REPORT

TO

LLOYD ENERGY SYSTEMS PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED SOLAR THERMAL POWER PLANT

OFF

CONDOBOLIN ROAD, LAKE CARGELLIGO, NSW

22 January 2009

Ref: 22606VTrpt

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed solar thermal power station (Stage 1) off Condobolin Road, Lake Cargelligo, NSW. The investigation was commissioned by Mr Steve Hollis of Lloyd Energy Systems Pty Ltd. The investigation was carried out in accordance with our proposal, Ref: P30306VTProp.

The solar thermal plant will require the construction of a single storey portal frame (turbine) building and 16 side by side modules. Each module is to cover an area 43m by 64m in plan dimensions and will contain a 20m high steel (lattice) tower supporting a solar receiver/storage/boiler unit. Each leg of the tower would be supported, either on pad or piled footings. 112 separate tracking (heliostat) dishes will be constructed within each module and these will radiate out from each tower. The heliostat support posts are to be founded on steel screw piles or anchors embedded into the ground. We have been advised that the heliostat footing would be subject to a horizontal force of 4.8kN (working load) with an eccentricity of 2.5m above ground surface. Some relatively minor cut and-fill earthworks are also proposed at the site.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions at twenty-five locations as a basis for comments and recommendations on subgrade preparation and earthworks, site classification, footing design, soil dispersion and aggression.

2 INVESTIGATION PROCEDURE

Twenty-five test pits (TPs) were excavated using a Case 580C backhoe with a 600mm bucket to a common depth of 3m below existing surface levels. The test locations, as shown on Figure 1, were set out by taped measurements from grid-line pegs previously installed by the project surveyor, Arndell Surveying, Drawing Ref: 10361 dated 3 December 2008.

The strength of the clay subsoil profiles was assessed from both from our observations and hand penetrometer readings of the test pit sidewalls and recovered disturbed samples. Groundwater observations were made both during and on completion of the test pits. No long term monitoring of groundwater levels was carried out.

Our geotechnical engineer, Mr Joseph Chaghouri, set out the test pit locations, nominated the sampling and testing locations, and prepared logs of the strata encountered. The surface levels shown on the test pit logs have been determined by interpolation from the supplied spot levels at the grid-line pegs. The test pit logs, which include field test results and groundwater observations, are attached to this report together with a set of explanatory notes, which describe the investigation techniques and their limitations and define the logging terms and symbols used.

Soil Test Services Pty Ltd (STS), a NATA registered laboratory carried out moisture content, plasticity (Atterberg Limits, linear shrinkage), Emerson crumb dispersion and soil pH tests on selected soil samples. The test results are summarised in the attached Tables A and B. Contamination testing of the site soils was outside the scope of this investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site lies within relatively flat terrain about 1.3km to the east of Condobolin Road. The supplied survey information indicates that the site itself slopes gently, approximately to the north-east, falling from about RL 176.0m at the south-west corner to RL 177.7m in the north-east corner. The site and surrounding areas are vacant, consisting of paddocks sparsely covered with grass. The clay soils exposed at the ground surface contain small shrinkage cracks.

3.2 Subsurface Conditions

The test pits disclosed a subsurface profile generally consisting of silty clays and silty sandy clays. The more pertinent details of the encountered subsurface profile are discussed below. Bedrock was not encountered within the maximum investigation depth of 3m. Reference should be made to the attached test pit logs for detailed descriptions of the subsurface conditions.

- **Silty Clay and Silty Sandy Clay** was encountered from ground surface to the test pit termination depths. These clays contained limestone gravel were predominantly of medium to high plasticity, and were of very stiff to hard strength. In places (Test pits A5, B1, B4, B5, C1, C4, E1, E3 and E5), the surface clays were of stiff to very stiff strength.

- **Groundwater** seepage was not encountered during and up to 28 hours of excavation of individual test pits. No long term groundwater monitoring was undertaken.

- **Laboratory Testing:** The soil plasticity tests on three selected samples indicate that the silty sandy clay is of high plasticity and has an inferred high potential for shrink/swell reactivity. Soil pH tests results for three samples indicated that the silty sandy clays are strongly acidic with pH values between 4.9 and 5.2, which indicate that some measures should be taken to protect buried concrete in contact with these soils. The Emerson Class 5 results on two of the three samples indicate that the silty sandy clay soils are slightly dispersive or have a low potential for dispersion but may be susceptible to increased erosion when simultaneously exposed to raindrop impact and running water. The test results on the third sample of the high plasticity silty sandy clay indicated an Emerson Class Number of 2; these clayey soils are highly dispersive and are likely to soften in the presence of water.

4 COMMENTS AND RECOMMENDATIONS

4.1 Subgrade Preparation

Subgrade preparation for the proposed building, module and pavement areas, if any, will require clearance of vegetation followed by stripping of root affected topsoil. Following stripping, the following subgrade preparation should be undertaken below the on-ground floor slab for the building, or where the site is to be raised by filling:

- The silty clay and silty sandy clay subgrade exposed after stripping and excavation to the proposed design subgrade levels should be proof rolled using a 4-5 tonne dead weight smooth drum vibratory roller under the supervision of an experienced earthworks superintendent, geotechnician or geotechnical engineer to check for any unstable areas. Proof rolling would not be required below floor slabs, which are to be fully suspended and do not rely on the underlying subgrade for support.
- Where unstable areas are encountered the area should be locally excavated down to a sound base and replaced with engineered fill as detailed in Section 4.1.2.
- If shrinkage cracking of the clay surface occurs during dry weather, then prior to pouring concrete slabs or placing the pavement layers, the exposed surface should be sprayed with water and re-rolled to close up the surface cracks.

4.1.1 Dispersive Soils

The Emerson dispersion tests indicated Class Numbers of 2 and 5 for the silty sandy clay soils. We recommend that the all site soils should be treated as having a moderate to high dispersion potential, that is, they have a moderate to high potential to soften upon the introduction of water. Soil dispersion is likely to occur where there is overland flow or concentrated flows of run-off water.

We recommend the following safeguards be adopted in design and construction works and for long term maintenance.

- Adequate drainage should be provided to prevent ponding of surface water. A constant grade should be maintained to the runoff discharge point.
- The site may become untrafficable when wet and appropriate cross-falls should be maintained at all times.
- Adequate drainage should be provided to direct water away from the edge of the building, the tower and heliostat footings, and any other on-ground slabs and pavements, both during and following construction.
- Design should make allowance for the early collection and piping or lined channelling of surface water, wherever possible.
- Services trenches should be kept away from footings, on-ground slabs and pavements. The base of any trench should not encroach on a line of influence of 1V in 2H but with an offset of not less than 1m.
- Trench backfill should be compacted to the same specification to properly compacted engineered fill.
- Design of water carrying services should adopt joints which are likely to remain water-tight in the reactive clay subsoil profile.
- The on-site materials should be placed and compacted to a relatively high density and high moisture content, as specified for engineered fill.

- Due to the dispersive nature of the soils, our preference would be to add a mixture of lime and gypsum, at least to the upper sections of the exposed fill to reduce erosion. Alternatively, the fill capped with a better quality, non-dispersive material.
- The outer 'loose' surface, which inevitably occurs for the outer metre or so of fill batters should be trimmed off and the surface vegetated or otherwise protected.
- If soil softening occurs during construction, the on-ground floor slab subgrade should be over-excavated to below the depth of moisture softening and that the excavated material be replaced with clean, well-graded fill compacted as specified in Section 4.1.2. Desirably, the earthworks should be completed rapidly and the surface sealed as soon as possible. The earthworks should be carefully planned and scheduled to maintain cross-falls during construction.
- We recommend that reference be made to AS2870 for drainage and vegetation precautions on reactive clay sites.

4.1.2 Engineered Fill and Compaction Control

Engineered fill should preferably comprise well-graded granular material, free of deleterious substances and having a maximum particle size of 75mm. The on-site clayey soils are less desirable but may be re-used provided unsuitable ('over-wet' and 'over-size') material and any deleterious material is excluded. The engineered fill for backfilling excavations should be compacted in layers of not greater than 200mm (or 150mm if light plant or non vibratory rolling is required) loose thickness, to a density between 98% and 102% of Standard Maximum Dry Density (SMDD). Clay fill should be placed within 2% of Standard Optimum Moisture Content (SOMC). However, it would be wise to have a capping layer of better quality-imported fill over the clayey fill. The use of these clay soils for engineered fill will be more time consuming, weather dependent and will entail more rigorous earthworks supervision and compaction control than granular fill.

All platform fill should either be retained or battered to a slope of compacted fill of no steeper than 1 Vertical (V) in 2 Horizontal (H) to prevent instability. All engineered fill areas should be over-filled and compacted and then the loose outer face of the fill should be cut back so that only well-compacted fill remains. We recommend a horizontal compacted fill platform extend beyond the building periphery by at least 2m. All exposed fill should be protected from erosion by quickly establishing a grass cover.

Density testing should be carried out at the frequencies recommended in AS3798. At least Level 2 testing (or Level 1 if floor slabs are to be founded in engineered fill) of earthworks should be carried out in accordance with AS3798. Preferably, the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

Earthworks recommendations provided in this report should be complemented by reference to AS3798.

4.2 Footing Design

4.2.1 Site Classification

The silty clays and silty sandy clays are relatively deep and have a relatively high potential for shrink-swell reactive movements as a result of seasonal or local changes in subsoil moisture. Although the behaviour of reactive clays and its effects on a building or other movement sensitive structures is very complex, the prediction of ground movements may be undertaken in accordance with the method suggested in AS2870 "Residential Slabs and Footings – Construction". This technique involves the use of suction profiles and the Instability Index, a measure of soil reactivity. The design suction profile should be related to local experimental data for characteristic wet and dry profiles and for depths of soil movement. At the time of writing, this information was not available for the Lake Cargelligo area. Nevertheless, some guidance for design is given in the paper "Assignment of AS2870 Soil Suction Change Profile Parameters to TMI Derived Climatic Zones for NSW" prepared by I.C. Barnett and R.I. Kingsland and published in the Proceedings, 8th Australia New Zealand Conference on Geomechanics, Hobart (1999). This paper presents soil suction change profiles for NSW linked to regional climatic zones delineated using Thornthwaite Moisture Index contours. As the site is located within a semi-arid climatic zone, a depth of design suction change, Hs of 4.0m and a change in suction at the soil surface of 1.5pF to 1.8pF is recommended in the paper for design. Using these recommended values, an assumed Instability Index of 3.0% to 3.5%, based on the soil plasticity tests, and an assumed depth of the cracked zone of 0.75Hs, it is estimated ground surface movements would be between 95mm and 110mm due to shrink/swell reactivity. These shrink-swell movements are equivalent to those experienced by residential building footings on a "Class E" site in AS2870 (i.e. free surface movements greater than 70mm).

The roots of the trees and in particular the roots of the large trees, absorb water causing shrinkage of the clay soils. Any new tree plantings should be kept well away, that is, 1.5 times their mature height from movement sensitive structures. This distance should be increased by 50% if lines or groups of tree plantings are proposed. Note that as their root systems continue to grow, the effect of this moisture depletion will extend closer, and may lead to uneven movements below the proposed building or other structures. If trees are subsequently removed, the effect of the readjustment in soil moisture in the underlying clays should be carefully assessed.

4.2.2 Building Footings

Once the ground is covered, the moisture conditions in the underlying clays will vary, causing differential shrinking or swelling in the foundation below the proposed building. If the floor is placed on an initially 'dry' site, moisture would be trapped below the slab as surface drying is prevented and this would tend to produce centre heave particularly in the long term. If the 'dry' period is followed by a prolonged wet spell, moisture would migrate in from the slab edges. Alternatively, if the building is placed over a seasonally 'wet' site, centre heave would probably occur due to edge drying and shrinkage. The differential movement under these latter conditions may not be large.

The proposed building may be may be supported on a stiffened raft footing system founded in the clays of adequate bearing capacity. Alternatively, the building may also be supported on a bored pile and beam footing system; refer to Section 4.2.4.

A heavily stiffened raft would provide a suitable building footing system as raft action will accommodate local variations in support and would distribute load and reduce the impact of differential movements on the building superstructure. Guidance on the design procedure for stiffened rafts on reactive sites is given in Appendix F of AS2870. The raft footings should be founded at least 1.0m below adjacent ground levels but below any existing fill. These footings may be designed for a maximum allowable working bearing pressure of 250kPa when founded in the silty clay and sandy clay profile of hard strength.

The following measures may be considered to help control but not eliminate moisture movement below the building. These would include but would not be limited to:

- Regrading earthworks platforms, wherever practicable, to maintain cross-falls away from the building perimeter and pavements to promote run-off and reduce ponding.
- Construction of paving around the building to protect the periphery of the floor slab. We recommend that the paving extending for a width of 2.5m around the building. A waterproof membrane installed beneath the floor slab and the paving.
- The surface water discharging from the roof and all paved areas should be dispersed in such a way as to avoid concentrated flows and erosion near the building, other structures and external pavements.
- Attention is drawn to other precautionary, site and foundation maintenance measures, including effects of leaking plumbing, trees and vegetation, as outlined in AS2870.
- Flexible and movement tolerant forms of construction should be adopted.

4.2.3 Heliostat and Tower Footings

The heliostat posts are to be spaced at about 3.5m to 4m intervals on arc lines radiating out from each tower. Apart from the relatively minor earthworks and individual footing trenches, the ground surface is to be left untreated in and around the heliostat poles and the towers. It is proposed that pad footings be used to support the heliostat posts and the tower legs. These pad footings should be founded at least 1.0m below adjacent ground levels but below any fill. If the pads are constructed during the current 'dry' period, the clay foundation materials below each footing will tend to wet-up and soften as moisture reaches an equilibrium value below the footing. Given this potential for foundation softening, these footings may be designed for a maximum allowable working bearing pressure of 250kPa when founded in the hard silty clay and silty sandy clay profile provided due allowance is made for the shrink-swell movements associated with seasonal moisture changes in the clay foundation. At the 1m footing foundation level, these movements would be about 55mm to 65mm for the assumed suction profile (as discussed in Section 4.2.1). Alternatively, piled footings may be used; refer to Section 4.2.5.

Imposed uplift and overturning forces on the pad footings due to wind loading may be resisted by footing deadweight, passive resistance of the foundation soils, and/or tie-down anchors. For pad footings, the lateral restraint may be calculated using a triangular earth pressure distribution with a 'passive' earth pressure coefficient, K_p, of 3.5 for the silty sandy clay or silty clay of at least very stiff to hard strength (but with a factor of safety of at least 2), assuming horizontal ground in front of the footing. This passive resistance value assumes excavation is not carried out within the zone of influence of the footing, which may be defined by an envelope radiating upwards from the base of the trench at a slope of 26° to the horizontal. A bulk unit weight of 20kN/m^3 should be adopted for the soils. Soil anchors installed in augered or percussive drill holes without the use of flush water and cement grouted into the hard clayey soils may be designed using a working bond stress of 100kPa, when bonded below the assumed 0.75Hs cracked zone. Design of helix anchors will be dependent on a number of factors (soil strength and cohesion, cone pull-out, anchor diameter, pitch and embedment depth as well as the strength/stiffness of the anchor itself); further geotechnical input would be required to confirm design parameters for specific helix anchor systems. Anchor group interaction must also be taken into account. Permanent anchors should have appropriate corrosion provisions.

Even under the relatively low bearing pressures, heliostat footing performance will be dominated by the shrink-swell ground movements. More frequent and extensive maintenance than normal will be required and this should be allowed for. The steel heliostat posts may be supported on base plates with long tie-down bolts and adequate clearance around the bolt holes in the base plates so that the verticality of the pole and height can be adjusted as the footing moves.

4.2.4 Piled Footings

The building, the tower legs and heliostat posts may also be supported by bored, cast in-situ piles or augered, grout injected piles founded in the underlying clays. A further pile alternative could be steel screw piles, which could have similar working end bearing pressures to a grout injected pile. However, the working bearing pressure is dependent on the pile diameter and embedment depth as well as the strength/stiffness of the pile itself. Consideration should be given to long term corrosion and advice should be sought from the manufacturer. Also it is important to ensure that steel screw piles can penetrate to achieve an adequate embedment into the foundation strata.

Bored or grout injected piles embedded at least 4 pile (base) diameters into the silty clay and sandy clay profile may be designed for a safe bearing pressure of 500kPa. A safe shaft adhesion of 25kPa may also be adopted for the clays of hard stiff strength under compressive vertical loading. Two-thirds of this adhesion value may be adopted in uplift. The bearing and adhesion values assume footing bases have been cleaned of loosened or softened materials and sockets are free of smeared material (a special roughening tool is normally required to achieve this in bored piles)..

In designing piled footings to resist lateral loads, both the ultimate lateral resistance and maximum pile deflections will need to be assessed. It is likely that the lateral resistance will govern only if large deflections can be tolerated or if the piles are relatively 'short' and 'stiff'. Piles may be designed using the methods given in Australian Standard AS2159 – 1978, SAA Piling Code, adopting an assumed undrained cohesion value of 125kPa and an elastic modulus of 35MPa for the hard silty sandy clay and silty clay.

The piles would be subject to shrink/swell movements due to moisture variations in the clay foundation soils unless they are appropriately anchored into the ground below the expected 4m depth of soil moisture change (defined as H_s in AS2870-

1996). The piles should be designed for negative friction effects as the soil dries and for uplift as it swells. Anchoring is normally achieved by shaft adhesion acting on the lengthened section of the pile below the 4m depth. Assuming the hard clay profile continues well below the termination depth of the test pits, pile anchoring may require pile founding depths, possibly of the order of 6m to 7m below ground surface. The imposed structural loadings should be taken into account when in assessing the final depth of the piles. The piles should be heavily reinforced to cater for potential uplift tensile stresses induced by swelling soils. Due to the limited nature of the investigation, supplementary proving work should be carried out to confirm the subsoil materials and conditions below the termination depth of the test pits. This work may be undertaken by drilling and testing in boreholes or using the piling rig during the initial stages of construction.

Differential movements between piles may be controlled by the use of uniform diameter piles and construction techniques which reduce variations in shaft adhesion. Factors that affect shaft adhesion include:

- Remoulding of the materials on the sidewalls of the pile excavation.
- Smearing of cuttings on the sidewalls of the pile excavation.
- Migration of pore water towards the pile excavation due to reduction in stress caused by removal of material.
- Softening of the materials exposed in the sidewalls of the pile excavation due to free water entering the excavation or from fresh concrete.

The boring technique should therefore produce reasonably clean pile bases and shafts which are free of softened or remoulded materials. The addition of water to assist in digging the pile excavation should be avoided. Casting of piles immediately on completion of drilling is required to reduce soil moisture change during construction, especially if groundwater is encountered.

Where adopted, the pile and beam footing system will be subject to uplift when the reactive clay 'wets-up' during extended wet periods and design should make provision for the use of void formers or other measures below the beams. The piles should be tied into the stiffening beams. Alternatively, the beams should be underlain with void formers or similar (at least 120mm thick) to minimise the impact of uplift pressures. Another uplift protection means can be to tyne/loosen the soil below the ground beams for say 150mm depth.

4.2.5 Footing Construction

All shallow footings should be poured with minimal delay (ie preferably on the same day of excavation) or the base of the footing should be protected by a concrete blinding layer after cleaning of loose spoil and inspection. To reduce potential problems, the exposed soils should be maintained at constant moisture contents. Material allowed to locally dry out or wet up during construction may experience additional reactive movements once covered.

Bored pile footings should be drilled, cleaned, inspected and poured with minimal delay, on the same day. Water should be prevented from ponding in the base of footings as this will tend to soften the foundation material, resulting in further excavation and cleaning being required. Piles should be dewatered (by conventional pumping methods) prior to concreting or the concrete may be poured using tremie methods.

In order to minimise potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the proposed footing design and construction requirements.

The initial stages of footing excavation/drilling, particularly if bored piles are adopted, should be inspected by a geotechnical engineer/engineering geologist to ascertain that the recommended foundation material has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. The need for further inspections can be assessed following the initial visit.

4.3 Soil Aggression

The soil chemical tests have revealed strongly acidic subsoil conditions (pH values between 4.9 and 5.2). When assessed in accordance with the criteria for concrete and steel piling exposure classifications given in Tables 6.1 and 6.3 of AS2159-1995 "Piling-Design and Installation", the soil chemical pH tests have revealed that the soils are generally mildly aggressive toward buried concrete and are non-aggressive toward steel structures.

In designing for concrete durability, reference should be made to concrete strength and cover requirements listed in Table 6.2 of AS2159-1995 for the mildly aggressive exposure classifications. The use of denser concrete mixes or blended cements to reduce leaching of the cement matrix is recommended for concrete exposed to soil with a pH values between of 4.5 to 5.5. As the pH is relatively low, we recommend that the cover to steel reinforcement be at least 50mm.

5 FURTHER GEOTECHNICAL WORK AND GENERAL COMMENTS

As detailed in this report, further geotechnical work is recommended as follows:

- Additional subsurface investigation of the deeper foundation materials where piled footings are to be founded and anchored below the 4m depth of design suction change.
- Inspect proof rolling of the fill, silty clay and sandy clay subgrade to detect soft spots requiring treatment.

- Inspect footing excavations to ascertain that the recommended foundation has been reached and to check initial assumptions regarding foundation conditions and possible variations that may occur.
- Density tests to control compaction of any pavement or engineered fill layers.

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long-term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgement from an experienced engineer. Such judgement often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil will most likely require classification in accordance with the Department of Environment & Climate Change (NSW) guidelines as Virgin Un-Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected. We strongly recommend this issue be addressed prior to commencement of excavation on site.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

Tony Walker
Associate

QA Review by:

Fernando Vega
Senior Associate
For and on behalf of
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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1	4.3.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %	pH TEST
A3	1.00-1.50	21.2	57	19	38	16.0	5.2
C1	1.00-1.50	17.9	56	18	38	16.0	5.0
E5	1.00-1.50	20.2	59	20	39	16.5	4.9

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil description

Approved Signatory
(A.Tatikonda)

Date: 22/1/09

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SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
SUMMARY OF EMERSON CLASS NUMBER TEST RESULTS

BOREHOLE NUMBER	DEPTH (m)	Air dried soil crumbs in water	Remoulded soil samples in water	Calcium or Gypsum Present	1: 5 Soil/Water Suspension	Emerson Class Number
A3	1.00-1.50	Slaking (No Dispersion)	No Dispersion	Absent	Dispersion	5*
C1	1.00-1.50	Slaking (Partial Dispersion) (Bare Hint)	na	na	na	2
E5	1.00-1.50	Slaking (No Dispersion)	No Dispersion	Absent	Dispersion	5*

NOTES:
- The lowest Emerson Class Number refers to the highest dispersion potential(Range: Class 1 to Class 8)
- Test Method: AS 1289 3.8.1-1997
- All contact water was distilled water;water temperature was between 22 & 23°C
- Refer to appropriate notes for soil descriptions
- na denotes not applicable
- * Vigorous shaking causes dispersion

Approved Signatory
(A.Tatikonda)

Date: 22/1/09

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **A1** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT **Method:** CASE 580C BACKHOE 600mm BUCKET **R.L. Surface:** ≈ 176.4m

Date: 16-12-08 **Datum:** ASSUMED

Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 28 HRS			0		CH	SILTY CLAY: high plasticity, dark brown, with a trace of roots.	MC>PL	VSt-H	230 440 580	GRASS COVER
			1		CH	SILTY SANDY CLAY: high plasticity, orange brown, with a trace of fine to coarse grained limestone gravel, ash and roots.		H	>600 >600 >600	
			2						>600 580 590	
									>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Test Pit No. **A2** 1/1

TEST PIT LOG

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 16-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 176.7m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 27.5m HRS						0		CH	SILTY CLAY: high plasticity, dark brown, with a trace of roots.	MC>PL	VSt	240 240	GRASS COVER
								CH	SILTY SANDY CLAY: high plasticity, orange brown, with ash and a trace of fine to coarse grained limestone gravel and roots.		H	320 >600 580 >600	
						1						>600 >600 590	
						2						>600 >600 >600	
												>600 >600	
						3			END OF TEST PIT AT 3.0m				
						4							
						5							
						6							
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **A3** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT

Date: 16-12-08

Method: CASE 580C BACKHOE 600mm BUCKET

R.L. Surface: ≈ 177.1m

Datum: ASSUMED

Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 27 HRS			0		CL-CH	SILTY CLAY: medium to high plasticity, dark brown, with a trace of roots.	MC>PL	VSt	350 380 370	GRASS COVER
					CH	SILTY SANDY CLAY: high plasticity, orange brown, with ash and a trace of fine to medium grained limestone gravel.		H	>600 500 >600 >600 >600 >600 >600 >600	
			3			END OF TEST PIT AT 3.0m				

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **A4**

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT

Date: 16-12-08

Method: CASE 580C BACKHOE 600mm BUCKET

R.L. Surface: ≈ 177.4m

Datum: ASSUMED

Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 26.5 HRS			0		CL-CH	SILTY CLAY: medium to high plasticity, dark brown, with roots.	MC>PL	VSt	320 350 340	GRASS COVER
	DS		1			SILTY SANDY CLAY: medium to high plasticity, orange brown mottled light grey, with fine to coarse grained limestone gravel and ash.		H	>600 >600 >600	
	DS		2						>600 >600 >600	
	DS								>600 >600	ORGANIC ODOUR
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **A5**

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 16-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.5m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 26 HRS			0		CL-CH	SILTY CLAY: medium to high plasticity, dark brown, with a trace of roots.	MC>PL	St -VSt	360 160 120	GRASS COVER
						SILTY SANDY CLAY: medium to high plasticity, orange brown mottled light grey, with fine to coarse grained limestone gravel and ash.		H		
			1						>600 >600 >600	
			2						>600 >600 >600	ORGANIC ODOUR
									>600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **B1** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT | **Method:** CASE 580C BACKHOE 600mm BUCKET | **R.L. Surface:** ≈ 176.3m

Date: 16-12-08 | **Datum:** ASSUMED

Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 25.5 HRS						0		CL	SILTY CLAY: low to medium plasticity, dark brown, with roots.	MC>PL	St -VSt		GRASS COVER
								CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with fine to medium grained limestone gravel and ash.		H		
						1						>600 >600 >600	
									SILTY SANDY CLAY: high plasticity, orange brown mottled some grey, with ash.			>600 >600	
						2			SILTY SANDY CLAY: high plasticity, green grey mottled orange brown, with ash.			>600 >600 >600	
						3			END OF TEST PIT AT 3.0m				
						4							
						5							
						6							
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **B2** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT

Date: 16-12-08

Method: CASE 580C BACKHOE 600mm BUCKET

R.L. Surface: ≈ 176.7m

Datum: ASSUMED

Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES U50 DB DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 25 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with roots.	MC>PL	VSt	340 200 210	GRASS COVER
					CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with fine to coarse grained limestone gravel and ash.		H		
	DS		1						>600 >600 >600	
	DS		2			SILTY SANDY CLAY: high plasticity, orange brown, with ash.			>600 >600	
	DS								>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **B3** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT **Method:** CASE 580C BACKHOE 600mm BUCKET **R.L. Surface:** ≈ 177.0m
Date: 16-12-08 **Datum:** ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 24.5 HRS						0		CL-CH	SILTY CLAY: medium to high plasticity, dark grey, with roots.	MC>PL	VSt - H	>600 300	
						1		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled green grey, with ash and a trace of fine to medium grained limestone gravel.		H	>600 >600 >600	
						2						>600 >600 >600	
						3			END OF TEST PIT AT 3.0m				
						4							
						5							
						6							
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Test Pit No. **B4** 1/1

TEST PIT LOG

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT **Method:** CASE 580C BACKHOE 600mm BUCKET **R.L. Surface:** ≈ 177.4m
Date: 16-12-08 **Datum:** ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 24 HRS			0		CL-CH	SILTY CLAY: medium to high plasticity, dark brown, with roots.	MC>PL	St -VSt	270 150 290	GRASS COVER
						SILTY SANDY CLAY: medium to high plasticity, orange brown mottled light grey, with ash and a trace of fine to medium grained limestone gravel.		H		
	DS		1						>600 >600 500	
	DS		2						>600 >600 >600	
	DS				CH	SILTY SANDY CLAY: high plasticity, orange brown mottled green grey, with ash.			>600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **B5**
1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 16-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
Logged/Checked by: J.C./
R.L. Surface: ≈ 177.5m
Datum: ASSUMED

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 23.5 HRS			0		CL-CH	SILTY CLAY: medium to high plasticity, dark brown, with a trace of roots.	MC>PL	St -VSt	250 290 120	
					CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with ash and fine to medium grained limestone gravel.		H		
			1						>600 >600 >600	
			2			SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and red brown, with ash.			>600 >600 >600	
									>600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **C1** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT **Method:** CASE 580C BACKHOE 600mm BUCKET **R.L. Surface:** ≈ 176.2m

Date: 16-12-08 **Datum:** ASSUMED

Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 23 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with roots.	MC>PL	St- VSt	180 270	
	DS		1		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with fine to medium grained limestone gravel and ash.		H	>600 >600 >600	
	DS		2			SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and light grey, with ash.			>600 >600 >600 >600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **C2** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 176.6m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0		CL	SILTY CLAY: medium plasticity, dark brown, with roots.	MC>PL	VSt	240 320	
	DS		1		CL-CH	SILTY SANDY CLAY: medium to high plasticity, brown mottled orange brown, with a trace of fine to medium grained limestone gravel and ash.		H	>600 >600 >600	
	DS		2						>600 >600	
	DS					SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and red brown, with ash.			>600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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Test Pit No. **C3** 1/1

TEST PIT LOG

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.0m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 0.5 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with roots.	MC>PL	H	>600 >600 >600	
					CL-CH	SILTY SANDY CLAY: medium to high plasticity, orange brown mottled some light grey, with a trace of ash.			>600 >600	
			1							
						SILTY SANDY CLAY: medium to high plasticity, orange brown mottled green grey and red brown, with ash.				
			2						>600 >600	
									>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **C4**
1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.4m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 1 HR			0		CL	SILTY CLAY: medium plasticity, dark brown and brown, with a trace of roots.	MC>PL	St H	>600 >600	
			1		CL-CH	SILTY SANDY CLAY: medium plasticity, orange brown mottled light grey, with a trace of fine to medium grained limestone gravel and ash.				
			2			SILTY SANDY CLAY: medium to high plasticity, orange brown mottled green grey and light grey, with a trace of ash.			>600 >600 >600 >600 >600 >600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **C5** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.5m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 1.5 HRS			0		CL	SILTY CLAY: low to medium plasticity, dark brown, with a trace of roots.	MC>PL	VSt-H	370 500 >600	
					CL-CH	SILTY SANDY CLAY: medium to high plasticity, orange brown and light grey, with a trace of fine to medium grained limestone gravel and ash.		H	>600 >600 >600	
			1							
						SILTY SANDY CLAY: medium to high plasticity, orange brown with ash.			>600 >600 >600	
			2							
						SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and red brown, with ash.			>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Test Pit No. **D1** 1/1

TEST PIT LOG

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 16-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 176.1m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 22.5 HRS			0		CL	SILTY CLAY: low to medium plasticity, dark brown, with roots.	MC>PL	VSt	280 300	
			1		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with a trace of fine to medium grained limestone gravel and ash.		H	>600 >600 >600	
			2		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled green grey, with a trace of ash.			>600 >600	
						SILTY SANDY CLAY: high plasticity, green grey mottled orange brown, with ash.			>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **D2** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 176.6m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 3.5 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown and brown, with a trace of roots.	MC>PL	VSt -H	>600 380 >600	
					CL-CH	SILTY SANDY CLAY: medium to high plasticity, orange brown mottled light grey, with a trace of fine to medium grained limestone gravel and ash.		H	>600 >600	
			1							
						SILTY SANDY CLAY: medium to high plasticity, orange brown, with ash.			>600 >600 >600	
			2							
						SILTY SANDY CLAY: medium to high plasticity, orange brown mottled green grey, with ash.			>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **D3** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.2m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 3 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with a trace of roots.	MC>PL	H	520	
	DS				CL-CH	SILTY SANDY CLAY: medium to high plasticity, brown mottled light grey, with fine to medium grained limestone gravel and a trace of ash and roots.			>600 >600 >600 >600	
			1							
	DS					SILTY SANDY CLAY: high plasticity, orange brown mottled green grey, with a trace of ash.			>600 >600 >600	
			2							
	DS								>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **D4**

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.4m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 2.5 HRS			0		CL	SILTY CLAY: low plasticity, dark brown, with roots.	MC>PL	H	>600 >600 >600	
					CL-CH	SILTY SANDY CLAY: medium to high plasticity, brown mottled light grey and green grey, with a trace of fine to medium grained limestone gravel, ash and roots.			>600 >600 >600	
			1		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and red brown, with ash.			>600 >600	
			2			SILTY SANDY CLAY: high plasticity, green grey mottled orange brown and red brown, with a trace of ash.			>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

TEST PIT LOG

Test Pit No. **D5** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT **Method:** CASE 580C BACKHOE 600mm BUCKET **R.L. Surface:** ≈ 177.5m
Date: 17-12-08 **Datum:** ASSUMED
Logged/Checked by: J.C./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 2 HRS	DS		0		CL	SILTY CLAY: low plasticity, dark brown, with a trace of roots.	MC>PL	H	>600 >600 >600	
						SILTY SANDY CLAY: medium plasticity, brown mottled light grey, with a trace of fine to medium grained limestone gravel, ash and roots.				
	DS		1.5		CH	SILTY SANDY CLAY: high plasticity, orange brown, with ash.			>600 >600 >600	
	DS		2.6						>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				

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TEST PIT LOG

Test Pit No. **E1**
1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 16-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 176.1m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 22 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with roots.	MC>PL	St-VSt	270 190 270	
					CH	SILTY SANDY CLAY: high plasticity, orange brown mottled light grey, with fine to coarse grained limestone gravel, and a trace of ash and roots.		H		
	DB		1						>600 >600 >600	
						SILTY SANDY CLAY: high plasticity, orange brown mottled green grey and some light grey, with ash.				
	DB		2						>600 >600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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TEST PIT LOG

Test Pit No. **E2**

1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD

Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)

Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT

Date: 17-12-08

Method: CASE 580C BACKHOE 600mm BUCKET

R.L. Surface: ≈ 176.6m

Datum: ASSUMED

Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 5.5 HRS						0		CL	SILTY CLAY: low to medium plasticity, dark brown and brown, with a trace of roots.	MC>PL	VSt	250 230	
								CL-CH	SILTY SANDY CLAY: medium to high plasticity, orange brown mottled light grey, with fine to coarse grained limestone gravel, roots and a trace of ash.		H	>600 >600 >600	
						1							
												>600 >600 >600	
						2							
									SILTY CLAY: medium to high plasticity, orange brown mottled green grey, with ash.			>600 >600 >600	
						3			END OF TEST PIT AT 3.0m				
						4							
						5							
						6							
						7							

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TEST PIT LOG

Test Pit No. **E3** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
Logged/Checked by: J.C./
R.L. Surface: ≈ 177.1m
Datum: ASSUMED

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 5 HRS			0		CL	SILTY CLAY: low to medium plasticity, dark brown mottled brown, with a trace of roots.	MC>PL	St-VSt	210 200 140	
					CH	SILTY SANDY CLAY: high plasticity, brown mottled light grey, with fine to medium grained limestone gravel and ash.		H		
	DS		1						>600 >600 >600	
	DS		2		CL	SILTY CLAY: medium plasticity, orange brown mottled green grey and brown, with ash.			500 510 410	
	DS								>600 560 580	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							

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Test Pit No.
E4
1/1

TEST PIT LOG

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
R.L. Surface: ≈ 177.4m
Datum: ASSUMED
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 4.5 HRS			0		CL	SILTY CLAY: low plasticity, dark brown mottled brown, with a trace of roots.	MC>PL	VSt	360 280 270	
					CH	SILTY SANDY CLAY: high plasticity, brown mottled green grey and some light grey, with ash.		H	>600 >600 >600	
			2			SILTY CLAY: high plasticity, green grey mottled brown and orange brown, with ash.			500 530 420 580 >600 >600	
			3			END OF TEST PIT AT 3.0m				

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7

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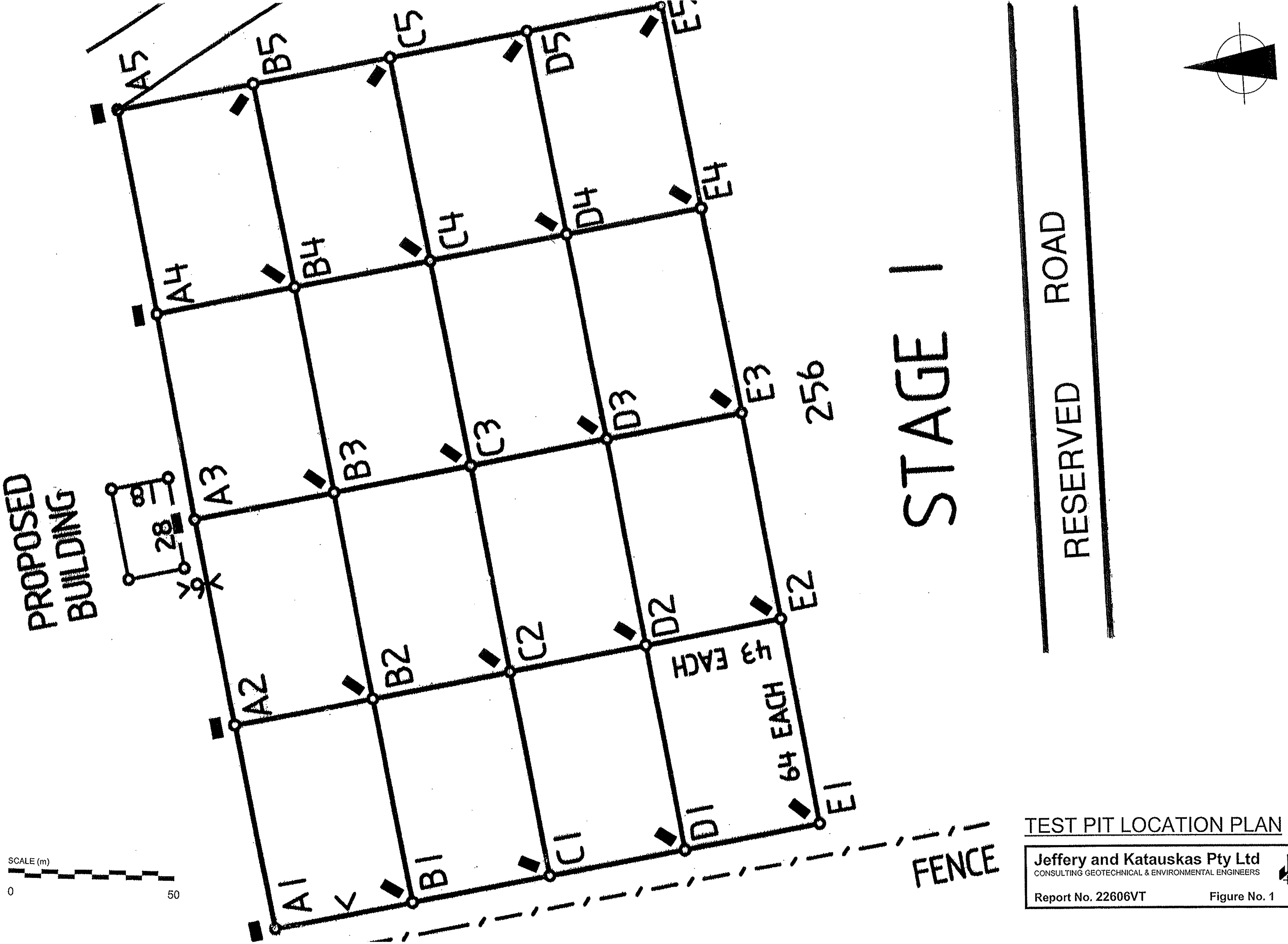
TEST PIT LOG

Test Pit No. **E5** 1/1

Client: LLOYD ENERGY SYSTEMS PTY LTD
Project: PROPOSED SOLAR THERMAL POWER PLANT (STAGE 1)
Location: OFF CONDOBLIN ROAD, LAKE CARGELLIGO, NSW

Job No. 22606VT
Date: 17-12-08
Method: CASE 580C BACKHOE 600mm BUCKET
Logged/Checked by: J.C./
R.L. Surface: ≈ 177.4m
Datum: ASSUMED

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 4 HRS			0		CL	SILTY CLAY: medium plasticity, dark brown, with a trace of roots.	MC>PL	St-VSt	330 250 140	
					CH	SILTY SANDY CLAY: high plasticity, brown mottled light grey and orange brown, with a trace of fine to medium grained limestone gravel and ash.		H		
			1						>600 >600 >600	
			2			SITLY SANDY CLAY: high plasticity, brown mottled green grey, with ash.			>600 >600	
						SILTY CLAY: high plasticity, green grey mottled brown and orange brown, with ash.			>600 >600	
			3			END OF TEST PIT AT 3.0m				
			4							
			5							
			6							
			7							



TEST PIT LOCATION PLAN

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Report No. 22606VT | Figure No. 1

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ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

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 grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	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, generally 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) either by use of hand penetrometer, 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. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with 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

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with 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 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. 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 usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

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 relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very 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

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

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 occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

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. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of 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 blown out of 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 which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg 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 with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

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 that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

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 joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always 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 presence on site.

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GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

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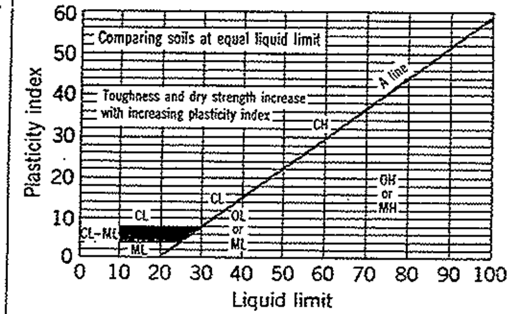
UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 µm and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than 75 µm sieve size[b] (The 75 µm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 µm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Identification Procedures on Fraction Smaller than 380 µm Sieve Size		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than 75 µm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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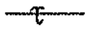
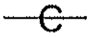
LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 — 0-4
	L	Loose 15-35 — 4-10
	MD	Medium Dense 35-65 — 10-30
	D	Dense 65-85 — 30-50
	VD	Very Dense >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
		0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
		0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
		0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
		1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
		3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
		10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	