Pacific Geotech
Consulting Geotechnical Engineers

GEOTECHNICAL REPORT: Proposed Residential Building

PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL
Approval no: DEV2021/1239
Date: 13 April 2022

Queensland Government

99-105 Hamilton Street

Redland Bay

Suzanne Stays

February 2022

PG-7768

VERSION 2

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Pacific Geotech
Consulting Geotechnical Engineers

Ref: PG-7768, 2022-02-24, GR VER 2
Author: Chris Kosiek

25th February, 2022

Suzanne Stays
Email: michael@suzannestays.com

ATTN: MICHAEL ROSSITER

Dear Sir,

GEOTECHNICAL INVESTIGATION – PROPOSED RESIDENTIAL BUILDING
99-105 HAMILTON STREET, REDLAND BAY

Enclosed is a copy of our report for the above project dated February 2022. An electronic copy of the report has been issued.

Should you have any queries regarding this report, please do not hesitate to contact Chris Kosiek at this office.

Yours faithfully,

C. KOSIEK (RPEQ 24394)

For and on behalf of
PACIFIC GEOTECH PTY LTD

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Appendices

1.0 INTRODUCTION

This report contains the results of the geotechnical investigation and provides advice and recommendations relating to the following:

- Subsurface conditions in accordance with AS 1726
- Foundation Recommendations
- Characteristic ground surface movements
- Earthworks considerations
- Batter slope recommendations
- Indicative pavement design parameters
- Construction considerations
- Preliminary acid sulfate conditions
- Aggressivity considerations
- Sediment/erosion control considerations

Proposed Development

It is understood that the proposed development is to comprise the construction of a five-storey residential building above a single level basement. Earthworks are envisaged to consist of cuts of up to 3m to create the proposed basement.

The proposed development is indicated below.

PROPOSED LAYOUT

2.0 METHODOLOGY

The geotechnical investigation comprised the drilling and sampling of three boreholes to depths of 6.0m, using a small track mounted Compac 018 drilling rig and 100mm solid flight augers, and one borehole to a depth of 1.0m using hand auger equipment. Dynamic Cone Penetrometer (DCP) testing was conducted adjacent to the boreholes.

The soil classification descriptions and field tests were carried out in general accordance with Australian Standards.

AS 1726	Geotechnical Site Investigations
AS 1289	Methods of Testing Soils for Engineering Purposes

Borehole records, Dynamic Cone Penetrometer test results and a site plan showing the test locations are appended to the report.

3.0 SITE DESCRIPTION

The site of the proposed development is located at 99-105 Hamilton Street, Redland Bay.

At the time of the investigation, the site was occupied by two existing residential buildings, swimming pool and associated concrete driveways.

Vegetation comprised various trees and shrubs and long grass cover.

The site sloped from west to east and drainage was considered poor to fair.

Refer following aerial and site photographs for typical site conditions.

AERIAL IMAGE

SITE PHOTOGRAPHS

4.0 GEOTECHNICAL MODEL

The subsurface profile encountered in the boreholes typically consisted of surficial fill material overlying a natural sandy/silty clay profile. The clays were initially stiff and very stiff increasing in strength to become hard by the borehole termination depths.

Table 1 presents a summary of the encountered subsurface profile. Detailed borehole record sheets are appended to this report.

TABLE 1 SUBSURFACE PROFILE SUMMARY

BH No.	FILL	NATURAL				BH TD
		Silty SAND	Silty/Sandy CLAY			
		Loose/Medium dense	Stiff	Very Stiff	Hard	
BH 01	0.0-0.1	NE	0.1-1.2	1.2-1.6 5.1 - TD	1.6- 5.1	6.0
BH 02	NE	0.0-0.1	NE	NE	0.1-TD	6.0
BH 03	0.0-0.1	0.1-0.2	0.2-0.4	0.4-0.6	0.6-TD	6.0
HA 04	NE	0.0-0.1	0.1-0.3	0.3-0.6	0.6-TD	1.0

Notes:
1. All depths in metres below ground level at time of investigation.
2. NE - Not Encountered; TD - Termination Depth.

Groundwater was not encountered in the boreholes at the time of drilling. Seepage could be expected through the surficial soils and along the soil/rock interface following periods of rainfall.

5.0 LABORATORY TESTING

Laboratory testing was carried out on samples retrieved from the site investigation program and was directed towards assessing the reactivity and acid sulfate potential of the subsurface material.

Laboratory testing included:-

- Shrink/Swell Index - to assess the reactivity of the subsurface material.
- pH_f/pH_{fox} – screening tests for potential acid sulfate soils.
- Chromium Suite – quantitative testing to determine the acid sulfate potential of the on-site soils.

The results of the laboratory testing are contained in Appendix C.

6.0 EARTHWORKS AND SITE PREPARATION CONSIDERATIONS

Earthworks are expected to comprise cuts up to 3m to create the proposed basement. Some minor reprofiling of the site removed from the basement excavation may also be required.

It is recommended that the following site preparation and earthworks procedures be carried out as part of the earthworks procedures during development.

- All earthworks operations should be carried out in general accordance with AS 3798-2007 "Guidelines on Earthworks for Commercial and Residential Developments".
- Trafficability across the site at the time of the investigation was assessed to be fair to good with no difficulties encountered at the time around the existing structures. It is possible that areas of water softened material may be present under the existing slabs and this should be allowed for in the earthworks control.
- If significant rainfall events occur during the earthworks operation, some difficulties could be experienced in trafficing the exposed surface, if removal of the existing surficial gravelly fill is undertaken.
- All topsoil (i.e. soil containing organic matter) tree roots and soils containing deleterious matter should be stripped from the construction area at the commencement of the earthworks operation.
- The stripped surface should be proof rolled under Pacific Geotech's supervision using a large vibrating roller of minimum weight of at least 12 tonnes, to identify areas of weak surficial soils and to compact the upper level fill material.
- The majority of the soils on site will be suitable for re-use as structural fill, provided material is free of organic matter and deleterious material. It is likely that the soils require conditioning to bring the soils to optimum If the clays were overly moist, difficulty in achieving compaction of the materials will be encountered and moisture conditioning will be required.
- The natural clays would be expected to be highly reactive and if they are re-used as structural fill on site, an increase in the potential ground surface movements may result.
- Imported fill should be of fair to good quality with a minimum Soaked CBR value of 10%, a maximum Iss=1.0% and a maximum particle size of 75mm.
- All filling should be undertaken in layer thicknesses of approximately 250mm (or as appropriate for the compaction equipment being used). Fill should be compacted to a minimum dry density ratio of 98% Standard in accordance with AS1289 5.1.1. and within +/- 2% of the material OMC.
- Field density testing should be carried out to check the standard of compaction achieved and the placement moisture content. The frequency and extent of testing should be as per guidelines in AS.3798-2007.
- All earthworks operations should be performed under appropriate supervision, in general accordance with the requirements of AS3798 and should be certified as controlled fill by the testing authority.

7.0 BATTERS

Maximum short term batter slopes of 45 degrees and maximum long term batter slopes of 26 degrees are recommended for the on-site materials (subject to inspection at the time of excavation). Steeper batters are possible by use of retaining structures.

For excavations of a very short term nature, and subject to assessment of factors such as the conditions at the time of excavation, length of time excavations are to remain open, working conditions/requirements and most importantly the soil structure in the cut face, etc., steeper excavations could be possible. Pacific Geotech should be contacted to determine an appropriate profile when construction details have been finalised.

It is essential that batters be suitably protected from erosion and scour. Runoff should not be allowed to discharge directly across the batters.

8.0 SITE CLASSIFICATION

Site investigation and laboratory test results indicate the development site would be classified Class M in accordance with AS 2870-2011 'Residential Slabs and Footings', with a characteristic ground surface movement of 40mm calculated.

It is recommended that the readers satisfy themselves that the use of AS 2870-2011 is applicable for the proposed design and the above site classification re-confirmed following the completion of the bulk earthworks operation.

9.0 BUILDING FOUNDATIONS

The appropriate foundation system for the support of the structure will be dependent on the final loads, ability of the structure to tolerate the settlement and potential ground surface movements and construction considerations on site.

9.1 High Level Footings

A high level footing system founding into very stiff or better clay may be adopted for the support of the proposed buildings.

An allowable bearing capacity of 125kPa in the natural stiff clays and 300kPa in the very stiff to hard clays would be available, subject to inspection at the time of excavation.

Where the existing uncontrolled fill is encountered, footings should be deepened to penetrate the uncontrolled fill material and found into the natural soils.

It is recommended that footing inspections be undertaken by Pacific Geotech, following excavation, to confirm the specified founding strata has been reached.

It is recommended that masonry walls supported on high level footings be suitably articulated.

Where footings are located adjacent to excavations such as underground service trenches, it is recommended that the footings be deepened to found at least 200mm below a line drawn up at 45 degrees from the base of the trench.

9.2 *Deep Foundations*

If the loads are excessive for high level footings, a deep foundation system could be adopted. Bored piers could be considered for the support of the proposed structure.

The deep foundation system should be designed in accordance with the recommendations of AS 2159-2009 'Piling - Design and Installation'.

The ultimate geotechnical strength ($R_{d,ug}$) of piles can be calculated using the unfactored, ultimate shaft adhesion and end bearing values given in Table 2. The $R_{d,ug}$ values given in Table 2 will need to be multiplied by a suitable geotechnical strength reduction factor ($ø_g$) to obtain the design geotechnical strength ($R_{d,g}$) of piles. In accordance with AS2159-2009, the $ø_g$ value must be determined by the designer, but based on the anticipated site, design and installation risk factors, a $ø_g$ value of 0.48 is recommended. Higher values may be applicable with suitable supervision.

If working stress methods are used in the pile design, the $R_{d,ug}$ values given in Table 2 will need to be divided by a factor of safety of 2.5 to caluculate the maximum single pile working load.

TABLE 2 ULTIMATE (UNFACTORED) PILE DESIGN PARAMETERS

Material		Preliminary Ultimate Unfactored End Bearing* (kPa)		Ultimate Unfactored Shaft Adhesion* (kPa)
		L<4D	L>4D	
Existing Fill		NR	NR	10
Natural clay	Stiff	300	450	20
	Very Stiff- Hard	900	1350	40

Notes:
*Geotechnical strength reduction factor needs to be applied to these parameters.
1. NR – Not Recommended.
2. L – pile length; D – pile diameter.

Construction Considerations

If bored piers are adopted, the bases of the bored pile holes must be thoroughly cleaned of all loose soil and rock debris using a proper cleaning tool. The practice of adding water and spinning the auger is generally not acceptable.

Groundwater was encountered in some of the boreholes during the investigation at this site. An allowance for the use of steel liners, which will likely have to be socketed into rock to achieve an impermeable seal against any water charged soils above, should be made. The groundwater seepages may be controllable by pumping. Shaft adhesion must be ignored for the portion of the pile that is permanently lined.

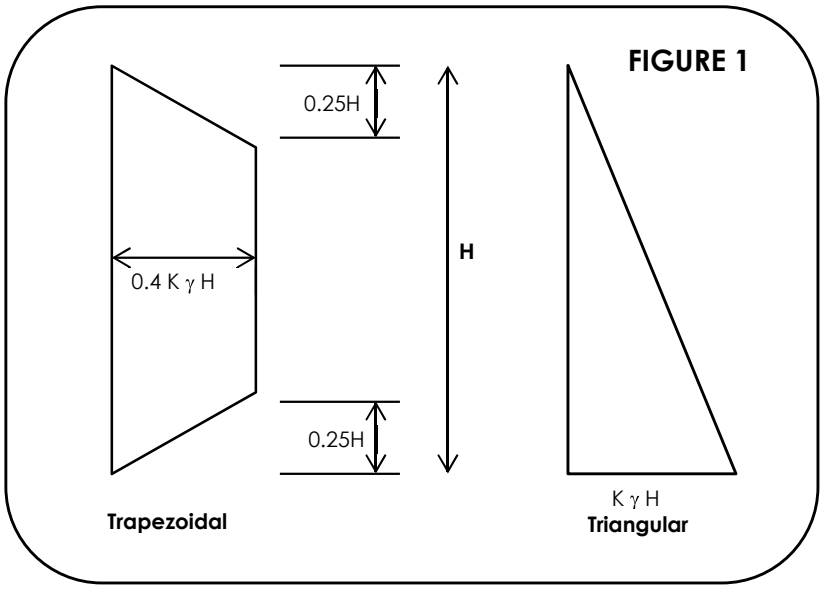
Drilling piles is not only dependent on the subsurface profile characteristics, but also the type (power and size) of the bored pile drilling rig, drilling teeth, size of pile, etc. It is recommended that a specialist drilling contractor be consulted to be able to manage the above conditions and materials encountered.

During construction, all bored piles must be inspected by a geotechnical engineer to confirm the geotechnical strength parameters presented in Table 2 and to check the capacity of the piles.

10.0 RETAINING WALLS

Retaining walls should be specifically engineer designed in accordance with AS 4678-2002 (Ref 9).

The design of flexible retaining walls could be undertaken using a triangular pressure distribution and the earth pressure parameters given in Table 3. Flexible walls are those which are free to rotate or tilt (such as cantilevered walls) and should be designed using active (Ka) earth pressure coefficient. Rigid walls are those which are restrained against rotation or tilt (i.e. single anchored/propped walls) and should be designed using the at-rest earth pressure (Ko) and a trapezoidal pressure distribution as per Figure 1.



Passive resistance (Kp) at the toe of the wall should be ignored in the zone where future disturbance (e.g. services trenches) could occur.

The effects of surcharge in the retained zone should be included by multiplying the vertical pressure developed by the surcharge by the appropriate lateral earth pressure coefficient. Allowance should also be made for the surcharge due to sloping crests if applicable.

TABLE 3 EARTH PRESSURE COEFFICIENTS (NON-SLOPING CREST BACKFILL)

Material	Unit Weight (kN/m³)	Friction Angle (degrees)	Active Ka	At Rest Ko	Passive Kp
Existing Fill	18	24	0.42	0.59	2.37
Natural Clays – Stiff to Very stiff	19	26	0.39	0.55	2.57

Notes: * Depends on fill material type and level of compaction. Assumes material compacted under 'Level 1' supervision.

Preference should be given to adopting thin soil layers and using small hand-controlled compaction equipment during backfilling against retaining walls. This is in order to limit the stress applied to the walls during construction. Should heavy compaction be required, then wall stresses will be well in excess of Ko and temporary propping should be used.

Clay backfill should not be placed dry of optimum moisture content, as this can lead to increased future swelling with changes to moisture content or inundation from water creating additional load on the back of the wall.

It is recommended that all retaining walls be drained for full height in order to minimise hydrostatic pressure build-up behind the wall. Additional guidelines on wall drainage are provided in Appendix G of AS 4678-2002.

11.0 PAVEMENT DESIGN CONSIDERATIONS

Considering the nature of the natural clays, a design CBR value of 4% and a modulus of subgrade reaction of 40kPa/mm are recommended for the natural clays for the pavement design. These values should be confirmed with additional on-site sampling and testing following the bulk earthworks operation on site.

Specific additional construction considerations are offered in regard to the construction of the pavements on the site:-

- Suitable subsurface drainage should be installed around the perimeter of the pavements
- It should be ensured that the subgrade of the pavement is suitably graded to allow any seepage to flow from under the pavement to the perimeter drains.
- Pavement materials should comply with MRS 11.05 specifications and the corresponding minimum dry density ratios are recommended:
  - i) Lower Sub-base (Type 2.5) 95% (Modified)
  - ii) Sub-base (Type 2.3) 95% (Modified)

iii) Base (Type 2.1) 98% (Modified)

- Inspections and testing should be carried out by Pacific Geotech following the completion of the bulk earthworks to confirm subgrade conditions across the pavement areas.

12.0 EARTHQUAKE CONSIDERATIONS

The design should consider the effects of an earthquake on the founding soils, as outlined in AS.1170.4-2007, Part 4. Reference to Section 4.2 in AS1170.4-2007, it is recommended that a site classification of "Class Ce – shallow soil site" be adopted, in accordance with the definitions presented in "Section 4.2 – Class Definitions".

13.0 PRELIMINARY ACID SULFATE SOIL CONSIDERATIONS

The boreholes were sampled for Acid Sulfate determination, in addition to geotechnical sampling.

The soil classification descriptions and field tests were carried out in general accordance with Australian Standards.

QASSIT	Queensland Acid Sulfate Soil Investigation Team Dept. of Natural Resources, 'Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland, 1998' (Oct. 1998, Revision 4.0).
QUEENSLAND GOVERNMENT	State Planning Policy Guideline, December 2013, Acid Sulfate Soils

Preliminary laboratory testing was undertaken in general accordance with the recommendations outlined in the QASSIT 'Acid Sulfate Soils Laboratory Methods Guidelines 2004' and was undertaken by Octief Pty Ltd to assess the potential acid sulfate conditions across the site. The results of the testing program are appended to this report.

The testing program comprised of initial screening tests on recovered samples, followed by quantitative testing using the Chromium Reducible Sulfur (CRS) suite.

Screening Tests

Screening tests were undertaken on soil samples collected from the bores. Two small sub-samples of each soil sample were prepared; one sub-sample from each sample was mixed with approximately 20mL of distilled water, and the other sub-sample mixed with approximately 20mL of hydrogen peroxide (H_2O_2), buffered to a pH of 5.4 with sodium hydroxide.

Slurry pHs were measured with a calibrated pH meter. The pH of the distilled water/soil slurry (pH_F) was measured approximately one hour after mixing, whilst the pH of the hydrogen peroxide/soil slurry (pH_{FOX}) was measured approximately one to two hours after mixing.

The pH screening tests can be used for the preliminary identification of a potential or actual ASS using a combination of three trigger factors as follows:

a) The strength of the reaction with peroxide is a useful indicator but cannot be used alone. Organic matter and other soil constituents such as manganese oxides can also cause a reaction.

b) A pH_{FOX} value at least one unit below pH_F may indicate a potential ASS. The great the difference between the two measurements, the more indicative the value is of a potential ASS. The lower the final pH_{FOX} value the better the indication of a positive result.

c) If the pH_{FOX} is less than 3, and the other two conditions apply, then it strongly indicates a potential ASS. The more the pH_{FOX} drops below 3, the more positive the presence of sulfides.

The results of the screening tests indicate an acid sulfate presence on site.

Summary

On the basis of the testing undertaken, soils on site have a very low potential of acid sulfate soils.

In accordance with the QASSIT guidelines and the State Planning Policy for Acid Sulfate Soils, treatment of the disturbed on-site soils for acid sulfate soils will not be required.

Testing should be undertaken during excavation, at a rate of 1 test per 1,000m^3 of material disturbed, to confirm the material does not require treatment during excavation.

14.0 SITE MANAGEMENT

To maintain the long term performance of the structure, good management of the soil conditions and the development is vital throughout the life of the development.

The following are some specific comments with respect to site management.

- The ground surface around the perimeter of the buildings should slope away from the structure and fall to the stormwater system. Water should not be allowed to pond adjacent to the buildings.
- Founding soils should not be allowed to become saturated.

- Service trenches under the buildings should be kept to a minimum. Saturation of the on-site material will result in an increase in potential ground surface movements.
- Footings should be poured immediately after excavation. If footings cannot be poured on the same day as excavation, a blinding layer of 50mm thickness is recommended.
- Trees, garden beds and other vegetation should be planted at a distance at least equivalent to their mature height away from the structures. This will assist in minimising shrinkage movements in the expansive on-soils.

15.0 LIMITATIONS

We have prepared this report for the Proposed Residential Building at 99-105 Hamilton Street, Redland Bay. The report is provided for the exclusive use of Suzanne Stays, for this project only and for the purposes outlined in the report. It should not be used by, or relied upon, for other projects on the same or different sites or by a third party. In preparing this report, we have relied upon information provided by the client or their agents.

The results are indicative of the subsurface conditions on site only at the specific testing locations. Subsurface conditions can change between test locations and the design and construction should take the spacing of the testing and testing methods adopted and the potential for variation between the test locations.

It is recommended that Pacific Geotech be engaged to provide advice and ensure the development is undertaken in accordance with the assumptions made in writing this report.

This is not to reduce the level of responsibility accepted by Pacific Geotech, but rather to ensure that the parties who may rely on the information contained in this report are aware of the responsibilities they assume in doing so.

C. KOSIEK (RPEQ 24394)

For and on behalf of
PACIFIC GEOTECH PTY LTD

APPENDICES

APPENDIX A

NOTES RELATING TO THIS REPORT

Notes Relating to this Report

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis.

Every care has been taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical conditions and contains recommendations or suggestions for design and construction. However, unexpected variations in ground conditions will occur. The potential for this will depend partly on testing, spacing and sampling frequency.

If variations are identified, Pacific Geotech would be pleased to assist with additional investigations or advice to resolve the matter.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Description and Classification Methods

The description and classification of soils and rocks used in this report are based on AS 1726.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the percent of other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silty	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density which can be correlated from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very Loose	less than 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) and can be quantified by the Pocket Penetrometer test, Vane Shear test, laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 - 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 - 400
Hard	greater than 400
Friable	strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc.

Planarity	
CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

Roughness	
POL	Polished
RJ	Rough
S	Smooth
SL	Slickened
VR	Very Rough

Defects	Type
BP	Bedding Parting
CL	Cleavage
CO	Contact
CS	Crushed Seam
CZ	Crushed Zone
DB	Drilling Break
DK	Dyke
DL	Drill Lift
DZ	Decomposed Zone
FC	Fracture
FL	Foliation
FZ	Fracture Zone
HB	Handling Break
IS	Infilled Seam
JT	Joint
H	Schistosity
SI	Sill
SM	Seam
SS	Shear Seam
SZ	Shear Zone
VN	Vein
VO	Void

Sampling

Sampling is undertaken during the fieldwork to allow examination of the soil or rock and to allow laboratory testing to be undertaken.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content and minor constituents. Bulk samples are similar but of greater volume required for some test procedures such as CBR testing.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and collecting a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

Investigation Methods

Test Pits: These are typically undertaken with a backhoe or a tracked excavator, allowing examination of the insitu soils. Limitations of test pits are the problems associated with collapse of the pits, disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of typical diameter of between 50mm to 75mm advance manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as fill, gravel, hard clays and collapse of the borehole (typically in non-cohesive soil).

Continuous Spiral flight Augers: The borehole is advanced using 65mm to 100mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. Augers of up to 300mm in diameter are used to recover larger volumes of sample. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights. Samples can be disturbed and layers may become mixed. Augering below the groundwater table can be less reliable than augering above the water table.

A Tungsten Carbide (TC) bit for auger drilling into rock can be used to indicate rock strength and continuity by variation in drilling resistance and from examination of recovered rock fragments but provides only an indication of the likely rock strength. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is advanced by a bit attached to the end of a hollow rod string, with water being pumped down the drill rods and returned up the annulus of the borehole, carrying the drill cuttings. Changes in stratification can be determined from the return, together with information from "feel" and rate of penetration.

The borehole can be stabilised through the use of drilling mud as a circulating fluid. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. This technique provides a reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel is used, which gives a core of about 50mm diameter. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a disturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposed", Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer, with a free fall of 760mm. The sample is driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense soils, hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of , say, 4, 6 and 7 blows, as
  N = 13
  4, 6, 7
- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as
  N > 30
  15, 30/40mm

Cone Penetrometer Testing (CPT): Cone Penetrometer Testing with or without pore pressure measurement (CPTu) is carried out using a Cone Penetrometer in general accordance with AS 1289 6.5.1, 1999.

In the tests, a 36mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the fractional resistance on a separate 135mm long sleeve, immediately behind the cone. Pore Pressure is recovered through a pore ring located either within, or more usually immediately behind the cone/tip.

As penetration occurs (at a rate of approximately 20mm per second) and data is recorded every 20mm of penetration, the results are presented graphically.

The information provided on the plot comprises:

- Cone resistance – expressed in mPa
- Sleeve friction – expressed in kPa
- Friction ratio – the ratio of sleeve friction to cone resistance expressed as a percentage.
- Pore pressure in kPa
- Tilt of probe (in degrees).

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and rising to 2% to as high as 8%, and higher in organic soils. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes, etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive.

Dynamic Cone Penetrometers:

Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod into the ground with a 9kg sliding hammer dropping 510mm and counting the blows for successive 100mm increments of penetration.

Logs

The borehole or test pit logs are an interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of the boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

Groundwater

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be flushed from the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes from which ongoing monitoring can be undertaken.

Fill

The present of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, steel ,etc.) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult to reliably determine the extent of the fill.

Laboratory Testing

Laboratory testing is carried out in general accordance with Australian Standard 1289 'Methods of Testing Soil for Engineering Purposes'.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage.

Review of Design

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/constraints are quite complex, it is prudent to have a design review.

Site Inspection

Pacific Geotech would be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related:

Requirements could range from:

i. a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii. a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii. full time engineering present on site.

APPENDIX B

BOREHOLE RECORD SHEETS

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH 01
Page 1 of 1

Project No.: PG-7768

Client:	Suzanne Stays	Commenced:	18/02/2022
Project Name:	Proposed Residential Building	Logged By:	SR
Hole Location:	99-105 Hamilton Street, Redland Bay	Checked By:	
Hole Position:			
Drill Model and Mounting:	Compac 018	RL Surface:	No survey
Hole Diameter:		Datum:	AHD Operator: SR

Drilling Information							Soil Description			DCP
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	DCP TEST (AS 1289.6.3.2-1997) Blows per 100 mm
AD/T			ASS 0.00-0.50 m			0.10		SM CI-CH	FILL SILTY SAND (SM) Loose, fine to medium grained, brown grey, medium plasticity fines, with fine sized gravel, with organics, dry to moist. NATURAL SILTY CLAY (CI-CH) Stiff, medium to high plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w=pl.	0 5 10 15 20 25
			ASS 0.50-1.00 m U50 0.50-0.60 m PP=220kPa			1				
			ASS 1.00-1.50 m			1.20		CI-CH	SILTY CLAY (CI-CH) Very stiff, medium to high plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w=pl.	
			ASS 1.50-2.00 m			1.60		CI	SILTY CLAY (CI) Hard, medium plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w>pl.	
			ASS 2.00-2.50 m			2				
			ASS 2.50-3.00 m							
			ASS 3.00-3.50 m			3				
						3.10		CI-CH	SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown mottled pale yellow brown, with fine sized gravel, with fine to medium grained sand, w>pl.	
			ASS 3.50-4.00 m							
			ASS 4.00-4.50 m			4				
			ASS 4.50-5.00 m							
			ASS 5.00-5.50 m			5				
						5.10		CH	SILTY CLAY (CH) Very stiff, high plasticity, pale grey white mottled pale red brown, with fine sized gravel, with fine to medium grained sand, w=pl.	
			ASS 5.50-6.00 m							
						6.00			Hole Terminated at 6.00 m	

Method
AS - Auger
RR - Rock Roller
WB- Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.
2. Standpipe installed to 5.6m.

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH 02
Page 1 of 1

Project No.: PG-7768

Client:	Suzanne Stays	Commenced:	18/02/2022
Project Name:	Proposed Residential Building	Logged By:	SR
Hole Location:	99-105 Hamilton Street, Redland Bay	Checked By:	
Hole Position:			
Drill Model and Mounting:	Compac 018	RL Surface:	No survey
Hole Diameter:		Datum:	AHD Operator: SR

Drilling Information								Soil Description			DCP
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional		DCP TEST (AS 1289.6.3.2-1997) Blows per 100 mm
AD/T			ASS 0.00-0.50 m			0.10		SM	NATURAL SILTY SAND (SM) Medium dense, fine to medium grained, pale red brown, medium plasticity fines, with fine sized gravel, with organics, dry.		0 5 10 15 20 25
								Cl			
			ASS 0.50-1.00 m U50 0.60-0.70 m PP=>600kPa			0.40		CI-CH	SANDY CLAY (Cl) Hard, medium plasticity, pale red brown, fine to medium grained sand, with fine sized gravel, w=ll.		
			ASS 1.00-1.50 m			1			SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w>pl.		
			ASS 1.50-2.00 m								
			ASS 2.00-2.50 m			2					
			ASS 2.50-3.00 m								
			ASS 3.00-3.50 m			3					
			ASS 3.50-4.00 m								
			ASS 4.00-4.50 m			4					
			ASS 4.50-5.00 m								
			ASS 5.00-5.50 m			5					
			ASS 5.50-6.00 m			5.60		CI-CH	SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown mottled grey, with fine sized gravel, with fine grained sand, w>pl.		
						6.00			Hole Terminated at 6.00 m		

Method
AS - Auger
RR - Rock Roller
WB- Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.
2. DCP refusal met at 0.78m.

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
BH 03
Page 1 of 1

Project No.: PG-7768

Client:	Suzanne Stays	Commenced:	18/02/2022
Project Name:	Proposed Residential Building	Logged By:	SR
Hole Location:	99-105 Hamilton Street, Redland Bay	Checked By:	
Hole Position:			
Drill Model and Mounting:	Compac 018	RL Surface:	No survey
Hole Diameter:		Datum:	AHD Operator: SR

Drilling Information							Soil Description			DCP
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	DCP TEST (AS 1289.6.3.2-1997) Blows per 100 mm
AD/T			ASS 0.00-0.50 m			0.10		GP	FILL GRAVEL (GP) Loose to medium dense, fine to medium sized, grey brown, with fine grained sand, dry.	0 5 10 15 20 25
						0.20		SM	NATURAL SILTY SAND (SM) Medium dense, fine to medium grained, pale red brown, medium plasticity fines, with fine sized gravel, with organics, moist.	
			ASS 0.50-1.00 m			0.40		CI-CH	SANDY CLAY (CI-CH) Stiff, medium to high plasticity, pale red brown, fine to medium grained sand, with fine sized gravel, w>pl.	
						0.60		CI-CH	SILTY CLAY (CI-CH) Very stiff, medium to high plasticity, pale red brown, with fine sized gravel, with fine grained sand, w>pl.	
			ASS 1.00-1.50 m			1		CI-CH	SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown, with fine sized gravel, with fine grained sand, w>pl.	
			ASS 1.50-2.00 m							
			ASS 2.00-2.50 m			2				
			ASS 2.50-3.00 m							
			ASS 3.00-3.50 m			3				
						3.10		CI-CH	SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown mottled grey, with fine sized gravel, with fine grained sand, w>pl.	
			ASS 3.50-4.00 m							
			ASS 4.00-4.50 m			4				
			ASS 4.50-5.00 m							
			ASS 5.00-5.50 m			5				
			ASS 5.50-6.00 m							
						6.00			Hole Terminated at 6.00 m	

Method
AS - Auger
RR - Rock Roller
WB- Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.

Pacific Geotech
Consulting Geotechnical Engineers

Borehole No.
HA 04
Page 1 of 1

Project No.: PG-7768

Client:	Suzanne Stays	Commenced:	18/02/2022
Project Name:	Proposed Residential Building	Logged By:	SR
Hole Location:	99-105 Hamilton Street, Redland Bay	Checked By:	
Hole Position:			
Drill Model and Mounting:	Hand Auger	RL Surface:	No survey
Hole Diameter:		Datum:	AHD Operator: SR

Drilling Information							Soil Description			DCP
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	DCP TEST (AS 1289.6.3.2-1997) Blows per 100 mm
HA						0.10		SM	NATURAL SILTY SAND (SM) Loose, fine to medium grained, pale red brown, medium plasticity fines, with fine sized gravel, with organics, dry to moist.	0 5 10 15 20 25
						0.30		CI		
								CI-CH	SANDY CLAY (CI) Stiff, medium plasticity, pale red brown, fine to medium grained sand, with fine sized gravel, w>pl.	
						0.60		CI-CH	SILTY CLAY (CI-CH) Very stiff, medium to high plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w>pl.	
						1.00			SILTY CLAY (CI-CH) Hard, medium to high plasticity, pale red brown, with fine sized gravel, with fine to medium grained sand, w>pl.	
						1			Hole Terminated at 1.00 m	
						2				
						3				
						4				
						5				

Method
AS - Auger
RR - Rock Roller
WB- Washbore

Water
Level (Date)
Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Remarks
1. Groundwater not encountered.

Support
C - Casing

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

APPENDIX C

LABORATORY TEST CERTIFICATES

Pacific Geotech
Consulting Geotechnical Engineers

SHRINK SWELL INDEX REPORT

CLIENT:	Suzanne Stays	PROJECT NUMBER:	PG-7768
ADDRESS:	Hamilton St Redland Bay	REPORT NUMBER:	PG-7768-SS-01
PROJECT NAME:	Proposed Unit Development	REPORT DATE:	28/02/2022
		TEST METHOD:	AS 1289.7.1.1

SAMPLE LOCATION:	**BH02 @ 0.5m**
SAMPLING METHOD:	U50
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	11/02/2022
DATE TESTED:	17/02/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	22.4
SHRINKAGE (%):	4.4
SWELL MOISTURE CONTENT INITIAL (%):	24.1
SWELL MOISTURE CONTENT FINAL (%):	26.9
SWELL (%):	1.2
UNIT WEIGHT (t/m³):	1.75
SHRINK SWELL INDEX Iss (%):	**2.7**
CRACKING:	no
CRUMBLING:	no

REMARKS:

P: (07) 5636 4680 F: (07) 5636 0286 E: info@pacgeo.com.au
3 Jowett Street, Coomera, Qld, 4209 | PO Box 499, Paradise Point, Qld, 4216
www.pacgeo.com.au
ABN: 62 615 248 952

Pacific Geotech
Consulting Geotechnical Engineers

SHRINK SWELL INDEX REPORT

CLIENT:	Suzanne Stays	PROJECT NUMBER:	PG-7768
ADDRESS:	99-105 Hamilton St Redland Bay	REPORT NUMBER:	PG-7768-SS-02
PROJECT NAME:	Proposed Unit Development	REPORT DATE:	28/02/2022
		TEST METHOD:	AS 1289.7.1.1

SAMPLE LOCATION:	**BH04 @ 0.5m**
SAMPLING METHOD:	U50
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	11/02/2022
DATE TESTED:	28/02/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	24.5
SHRINKAGE (%):	4.8
SWELL MOISTURE CONTENT INITIAL (%):	21.9
SWELL MOISTURE CONTENT FINAL (%):	25.1
SWELL (%):	0.2
UNIT WEIGHT (t/m³):	1.75
SHRINK SWELL INDEX Iss (%):	**2.6**
CRACKING:	no
CRUMBLING:	no

REMARKS:

P: (07) 5636 4680 F: (07) 5636 0286 E: info@pacgeo.com.au
3 Jowett Street, Coomera, Qld, 4209 | PO Box 499, Paradise Point, Qld, 4216
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ABN: 62 615 248 952

Main Laboratory: Unit 34 / 53-57 Link Drive, Yatala QLD 4207, Australia
Tel: +61 (07) 3386 1164
Email: octieflab@octief.com.au
Website: www.octief.com.au

CERTIFICATE OF ANALYSIS

Report No. 22-0850
Rev No. 00

Client:	Pacific Geotech Pty Ltd	Sample Date:	18/02/2022
Client Contact:	Peter Elkington	Date Samples Received:	28/02/2022
Client Address:	3 Jowett Street	Date Analysis Commenced:	28/02/2022
	Coomera QLD 4209	No. Samples Received:	36
Purchase Order #:	PG-7768	No. Samples Analysed:	36
Project / Site Ref:	99-105 Hamilton St, Redland Bay	Date Issued:	28/02/2022

Lab Ref No.			pH	pH_{FOX}	pH_{FOX} Reaction Rating
Units	Sample Description	Depth (m)	pH	pH	
LOR			0.1	0.1	
22-0850/1	BH01	0.5	6.1	6.9	XXXX
22-0850/2	BH01	1.0	6.5	6.0	X
22-0850/3	BH01	1.5	6.2	5.6	X
22-0850/4	BH01	2.0	6.0	5.3	X
22-0850/5	BH01	2.5	5.8	5.1	X
22-0850/6	BH01	3.0	5.8	5.0	X
22-0850/7	BH01	3.5	5.9	5.3	X
22-0850/8	BH01	4.0	6.0	5.1	X
22-0850/9	BH01	4.5	5.8	5.0	X
22-0850/10	BH01	5.0	5.8	5.0	X
22-0850/11	BH01	5.5	5.9	4.9	X
22-0850/12	BH01	6.0	5.9	4.9	X
22-0850/13	BH02	0.5	5.8	5.1	X
22-0850/14	BH02	1.0	5.7	5.2	X
22-0850/15	BH02	1.5	5.8	5.4	X
22-0850/16	BH02	2.0	5.8	5.4	X
22-0850/17	BH02	2.5	5.9	5.0	X
22-0850/18	BH02	3.0	5.7	4.8	X
22-0850/19	BH02	3.5	5.7	4.9	X
22-0850/20	BH02	4.0	5.8	5.1	X
22-0850/21	BH02	4.5	5.8	5.1	X
22-0850/22	BH02	5.0	5.6	5.0	X
22-0850/23	BH02	5.5	5.7	4.5	X
22-0850/24	BH02	6.0	4.9	4.2	X
22-0850/25	BH03	0.5	5.7	5.1	X
22-0850/26	BH03	1.0	6.1	5.3	X
22-0850/27	BH03	1.5	5.8	5.2	X
22-0850/28	BH03	2.0	5.8	5.1	X
22-0850/29	BH03	2.5	5.9	5.0	X
22-0850/30	BH03	3.0	6.1	5.1	X
22-0850/31	BH03	3.5	5.8	4.9	X
22-0850/32	BH03	4.0	5.7	4.8	X
22-0850/33	BH03	4.5	5.7	4.7	X
22-0850/34	BH03	5.0	5.9	4.6	X

Lab Ref No.			pH	pH_{FOX}	pH_{FOX} Reaction Rating
Units	Sample Description	Depth (m)	pH	pH	
LOR			0.1	0.1	
22-0850/35	BH03	5.5	5.8	4.5	X
22-0850/36	BH03	6.0	5.3	4.1	X

Test Methodology: Analysis is conducted in accordance with inhouse method LAB300 which is in compliance with AS 4969-2008. Analysis Methods are derived from: Ahern CR, McElnea AE, Sullivan LA (2004). Acid Sulfate Soils Laboratory Methods Guidelines. Queensland Acid Sulfate Soils Manual 2004. Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia.

pH Screen Reaction Rating Table

Reaction Scale	Rate of Reaction
X	Slight Reaction
XX	Moderate Reaction
XXX	High Reaction
XXXX	Very vigorous reaction, gas evolved and heat generated, commonly >80°C

Approved Signatories:

Checked By: Lachlan Modina
Senior Laboratory Technician

Approved By: Daryl Surkitt
Manager Laboratory Technical Services

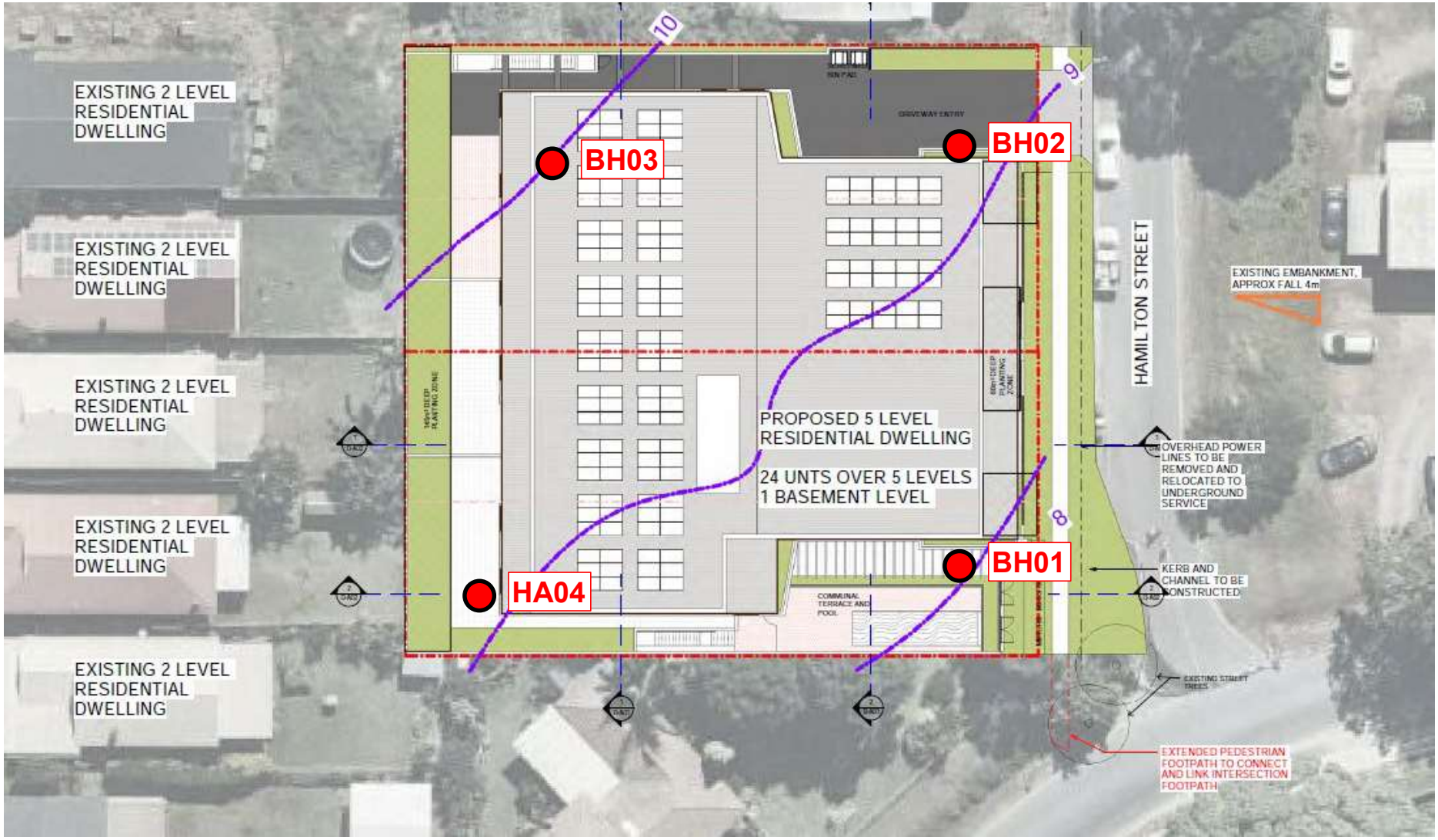
Notes: *NATA Accreditation does not cover the sampling performance*
OCTIEF accepts no responsibility for the collection, packaging and transportation of samples submitted by external parties
All samples are analysed as received and the results contained within this report relate only to the sample(s) submitted for analysis.
Measurement uncertainty data is available here.

NATA Accreditation Number: 15172
Accredited for compliance with ISO/IEC 17025- Testing

Tests not covered by NATA are denoted with *

APPENDIX D

SITE PLAN



Pacific Geotech
Consulting Geotechnical Engineers

Drawn AB	Project:	Proposed Residential Building	Drawing No. PG-7768-01	A4
Date Feb 2022	Location:	99-105 Hamilton Street, Redland Bay		
Checked	Client:	Suzanne Stays		