/10/2025
**Cone Ref:** 000865

**Test Name:** CPT-02
**Job Number:** 250859

Depth has been corrected for inclination

Depth (m)

$q_c$ (MPa)

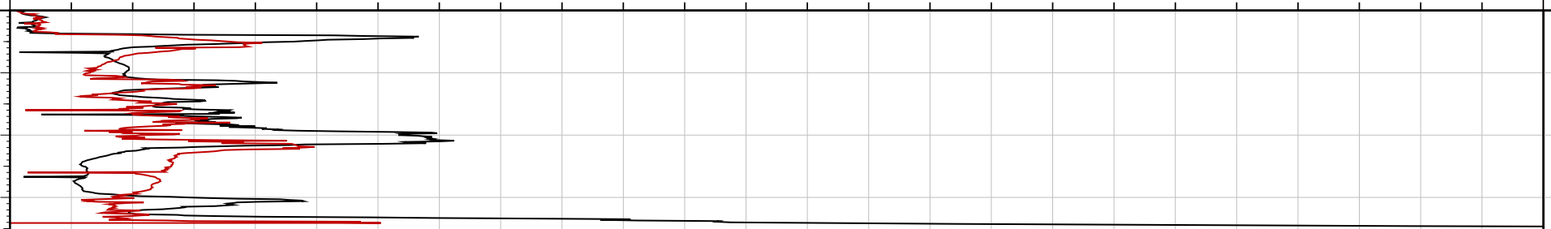
$f_s$ (MPa)

Dissipations - - - - -

$u_2$ (MPa)

Temp (°C)

Incl. (°)



GROUND INVESTIGATION

# Calculated CPT Log

**Date:** 7/10/2025

**Project:** Jacks Point

| | | | | | |
|---|---|---|---|---|---|
| 1 Sensitive fine-grained | 4 Silt mixtures: clayey silt & silty clay | 7 Dense sand to gravelly sand |
| 2 Clay - organic soil | 5 Sand mixtures: silty sand to sandy silt | 8 Stiff sand to clayey sand |
| 3 Clays: clay to silty clay | 6 Sands: clean sands to silty sands | 9 Stiff fine-grained |

**Test Name:** CPT-02

**Job Number:** 250859

Depth has been corrected for inclination

Depth (m)

$q_t$ (MPa) 5 10 15 20 25 30 35 40 45 — $f_s$ (MPa) 0.25 0.50 0.75 1.00

$u_0$ - - - $u_2$ (MPa) 0.0 0.5 1.0 1.5 2.0

Water level 1.25 m
Measured

$R_f$(%) 2 4 6 8

SBT $I_c$ 2 4 6 8

SBTn $I_{cn}$ 2 4 6 8

$Q_{tn}$ 100 200 300 400

$B_q$ 0 0.4 0.8

γ (kg/m³) 16 18 20 22

$D_r$(%) 10 20 30 — 70 80 90

$S_u$ (kPa) 50 100 150 — 350 400 450

$N_{kt}$ 15

Φ' 30 35 40 45

$V_s$ (m/s) 100 200 300 400

$G_0$ (MPa) 100 200 300 400

M (MPa) 100 200 300 400

E (MPa) 100 200 300 400

N60 10 20 30 40

Depth has been corrected for inclination

# CPT Details

## General Information

| | | | |
|---|---|---|---|
| **Project:** | Jacks Point | **Location:** | Jacks Point 9371, New Zealand |
| **Contractor:** | Ground Investigation | | |
| **WGS84 (deg):** | -45.082791, 168.756964 | **Rig details:** | Pagani 02 |
| **Elevation (m):** | Unknown | **Location method:** | Handheld GPS |
| **Date:** | 7/10/2025 11:00:32 AM | **Elevation datum:** | |

## Test Setup

| | |
|---|---|
| **Standard:** | ISO 22476-1:2012 |
| **Test type:** | |
| **Pre-Drill (m):** | 0.00 |
| **Start length (m):** | 0 |
| **Cone ID:** | 000865 |
| **Cone type:** | 10cm2 Compression |
| **Cone class:** | |
| **Manufacturer:** | |
| **Calibration date:** | |
| **Cone area ratio:** | 0.79 |
| **Sleeve area ratio:** | 0 |
| **Sleeve offset:** | 0.07 |
| **Filter type:** | U2 Grease Slot |
| **Saturation method:** | Silicone grease |
| **Rig setup variation:** | |

## Test Result

| | |
|---|---|
| **Termination reason:** | High cone end resistance |
| **Termination depth:** | 3.48 |
| **Ground water level:** | 1.25 |
| **Water level origin:** | Measured |
| **Backfill:** | Bentonite |
| **Observations and materials encountered:** | |
| **Deviations and interuptions:** | Deviations:<br>Interuptions: |
| **Corrections applied:** | |
| **Test catagory:** | |
| **Operator name:** | Brendon Lemm |
| **Manager name:** | |

# CPT Formulas

**Test Name:** CPT-02

**Job Number:** 250859

**Corrected cone resistance:**

$$q_t = q_c + u_2 \bullet (1 - a)$$

**Friction ratio:**

$$R_f = \frac{f_s}{q_c} \bullet 100$$

**Non-normalised soil behaviour type (SBT):**

Calculated using $q_{net}$ and $R_f$ for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Soil behaviour type index, (used for non-normalised SBT) :**

$$I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$$

**Friction ratio:**

$$F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$$

**Refined normalised cone resistance:**

$$Q_{tn} = \frac{(q_t - \sigma_{v0}) \,/\, \sigma_{atm}}{\left(\sigma'_{v0} \,/\, \sigma_{atm}\right)^n} \quad \text{where} \quad n = 0.381 \bullet I_c + 0.05 \bullet \left(\sigma'_{v0} \,/\, \sigma_{atm}\right) - 0.05 \leq 1.0$$

**Normalised soil behaviour type index:**

$$I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$$

**Normalised pore pressure:**

$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

**Normalised soil behaviour type (SBTn):**

Calculated using $Q_{tn}$ and $F_r$ for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Undrained shear strength ($s_u$):**

$$s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$$

**Relative density ($D_r$):**

$$D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$$

**Friction angle (Φ'):**

$$\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$$

**Small strain shear modulus ($G_0$):**

$$G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated shear wave velocity ($V_s$):**

$$V_S = \sqrt{\frac{G_0}{\rho}} \quad \text{where} \quad \rho = \frac{\gamma}{\gamma_w}$$

**Constrained modulus (M):**

$$M = \alpha_M (q_t - \sigma_{v0})$$

when $I_c > 2.2$

$\alpha_M = Q_t$ when $Q_t < 14$

$\alpha_M = 14$ when $Q_t > 14$

when $I_c < 2.2$

$$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$$

**Youngs modulus ($E_s$):**

$$E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated SPT $N_{60}$:**

$$N_{60} = \frac{q_t \,/\, p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$$

## Zero Readings

| kPa | Initial zeros | Final zeros | Final difference | Clean zeros | Clean difference |
|---|---|---|---|---|---|
| Cone resistance | 21,608.10 | 21,591.80 | -16.32 | - | - |
| Sleeve friction | 255.10 | 254.60 | -0.45 | - | - |
| Pore pressure | 2,991.30 | 2,978.70 | -12.67 | - | - |

# Measured CPT Log

**Client:** Geosolve Ltd
**Project:** Jacks Point
**Remarks:** Field water measurement: Unknown, depth: 4.05 m

**Depth (m):** 4.05
**Termination:** High cone end resistance

**Standard:** ISO 22476-1:2012 CETANZ TG6
**Date:** 7/10/2025
**Cone Ref:** 000865

**Test Name:** CPT-03
**Job Number:** 250859

Depth has been corrected for inclination

Depth (m)

$q_c$ (MPa) 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46

$f_s$ (MPa) 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00 1.05 1.10 1.15

Dissipations - - - - -

$u_2$ (MPa) 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

Temp (°C) 15 30

Incl. (°) 0 10

Depth has been corrected for inclination

GROUND INVESTIGATION

# Calculated CPT Log

**Date:** 7/10/2025

**Project:** Jacks Point

| | | | | | |
|---|---|---|---|---|---|
| 1 Sensitive fine-grained | 4 Silt mixtures: clayey silt & silty clay | 7 Dense sand to gravelly sand |
| 2 Clay - organic soil | 5 Sand mixtures: silty sand to sandy silt | 8 Stiff sand to clayey sand |
| 3 Clays: clay to silty clay | 6 Sands: clean sands to silty sands | 9 Stiff fine-grained |

**Test Name:** CPT-03

**Job Number:** 250859

Depth has been corrected for inclination

Depth (m)

$q_t$ (MPa) / $f_s$ (MPa)

$u_0$ - - - $u_2$ (MPa)

$R_f$(%)

SBT $I_c$

SBTn $I_{cn}$

$Q_{tn}$

$B_q$

$\gamma$ (kg/m$^3$)

$D_r$(%) $S_u$ (kPa) $N_{kt}$ 15

$\Phi'$

$V_s$ (m/s)

$G_0$ (MPa)

M (MPa)

E (MPa)

N60

# CPT Details

## General Information

| | | | |
|---|---|---|---|
| **Project:** | Jacks Point | **Location:** | Jacks Point 9371, New Zealand |
| **Contractor:** | Ground Investigation | | |
| **WGS84 (deg):** | -45.083784, 168.756655 | **Rig details:** | Pagani 02 |
| **Elevation (m):** | Unknown | **Location method:** | Handheld GPS |
| **Date:** | 7/10/2025 11:47:58 AM | **Elevation datum:** | |

## Test Setup

| | |
|---|---|
| **Standard:** | ISO 22476-1:2012 |
| **Test type:** | |
| **Pre-Drill (m):** | 0.00 |
| **Start length (m):** | 0 |
| **Cone ID:** | 000865 |
| **Cone type:** | 10cm2 Compression |
| **Cone class:** | |
| **Manufacturer:** | |
| **Calibration date:** | |
| **Cone area ratio:** | 0.79 |
| **Sleeve area ratio:** | 0 |
| **Sleeve offset:** | 0.07 |
| **Filter type:** | U2 Grease Slot |
| **Saturation method:** | Silicone grease |
| **Rig setup variation:** | |

## Test Result

| | |
|---|---|
| **Termination reason:** | High cone end resistance |
| **Termination depth:** | 4.05 |
| **Ground water level:** | |
| **Water level origin:** | Unknown |
| **Backfill:** | Bentonite |
| **Observations and materials encountered:** | |
| **Deviations and interuptions:** | Deviations:<br>Interuptions: |
| **Corrections applied:** | |
| **Test catagory:** | |
| **Operator name:** | Brendon Lemm |
| **Manager name:** | |

# CPT Formulas

**Test Name:** CPT-03

**Job Number:** 250859

**Corrected cone resistance:**

$$q_t = q_c + u_2 \bullet (1 - a)$$

**Friction ratio:**

$$R_f = \frac{f_s}{q_c} \bullet 100$$

**Non-normalised soil behaviour type (SBT):** Calculated using $q_{net}$ and $R_f$ for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Soil behaviour type index, (used for non-normalised SBT) :**

$$I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$$

**Friction ratio:**

$$F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$$

**Refined normalised cone resistance:**

$$Q_{tn} = \frac{(q_t - \sigma_{v0}) \,/\, \sigma_{atm}}{\left(\sigma'_{v0} \,/\, \sigma_{atm}\right)^n} \quad \text{where} \quad n = 0.381 \bullet I_c + 0.05 \bullet \left(\sigma'_{v0} \,/\, \sigma_{atm}\right) - 0.05 \leq 1.0$$

**Normalised soil behaviour type index:**

$$I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$$

**Normalised pore pressure:**

$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

**Normalised soil behaviour type (SBTn):** Calculated using $Q_{tn}$ and $F_r$ for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Undrained shear strength ($s_u$):**

$$s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$$

**Relative density ($D_r$):**

$$D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$$

**Friction angle (Φ'):**

$$\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$$

**Small strain shear modulus ($G_0$):**

$$G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated shear wave velocity ($V_s$):**

$$V_S = \sqrt{\frac{G_0}{\rho}} \quad \text{where} \quad \rho = \frac{\gamma}{\gamma_w}$$

**Constrained modulus (M):**

$$M = \alpha_M (q_t - \sigma_{v0})$$

when $I_c > 2.2$

$\alpha_M = Q_t$ when $Q_t < 14$

$\alpha_M = 14$ when $Q_t > 14$

when $I_c < 2.2$

$$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$$

**Youngs modulus ($E_s$):**

$$E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated SPT $N_{60}$:**

$$N_{60} = \frac{q_t \,/\, p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$$

## Zero Readings

| kPa | Initial zeros | Final zeros | Final difference | Clean zeros | Clean difference |
|---|---|---|---|---|---|
| Cone resistance | 21,602.70 | 21,624.40 | 21.76 | - | - |
| Sleeve friction | 255.20 | 254.90 | -0.26 | - | - |
| Pore pressure | 2,977.20 | 2,980.20 | 2.95 | - | - |

# Measured CPT Log

**Client:** Geosolve Ltd
**Project:** Jacks Point
**Remarks:** Field water measurement: Unknown, depth: 11.05 m

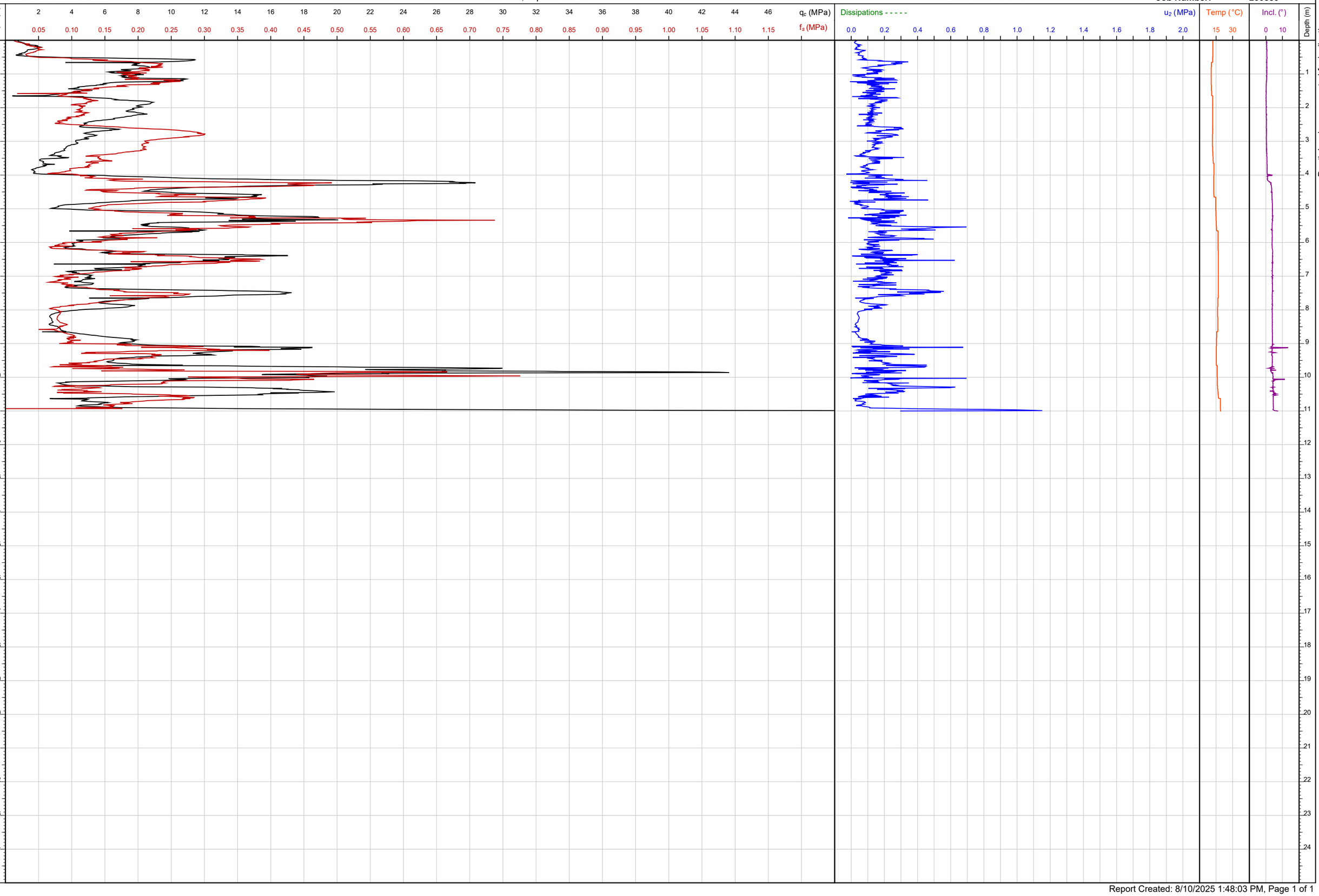
**Depth (m):** 11.00
**Termination:** High cone end resistance

**Standard:** ISO 22476-1:2012 CETANZ TG6
**Date:** 7/10/2025
**Cone Ref:** 000865

**Test Name:** CPT-04
**Job Number:** 250859

Depth has been corrected for inclination

Depth has been corrected for inclination



GROUND INVESTIGATION

# Calculated CPT Log

**Date:** 7/10/2025

**Project:** Jacks Point

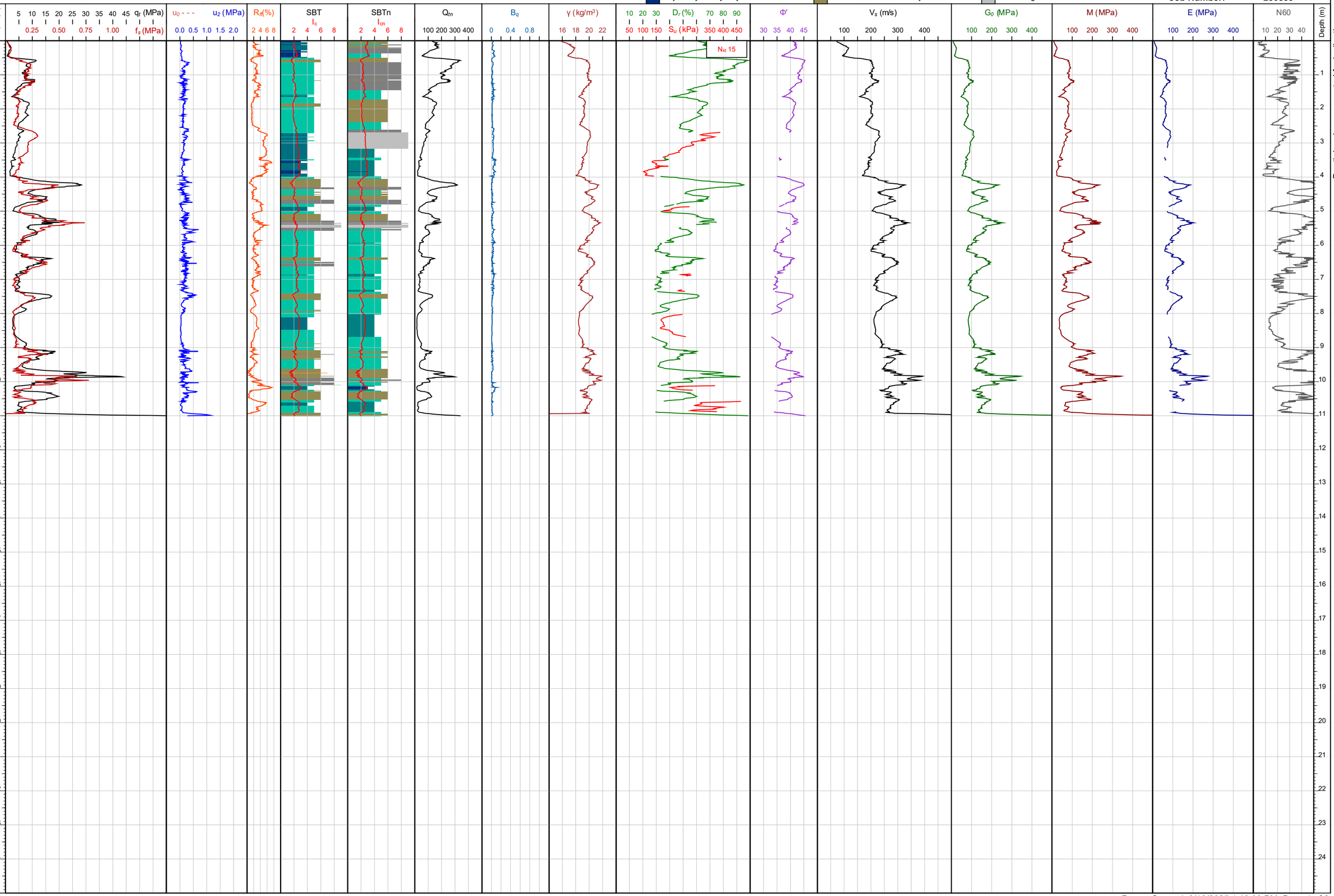
| | | | |
|---|---|---|---|
| 1 Sensitive fine-grained | 4 Silt mixtures: clayey silt & silty clay | 7 Dense sand to gravelly sand | |
| 2 Clay - organic soil | 5 Sand mixtures: silty sand to sandy silt | 8 Stiff sand to clayey sand | |
| 3 Clays: clay to silty clay | 6 Sands: clean sands to silty sands | 9 Stiff fine-grained | |

**Test Name:** CPT-04

**Job Number:** 250859

Depth has been corrected for inclination

Depth has been corrected for inclination



# CPT Details

## General Information

| | | | |
|---|---|---|---|
| **Project:** | Jacks Point | **Location:** | Jacks Point 9371, New Zealand |
| **Contractor:** | Ground Investigation | | |
| **WGS84 (deg):** | -45.083086, 168.755440 | **Rig details:** | Pagani 02 |
| **Elevation (m):** | Unknown | **Location method:** | Handheld GPS |
| **Date:** | 7/10/2025 12:36:19 PM | **Elevation datum:** | |

## Test Setup

| | |
|---|---|
| **Standard:** | ISO 22476-1:2012 |
| **Test type:** | |
| **Pre-Drill (m):** | 0.00 |
| **Start length (m):** | 0 |
| **Cone ID:** | 000865 |
| **Cone type:** | 10cm2 Compression |
| **Cone class:** | |
| **Manufacturer:** | |
| **Calibration date:** | |
| **Cone area ratio:** | 0.79 |
| **Sleeve area ratio:** | 0 |
| **Sleeve offset:** | 0.07 |
| **Filter type:** | U2 Grease Slot |
| **Saturation method:** | Silicone grease |
| **Rig setup variation:** | |

## Test Result

| | |
|---|---|
| **Termination reason:** | High cone end resistance |
| **Termination depth:** | 11 |
| **Ground water level:** | |
| **Water level origin:** | Unknown |
| **Backfill:** | Bentonite |
| **Observations and materials encountered:** | |
| **Deviations and interuptions:** | Deviations:<br>Interuptions: |
| **Corrections applied:** | |
| **Test catagory:** | |
| **Operator name:** | Brendon Lemm |
| **Manager name:** | |

# CPT Formulas

**Test Name:** CPT-04

**Job Number:** 250859

**Corrected cone resistance:**
$$q_t = q_c + u_2 \bullet (1 - a)$$

**Friction ratio:**
$$R_f = \frac{f_s}{q_c} \bullet 100$$

**Non-normalised soil behaviour type (SBT):**
Calculated using $q_{net}$ and $R_f$ for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Soil behaviour type index, (used for non-normalised SBT) :**
$$I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$$

**Friction ratio:**
$$F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$$

**Refined normalised cone resistance:**
$$Q_{tn} = \frac{(q_t - \sigma_{v0}) / \sigma_{atm}}{(\sigma'_{v0} / \sigma_{atm})^n} \quad \text{where} \quad n = 0.381 \bullet I_c + 0.05 \bullet (\sigma'_{v0} / \sigma_{atm}) - 0.05 \leq 1.0$$

**Normalised soil behaviour type index:**
$$I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$$

**Normalised pore pressure:**
$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

**Normalised soil behaviour type (SBTn):**
Calculated using $Q_{tn}$ and $F_r$ for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

**Undrained shear strength ($s_u$):**
$$s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$$

**Relative density ($D_r$):**
$$D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$$

**Friction angle (Φ'):**
$$\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$$

**Small strain shear modulus ($G_0$):**
$$G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated shear wave velocity ($V_s$):**
$$V_S = \sqrt{\frac{G_0}{\rho}} \quad \text{where} \quad \rho = \frac{\gamma}{\gamma_w}$$

**Constrained modulus (M):**
$$M = \alpha_M (q_t - \sigma_{v0})$$
when $I_c > 2.2$
$\alpha_M = Q_t$ when $Q_t < 14$
$\alpha_M = 14$ when $Q_t > 14$
when $I_c < 2.2$
$$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$$

**Youngs modulus ($E_s$):**
$$E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

**Estimated SPT $N_{60}$:**
$$N_{60} = \frac{q_t / p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$$

## Zero Readings

| kPa | Initial zeros | Final zeros | Final difference | Clean zeros | Clean difference |
|---|---|---|---|---|---|
| Cone resistance | 21,608.10 | 21,624.40 | 16.32 | - | - |
| Sleeve friction | 255.70 | 255.10 | -0.58 | - | - |
| Pore pressure | 2,978.40 | 2,978.30 | -0.1 | - | - |

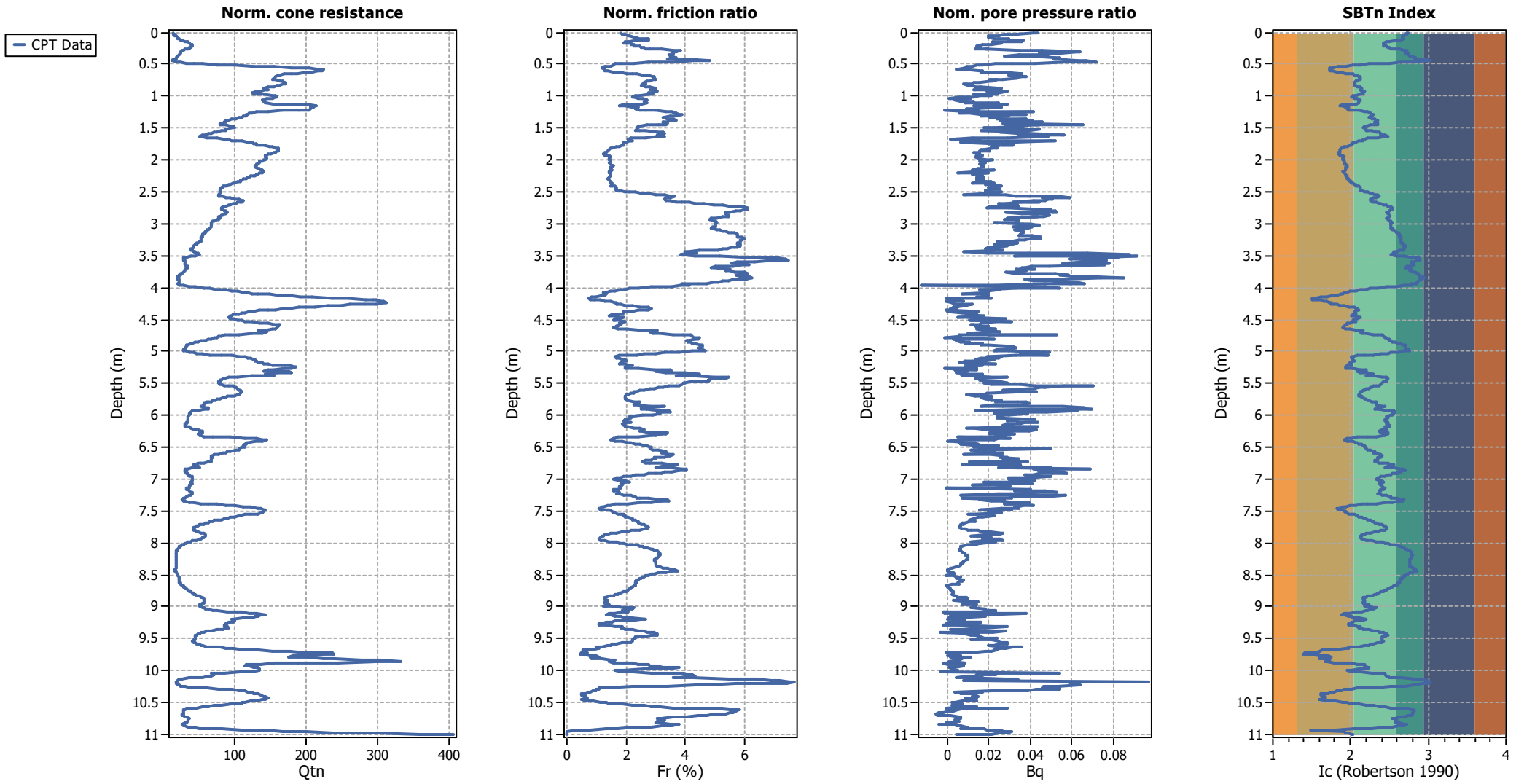
# Appendix D:

Liquefaction results for CPT4

**GeoLogismiki**
Geotechnical Engineers
Merarhias 56
http://www.geologismiki.gr

**Project:**

## Overlay Normalized Plots



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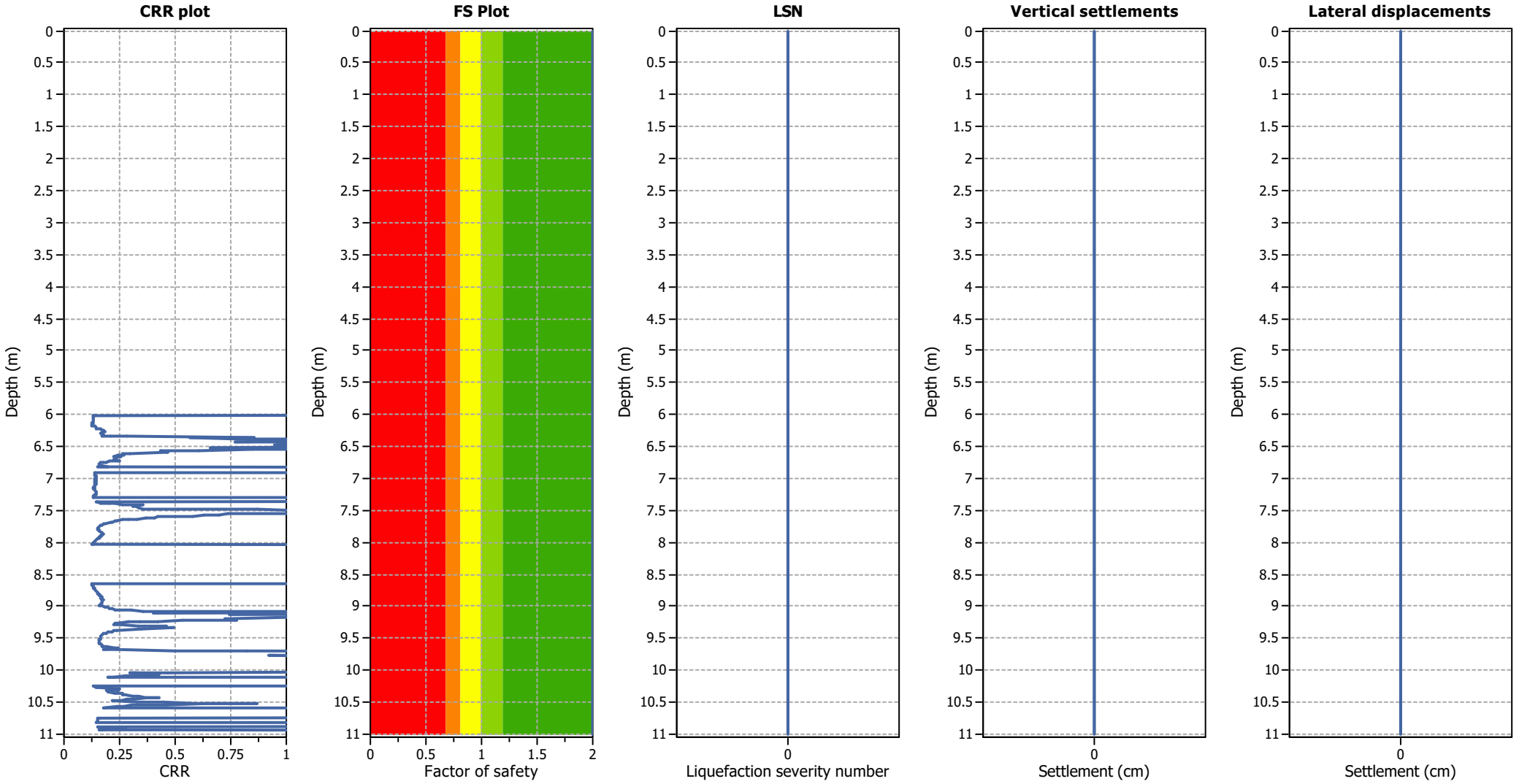
Geotechnical Engineers
Merarhias 56
http://www.geologismiki.gr

**Project:**

## Overlay Cyclic Liquefaction Plots



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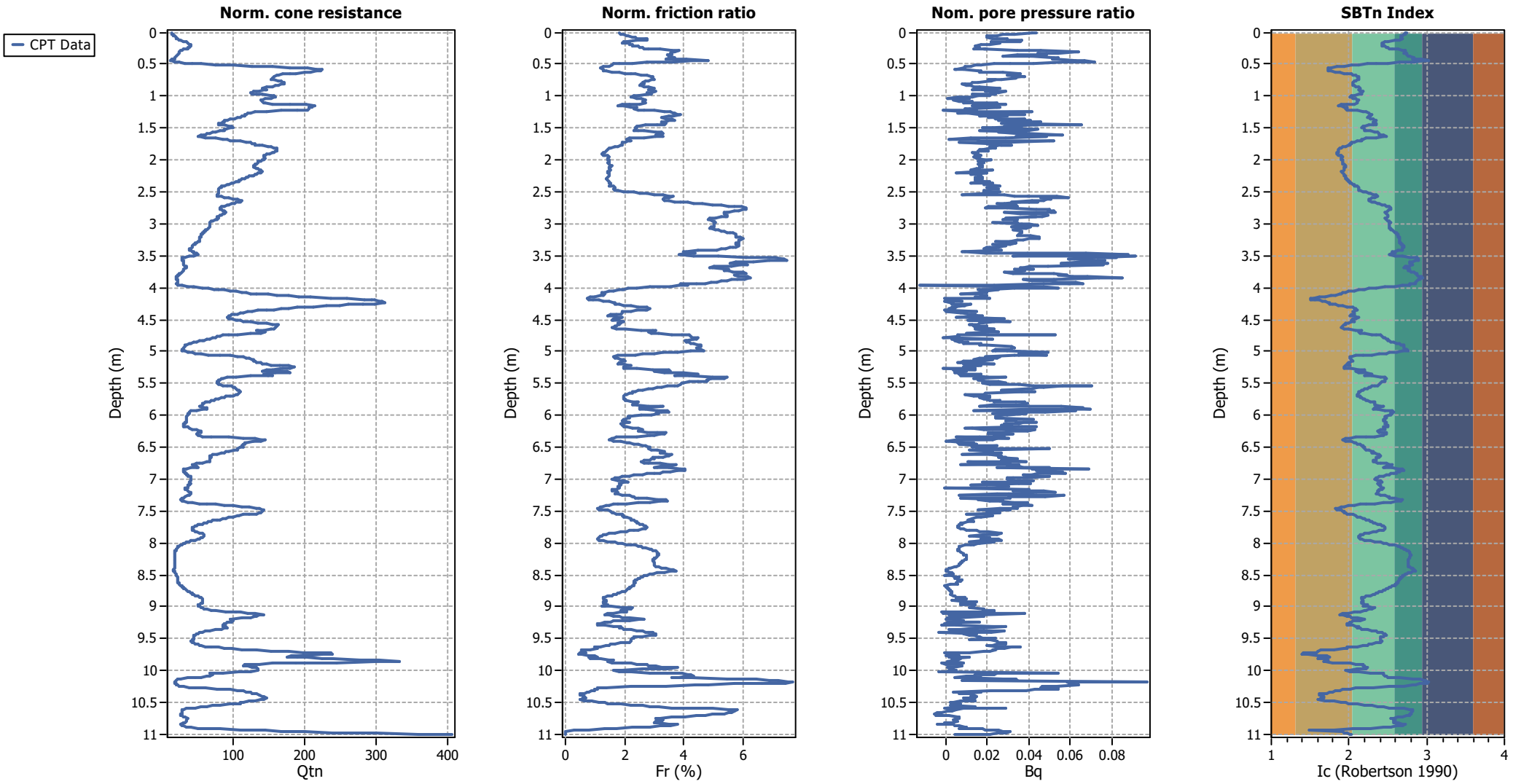
Geotechnical Engineers
Merarhias 56
http://www.geologismiki.gr

**Project:**

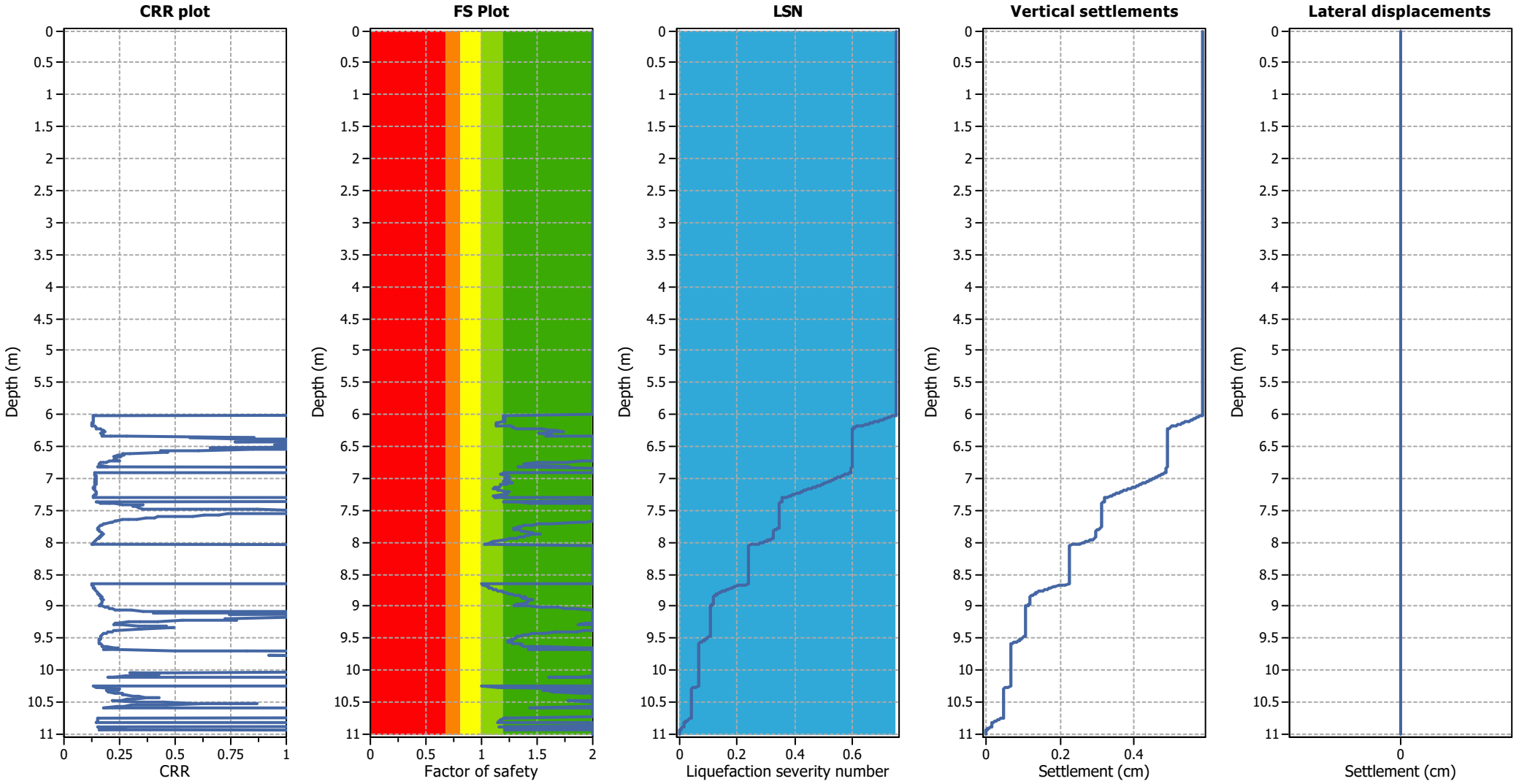
## Overlay Normalized Plots



**GeoLogismiki**
Geotechnical Engineers
Merarhias 56
http://www.geologismiki.gr

**Project:**

## Overlay Cyclic Liquefaction Plots



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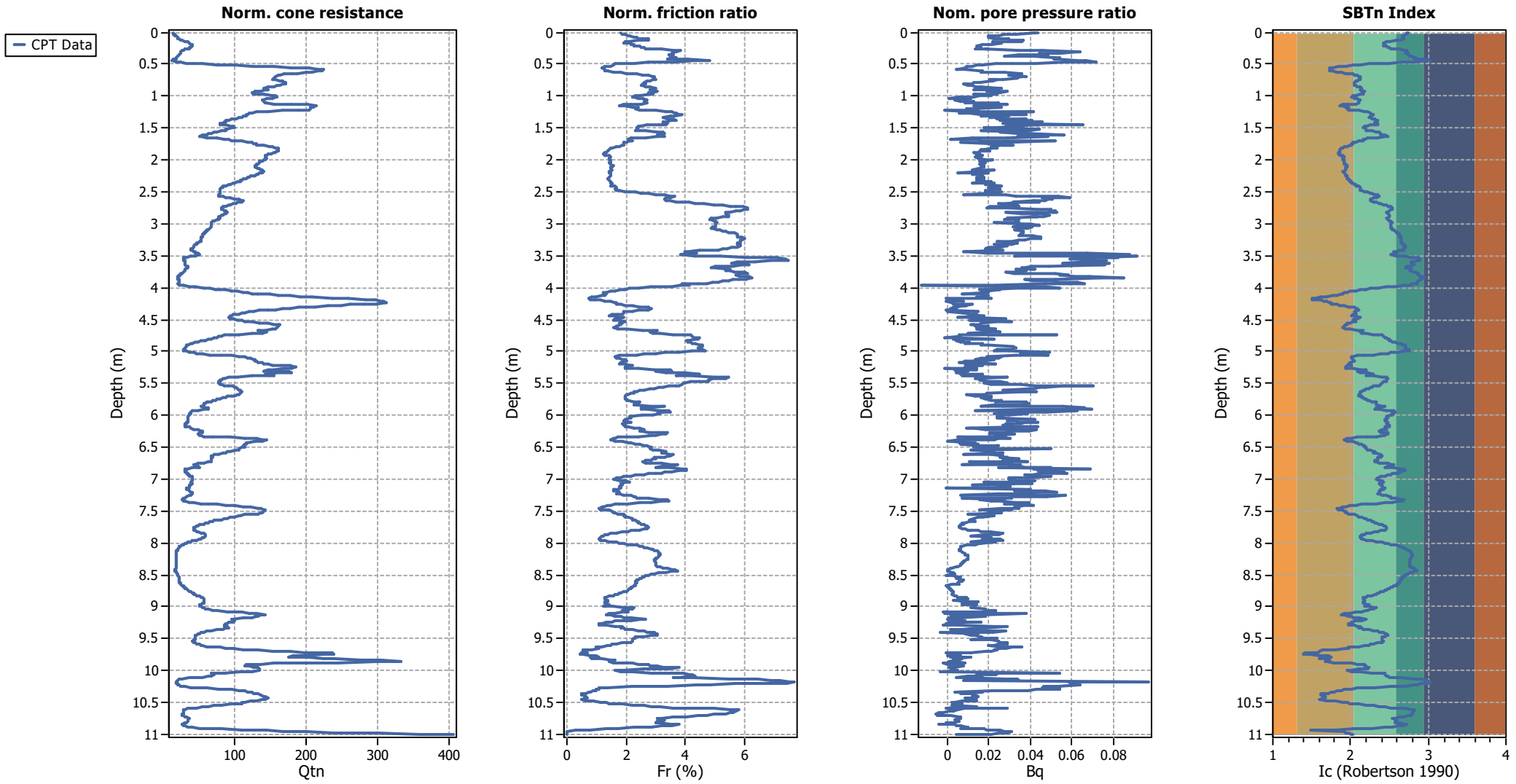
**Project:**

## Overlay Normalized Plots



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Geotechnical Engineers
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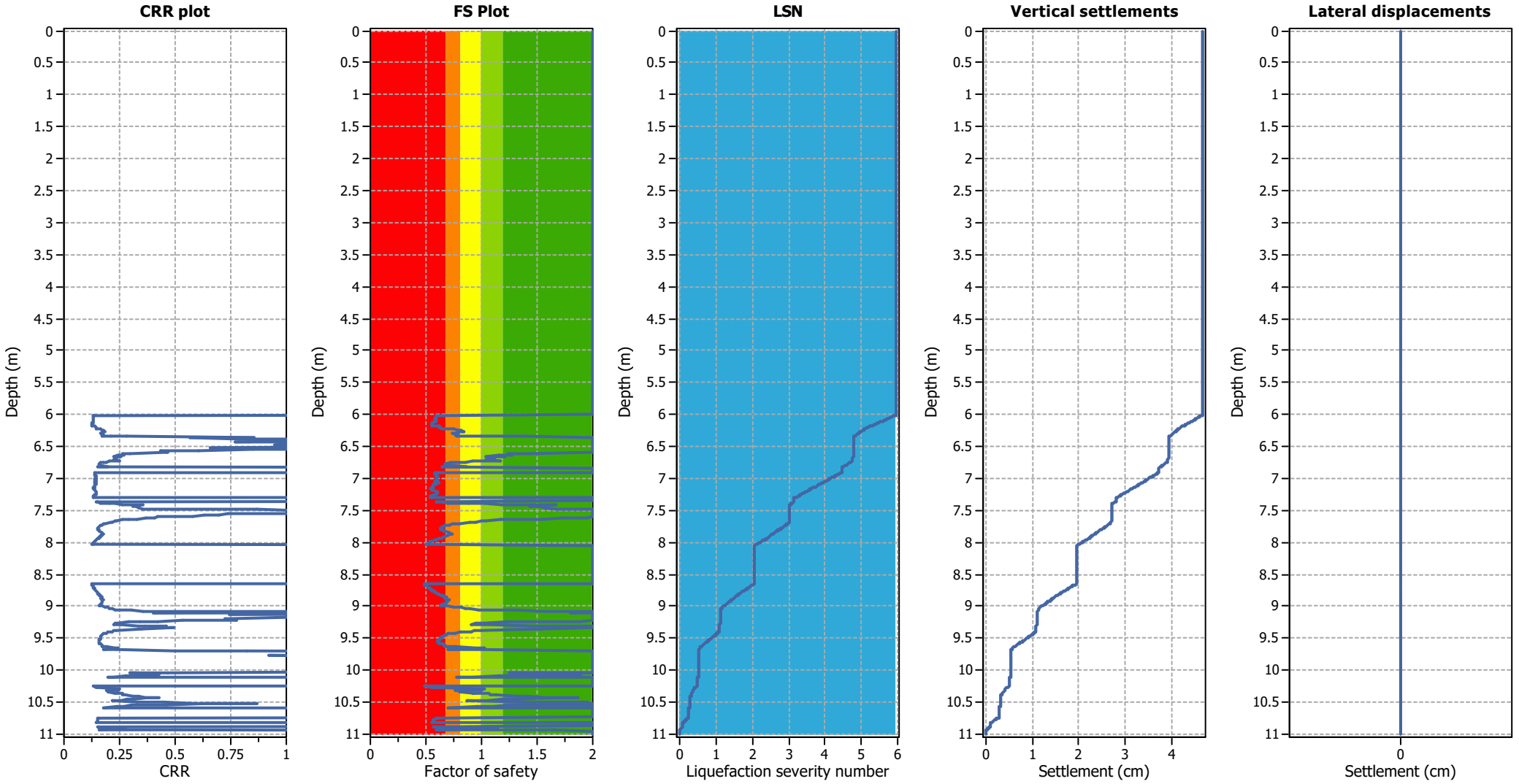
http://www.geologismiki.gr

**Project:**

## Overlay Cyclic Liquefaction Plots



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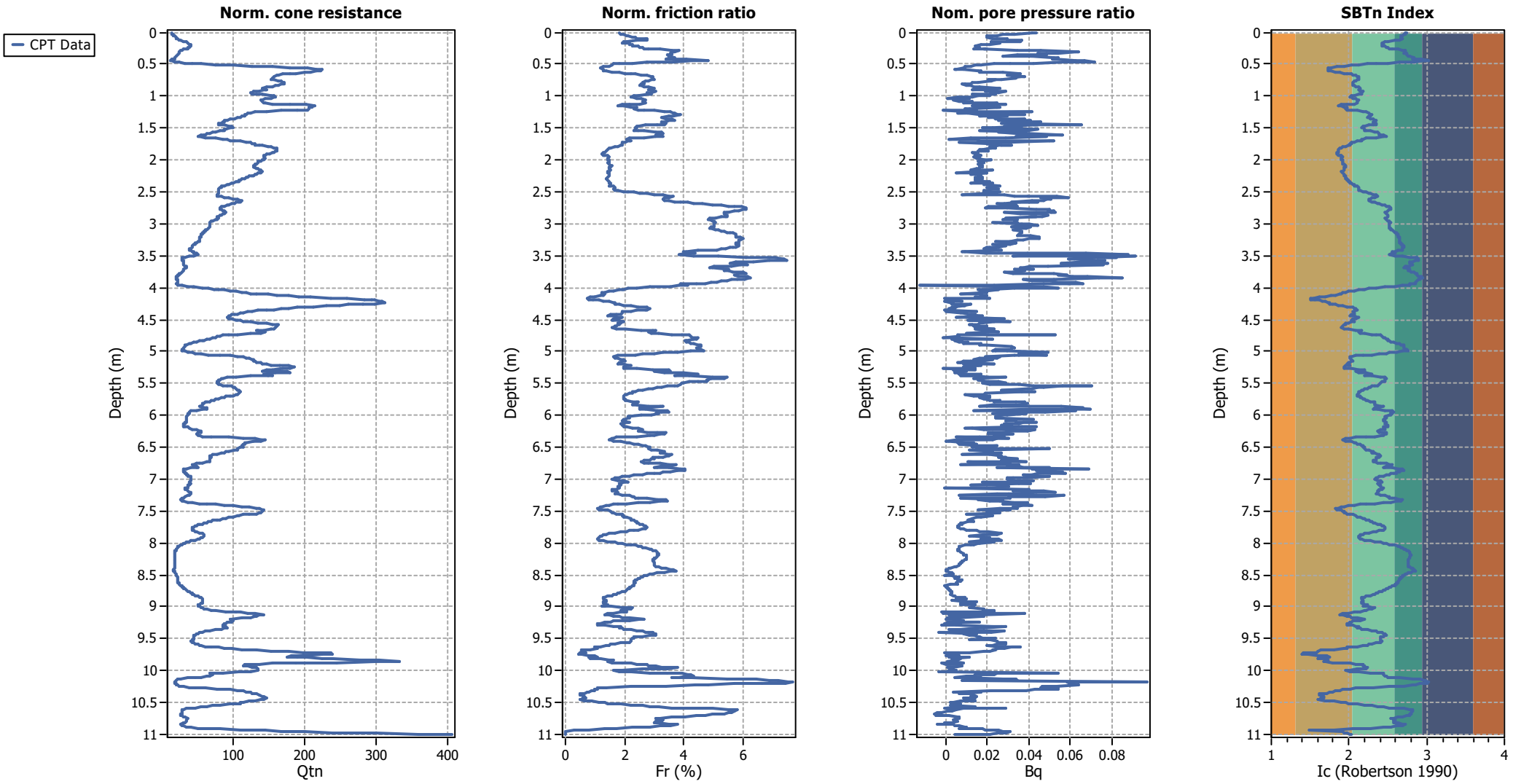
**Project:**

## Overlay Normalized Plots



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**Project:**

## Overlay Cyclic Liquefaction Plots