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ARDILL PAYNE AND PARTNERS PTY LTD

PRECINCT A
CUMBALUM URBAN RELEASE AREA
SLOPE STABILITY ASSESSMENT

04097/1-H
2 October 2009

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04097/1-H ps:PS
2 October 2009

Ardill Payne and Partners Pty Ltd
PO Box 20
BALLINA NSW 2478

Attention: Mr Paul Snellgrove

Dear Sir,

RE: SLOPE STABILITY ASSESSMENT, PRECINCT A, CUMBALUM URBAN RELEASE AREA

Please find attached our report on the stability of the natural slopes within Precinct A of the Cumbalum Urban Release Area.

The assessment has been carried out broadly in accordance with the "Practice Note Guidelines for Landslide Risk Management 2007", AGS (2007C), Journal and News of the Australian Geomechanics Society, Volume 42, No 1, March 2007.

If you have any questions or wish to discuss or clarify any of the issues raised in this report, please contact Philip Shaw at our Brisbane office.

For and on behalf of
SHAW URQUHART PTY LTD

Philip Shaw

PHILIP SHAW
Principal Geotechnical Engineer

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TABLE OF CONTENTS

1. INTRODUCTION

At the request of Ardill Payne and Partners Pty Ltd, Shaw Urquhart Pty Ltd has carried out an assessment of the stability of the natural slopes within Precinct A of the Cumbalum Urban Release Area (CURA).

The area of Precinct A has been divided into two sections for ease of reference as shown on Figures 2 and 3.

Shaw:Urquhart has been provided with a site contour plan of the Precinct which is understood to be based on a combination of ortho-photo contour values and limited ground survey measurements. In some localised areas, there is disagreement between the elevation values of the two survey methods which has led to localised contour anomalies. These are generally apparent as very closely-spaced and oddly-shaped contours, however some anomalies are less obvious. As such, care should be taken in inferring slope angles and topographic features based on the contours alone and should be confirmed by field observations and measurements.

2. SCOPE OF WORK

The scope of work carried out for the stability assessment included the following activities:

- A walk-over assessment by an Engineering Geologist to view the site and make observations of local geology and geomorphology with regard to the past, present and potential future stability of the natural slopes. The results of the walk-over assessment and some site observations and interpretations are shown on Figures 2 and 3, and are discussed in Sections 3 and 4. Site observation notes are presented in Appendix B.
- Backhoe test pits excavated at selected locations to assess the broad-scale subsurface conditions present on site. Engineering logs of the test pits along with explanation sheets describing the terms and symbols used are presented in Appendix A.

The slope stability studies and subsurface investigations were restricted to areas of the proposed development located on higher ground above approximately RL4m to RL6m with slopes of typically greater than approximately 5°.

The assessment has been carried out broadly in accordance with the "Practice Note Guidelines for Landslide Risk Management 2007", AGS (2007C), Journal and News of the Australian Geomechanics Society, Volume 42, No 1, March 2007.

3. SITE CONDITIONS

3.1 Surface Conditions

The study area is dominated by a major north-west to south-east trending ridge known locally as the Cumbalum Ridge. At the northern end, the ridge has an extension to the east and a narrow valley separates this extension from another, smaller, east-west trending ridge located in the north-west corner of the study area.

The crests of the ridges typically rise from around RL55m to RL85m. The ridge crests are mainly covered with open, grassed paddock with scattered trees. Slope angles on the ridge crests are gentle to moderate, generally around 5° to 10°.

The slopes of the upper and middle flanks of the ridges fall in all directions with slope angles typically in the range of 12° to 25° with local areas of steeper slopes. Slope angles on the lower slopes tend to be flatter, at around 5° to 15°. The ridge slopes are mainly covered with open, grassed paddock with some areas of dense tree cover.

The north-western corner of the site is incised by a number of steep-side drainage gullies draining into a large farm dam (Site Observation Location 34) located in a narrow valley adjacent to the northern boundary of the Coop Property. The small creek which drains eastwards from the dam forms an area of marshy ground on the floor of the valley (Site Observation Location 28).

Very steep slopes were observed in this area. Slope angles of around 25° to 36° were observed at site observation Locations 60, 61 and 62 on the sides of a steep gully. Very steep slopes of 25° to 35° were also observed on the southern, eastern and western sides of the dome-shaped hill at site observation locations 36, 37 and 38. A steep eroded cliff around 5m high was noted at Site Observation Location 65. Very steep slopes of up to 30° were observed along the north boundary of the Coop Property at Site Observation Locations 70 and 71.

Exposures of red-brown silty clay with soil scarring and shallow slumping were observed at Site Observation Locations 36 and 62. Vegetation cover on the ridge crests and flanks in this area is mainly grassed paddock with a number of areas of dense woodland with surface boulders.

In the area of Site Observation Locations 21 to 27, the natural slopes are steep to very steep, typically around 24° to 27°. On the up-slope side of the access driveway at this location is an area of terraced ground with a possible small, shallow landslide at Site Observation Location 21. A broad, bowl-shaped area was noted at Site Observation Location 26 and a possible shallow landslide around 15m wide was noted at Site Observation Location 27.

At Site Observation Location 29, the creek channel has eroded into the northern bank of the creek forming very steep slopes of around 28° to 30°.

Slope angles on the broader, east-west trending ridge crest are gentle to moderate, generally around 5° to 10°, with moderate to steep slopes falling to the north and south at typically 10° to 25° with locally steeper areas.

A medium size farm dam is present on the central eastern side of the site (Site Observation Location 45) and two very small dams are located in the northern side of the ridge crest at Site Observation Location 40. Some gully erosion was noted in the creek channel flowing into the farm dam at Site Observation Location 46.

An area of possible slope instability with strong groundwater seepage was noted in the south western area of the site at Site Observation Location 56.

Three houses are located on the Barlow property. The Barlow house is located on the ridge crest in the north western side of the site and is accessed via a sealed driveway. A second house is located near the driveway entrance on the west side of Sandy Flat Road. A timber house (apparently disused) is located on the south side of Sandy Flat Road in the northern central part of the site.

Two houses are located on the Vixsun Pty Ltd and Coop properties and a further two are located immediately west of the site within the future bypass easement.

A number of areas of dense woodland with numerous surface boulders were observed on the site, at Site Observation Locations 56, 60, around 64 and 65, around 70 to 71, around 76, 77 and 78 and in the area of Site Observation Locations 93, 94 and 95.

A large area of excavation has been carried out in the south western corner of the site around Site Observation Location 49, used as a borrow area for the Ballina Heights development.

It is understood that a sewer main crosses the south western corner of the site, with manholes at Site Observation Location 47. It is also understood, from anecdotal evidence, that a fibre optic cable crosses the centre of the site in an approximately north-south orientation, however the exact location of the cable is not known. A water main marker was noted at Site Observation Location 75 in the north western area of the site.

Some site observations are shown on Figures 2 and 3 and are described in Appendix B.

3.2 Subsurface Conditions

According to published geology maps of the area (1:250,000 "Tweed Heads" sheet), the site is underlain by weathered volcanic rocks of the Tertiary Lismore Basalt with weathered metamorphic rocks of the Palaeozoic Neranleigh-Fernvale Beds exposed in cut batters at the bases of slopes at some locations.

The regional geology is summarised on Figure 1 and includes observations from the current studies.

3.2.1 Elevated Areas

A prominent, linear outcrop of weathered basalt is located on the northern edge of the upper ridge slopes at or near Site Observation Locations 39, 40 and 41. Weathered metasiltstone is exposed at Site Observation Location 32 and it is considered that the interface between the two rock types is located immediately up-slope of this location (and possibly on the northern side of the creek) at around RL14m to RL16m. Weathered metasiltstone is also exposed on the cut side of the farm dam at Site Observation Location 46 and fragments of metasandstone and greywacke were observed in clay soils in the south eastern corner of the site at Site Observation Location 84.

Subsurface investigations indicate that the soil profile across the site is relatively consistent, comprised of a surface layer of typically 0.8m (TP8) to greater than 3.0m (TP22) of red brown clayey silt and silty clay/clayey silt with basalt cobbles and occasional boulders underlain by to extremely weathered to highly weathered basalt. In test pit TP18, the red brown residual soils were underlain by extremely to highly weathered metasiltstone at a depth of 1.0m.

In test pits TP3, TP13 and TP16 (located on the lower slopes of the ridge flanks), the residual soils are underlain by extremely to highly weathered metasiltstone. Test pit TP12 encountered a surface layer of 1.2m of clayey silt fill with numerous cobbles and boulders, underlain by natural soils. Fill is also present as embankments for farm dams and access tracks and in the house platform at Site Observation Location 67.

Exposures of yellow brown silty clay containing metasiltstone fragments were observed at Site Observation Locations 35 and 64 and exposures of extremely to highly weathered metasiltstone were observed at Site Observation Locations 38 and 72. At Site Observation Location 72, foliation planes in the metasiltstone were observed dipping west at 60° to 75°.

At Site Observation Location 98 is a cut batter, around 4m high and 90m long, exposing residual, red-brown clay soils and basalt cobbles and boulders.

Red-brown to brown colluvial soils are exposed in the road cutting on the south west side of Sandy Flat Road at Site Observation Location 18.

Approximate test pit locations are shown on Figures 2 and 3.

3.2.2 Flood Plain Areas

No subsurface investigations were carried out in the flood plain areas as part of the current study.

From previous investigations in the area, the flood plain is expected to be underlain by an inter-bedded sequence of alluvial clays (locally organic-rich) and sands with localised gravel layers. The alluvial soils are in turn underlain by residual clay soils and, depending on location, weathered basalt or weathered sedimentary rocks.

3.3 Groundwater

Groundwater seepage was not observed in any of the test pits.

Strong surface groundwater seepage was observed in the area of Site Observation Locations 52, 57 and 58 in the south western area of the site. Surface groundwater seepage was also note at Site Observation Location 74 in the north western area of the site. In general, it is expected that groundwater seepage will tend to occur at or near the interface of the weathered basalt or residual, basalt derived soils and the underlying metamorphic rocks.

It is expected that the small number of farm dams present on site are mainly replenished by surface water flow rather than springs.

Surface water was observed in the northern area of the site below approximately RL4m to RL6m. In this area and in the low-lying ground in the south eastern part of the site, it is expected that the groundwater level will lie at, or at shallow depth below, the ground surface.

4. STABILITY OF NATURAL SLOPES

4.1 Discussion

Natural slopes are formed by processes which reflect the site geology, climate and environment. These processes result in ongoing down slope movements of materials within the slope. The area of influence of these down slope movements may range from local to regional. The natural process may be influenced by human intervention in the form of construction and related activities. It must be accepted that the risks associated with construction on or immediately adjacent to steep slopes are greater than construction on level ground in the same geological environment. The impact of construction may be adverse and poor construction practice and techniques may increase the potential likelihood of ground movement.

It is not technically feasible to assess the stability of the natural slopes on a particular site in absolute terms such as "stable" or "unstable". However, a degree of likelihood of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface conditions and with the benefit of experience gained in similar geological and engineering environments.

A number of different methodologies have been used for slope stability studies in various areas of Australia. A five-fold subdivision of landslide likelihood categories has been developed by the Australian Geomechanics Society-Sydney Group (AGS-SG) and is described in their 1985 paper on "Geotechnical Risk Associated with Hillside Development". In March 2000, the AGS Sub-Committee on Landslide Risk Management subsequently published "Landslide Risk Management Concepts and Guidelines" which reviews and revises the earlier publication.

The following definitions of terms are taken from the Australian Geomechanics Society Sub-Committee on Landslide Risk Management publication titled "Landslide Risk Management Concepts and Guidelines" (March 2000), Appendix A (hereafter referred to as "the AGS report"). Brief definitions of some terms used in this report are as follows:

Risk – a measure of the probability and severity of an adverse effect to health, property or environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation involves a comparison of the probability and consequences in a non-product form.

Hazard – A condition with the potential for causing an undesirable consequence (eg. a landslide). The description of a landslide hazard should include location, volume or area and classification. The velocity of potential landslides and the probability of occurrence should also be included, if known.

Probability – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1.

Likelihood – used as a qualitative description of probability or frequency.

Landslide - synonymous with "landslip", refers to an event where a portion of hillside or sloping ground becomes detached from the parent material and moves down slope. They may be subdivided according to size, the type of materials involved as well as the mechanisms of failure and the speed at which the failed material moves.

The general approach of these publications is to define and assess "risk" as a function of the likelihood or probability of an event occurring (such as a landslide) and the potential consequences of such an event (eg. damage to property, loss of life etc.). Landslide hazard zonation is a method of assessing the distribution of areas of different relative likelihood of a potential hazard (in this case, ground movement) to incorporate management of the hazard and associated risk into local planning and development.

In simple form, the risk assessment process involves answering the following questions:

- What might happen?
- How likely is it?
- What damage or injury may result?
- How important is it?
- What can be done about it?

In this study, only a preliminary assessment is made of the first two items listed above, namely "what might happen" (small to larger scale slope movement) and "how likely is it". Site observations indicated a number of areas of previous and continuing instability as described in Section 4.3. It is understood however that there is no documented record of the slope instability and the periodic history and frequency of slope instability on the site is therefore not known.

As noted above, the concept of "risk" associated with a hazard (in this case, medium to larger-scale slope instability) may be defined as a function of Likelihood and Probability/Significance. At this stage, the nature and locations individual structures and the expected large-scale earthworks associated with construction of the development are not known. It is therefore recommended that risk assessments be carried out for known hazards (including slope instability) when this information has been finalised.

The assessment of risk is based on slope stability analyses of natural slopes on other sites of similar geology.

The main causes of landslides are well documented in the literature and include the following factors:

- Slope angle.
- Underlying geology and soil types.
- Vegetation cover.
- Variable and transient factors such as rainfall intensity, overland water flows, groundwater flows, piezometric pressure and seismic vibrations.
- Presence of soil masses in a potentially unstable condition.
- Man-made factors such as excavations, construction activity, removal of vegetation and changes to the surface and subsurface drainage.

In a given area, some of the above factors can be identified, while other possible contributing factors can be considered. From a study of existing landslides and an assessment of the likely mechanisms and influences on these events, it is possible to develop an understanding of the processes involved which in turn allows an assessment to be made of the potential, relative likelihood of similar conditions arising in other adjacent areas.

Landslides within the study area may also be induced by man-made factors. Known causes of landslides in other areas include but are not limited to:

- Construction of loose, uncompacted fill slopes.
- Undercutting of steep slopes.
- Relocation of water courses adjacent to the toes of slopes.
- Concentrated stormwater run-off from roads or building platforms causing fill failures.
- Poor design and/or construction of retaining structures.
- Ground saturation of land below septic waste disposal absorption fields.

This preliminary assessment has not attempted to assess slope stability issues relating to man-made structures.

For slope stability assessments, the following terms and their descriptions are generally used.

Likelihood	Description
Very Low	Not Credible
Low	Rare
Medium	Unlikely
High	Possible
Very High	Likely

4.2 Hazard Identification

Based on site observations, it is expected that the nature of potential instability on the natural slopes would take the form of shallow soil creep, soil scarring and small to medium size, shallow landslides. The most likely location for potential instability is at or close to the interface between the red-brown clay soils and underlying grey to yellow brown clayey silt/extremely weathered metasiltstone. Larger-scale instability could be triggered by engineering works such as excavations, filling and changes in drainage patterns.

In relation to run-out distances, consideration has been given to the observations of Shaw:Urquhart personnel over many years in relation to landslides in the Ballina area in similar geology and topography. It is our general observation that landslides on slopes angles typical of the High Likelihood areas on this site have very limited run out distances and are generally contained within the steeper section of slope. The landslides are shallow and tend to be rotational with much of the soil debris remaining intact. The volume of water within the spoil mass tends to not be sufficient to result in a mud slide or debris flow type failure mechanism. Once the landslide has occurred, erosion of the landslide debris due to stormwater runoff can result in the transportation of soils some distance down-slope from the landslide but this does not constitute a significant risk and can be managed.

4.3 Results of Slope Stability Assessment

A number of areas of existing or possible slope instability were observed on the site, summarised as follows:

- Steep to very steep southern slopes in the area of Site Observation Locations 21 to 27. On the up-slope side of the access driveway is an area of terraced ground with a possible small, shallow landslide at Location 21. This possible ground movement may be associated with the up-slope overflow discharge of the rainwater tank for the adjacent house. A broad, bowl-shaped area was noted at

Location 26 and a possible shallow landslide around 15m wide was noted at Location 27.

- Site Observation Location 29, where the creek channel has eroded into the northern bank of the creek forming very steep slopes of around 28° to 30°. This area may represent a medium-sized landslide on the creek bank resulting from undercutting of the bank by erosion.
- North facing slopes in the area of Site Observation Locations 30 to 32 at and adjacent to the interface between the overlying red-brown residual soils and weathered basalt and the underlying weathered metamorphic rocks. No existing landslides were observed in this area, however it is known from other similar sites that this interface zone is prone to instability due to perched water tables forming at the base of the weathered basalt and residual basalt-derived soils.
- Very steep slopes with soil slumping and scarring and slope terracing were observed at Site Observation Locations 36, 37, 38 and 62.
- Small, shallow soil slumps or small landsides were noted in the side of the drainage gully at Site Observation Location 60.
- Very steep slopes and severe slope erosion and undercutting were noted at Site Observation Location 65.
- A possible shallow landside was noted in the very steep slopes and shallow gully at Site Observation Location 70.
- Strong groundwater seepage and possible slope instability were noted in the area of Site Observation Locations 52, 56, 57 and 58.

Localised soil erosion and slumping may also occur on the banks of steep, incised drainage gullies.

Areas of fill are present on the site. The farm tracks and farm dams present on site have largely been formed by cut and fill. It is expected that the fill is uncontrolled and fill batters are susceptible to slumping and localised failure. Localised erosion and slumping is also likely on the cut batters excavated in clay soils. Fill is also present on the eastern side of the Coop residence.

In order to simplify the interpretation of the results of the stability assessment, and to assist in interpreting the local geomorphology and geology in terms of potential slope instability, the site may broadly divided into areas of different Likelihood of slope instability as follows:

- **Low Likelihood**: - Low-lying areas and the crests and upper slopes of ridges and spurs with slopes of less than 12°.
- **Medium Likelihood: -** Areas with slopes of 12° to 18°.
- **High Likelihood:** - Areas with slopes of 18° or steeper.

It should be appreciated that likelihood of slope instability is not defined by slope angle alone and hazard zoning needs to also taken into account many other parameters including drainage, observations on site and site geology as understood from subsurface investigations.

Due to the potential localised inaccuracies of the contours on the site plan, the boundaries between the different zones should be considered as approximate only, to be confirmed at the design stage by more accurate survey.

The interpreted zones of different likelihood of instability are presented on Figures 3 and 4. These are as interpreted from measured slope angles, site observations and subsurface investigations and may not strictly follow the simplified slope angle categories described previously.

4.4 Constraints to Residential Development

Preliminary development constraints outlined in Table 1 may be considered typical for a site of this type and may be considered for preliminary concept planning purposes.

TABLE 1: EXAMPLES OF TYPICAL CONSTRAINTS ON STEEPLY SLOPING LAND

Low Likelihood	• Minimise earthworks. Maximum unsupported cut depths and fill thicknesses of 1.5m battered no steeper than 2H:1V are recommended unless subject to site-specific engineering investigations and design. Steeper and deeper unsupported cuts and fills should be supported with engineered retaining walls. • Pre-strip the vegetation and topsoil prior to placement of any filling, and bench engineered fill into the natural slope and compact to standards appropriate to its purpose. • Provide appropriate surface and subsurface drains, and direct water collected by these drainage systems, together with roof run-off, into the stormwater system.
Medium Likelihood	For residential buildings constructed on natural slopes and founded in residual soils, it is recommended that the type of building be restricted to lightweight structures of timber or similar construction to limit surcharge loadings on the slope. Depending on the results of an appropriate, site specific, geotechnical assessment, the constraints typically incude: • Avoid development upon, or in the vicinity of, areas of groundwater seepage (springs). • Identify and avoid development near locally over-

	steepened areas or gullies. • Pay particular attention to drainage and erosion control measures during site development. • Locate footings on rock where practical, or in the residual soil profile. • Minimise bulk earthworks. Maximum unsupported cut depths and fill thicknesses of 1.5m, and batters no steeper than 2H:1V are recommended unless subject to site-specific engineering investigations and design. Steeper and deeper cuts and fills should be supported with engineered retaining walls. • Found engineered retaining walls in weathered rock where practicable, and designed to resist applied soil and water forces, allowing for the sloping ground.
High Likelihood	New residential developments should only be permitted in areas zoned High Likelihood where: • Detailed geotechnical investigations can demonstrate the High Likelihood zoning of the site is inappropriate and a lesser classification is justified; and/ or in combination with • Engineering works, which will allow the landslide likelihood category to be downgraded. Prior to any work proceeding in High Likelihood areas, a visual assessment should be conducted by an experienced geotechnical consultant. The visual assessment will probably be insufficient to define the degree of risk but should be used to establish the scope of geotechnical investigation work required.

4.5 Risk Assessment

As discussed previously "risk" as defined in the Australian Geomechanics Society publications is a measure of the probability and severity of an adverse effect to health, property or environment. Risk is often estimated by the product of numerical probability x consequences. However, a more general interpretation involves a comparison of the probability and consequences in a non-product form.

To carry out a full risk assessment of the Precinct A area would require a full understanding of the allotment layouts, road geometry and the nature of the various developments, residential and commercial, proposed for the area.

At this stage only a general assessment is feasible based on assumptions regarding the proposed development.

It is our opinion based on Appendix C of the Practice Note Guidelines for Landslide Risk Management 2007 that, if development is restricted to areas having a Low or Medium Likelihood of instability and the geotechnical development constraints listed in the geotechnical reports are strictly followed, the areas identified on the Structure Plan can be developed with a Low to Very Low risk of damage to property.

It is envisaged that, at the time of development, when allotment layouts and proposed building envelopes are known, site-specific risk assessments will be carried out for each proposed building envelope.

4.6 Additional Recommendations for Development of Sloping Land

This study is of a preliminary nature only and it is recommended that site-specific slope stability studies be carried out for all individual residential allotments, access roads and other structures prior to construction, preferably in conjunction with appropriate geotechnical investigations. These would typically be required in areas of Medium and High likelihood of slope instability.

Historically, the area around the interface between the underlying metamorphic rocks and the overlying volcanic rocks tends to have a higher likelihood of slope instability than other areas with similar topography. The reasons for this are that the interface tends to be formed of residual and colluvial soils trapped beneath the volcanic rocks, and this layer naturally channels groundwater and forms surface seepage zones. Also, the volcanic rocks were deposited over the old topography and the orientation of the interface may locally dip out of the hill slopes at a potentially unstable angle. There is potential that the interface zone may be encountered in large-scale excavations and it is recommended that further studies be carried out at the final design stage, when the nature of the proposed development is better understood, to assess the location of the interface zone in more detail and its potential impact on slope stability and the proposed development.

It is expected that localised existing areas of fill on the site will be uncontrolled. It is recommended that areas of existing fill be removed and replaced with engineered fill. Existing cuts should be re-formed with batters no steeper than 2H:1V or should be supported using suitable, engineering-designed retaining structures.

Provision of adequate drainage is critical in maintaining the stability of structures built on sloping ground. It is recommended that subsoil drains be installed wherever indications of subsurface groundwater seepage are encountered. It is also recommended that discharge from all gutters and down-pipes and overland water flow from paths, pavements, driveways and hard-standings be collected and channelled into a lined or piped stormwater reticulation system.

It should be appreciated that removal of trees and shrubs can have an adverse affect on the stability of the natural slopes. A number of densely treed areas are present in Precinct A and removal of existing trees should be kept to a minimum and any trees removed should be replaced by planting new trees as close as possible to their original location.

In general, it is recommended that all development on hillside areas should follow good engineering and construction practice in accordance with the attached extracts from the "Practice Note Guidelines for Landslide Risk Management 2007", AGS (2007C), Journal and News of the Australian Geomechanics Society, Volume 42, No 1, March 2007.

5. CIVIL ENGINEERING ISSUES

5.1 Excavatability

Table 2 presents a brief summary of an assessment of the excavation characteristics of the various types of materials likely to be encountered on the site.

TABLE 2: SUMMARY OF EXCAVATION CHARACTERISTICS

Material description	Bulk Excavations	Footing and Trench Excavations
Alluvial* and Residual Soils and Extremely Low Strength Rock	D6-D7 size tractor, 15 to 20 tonne excavator.	15 to 20 tonne excavator.
Very Low to Low Strength Rock	D6-D7 size tractor, 25 to 30 tonne excavator.	25 to 30 tonne excavator, some use of rock bucket.
Low to Medium Strength Rock	D7-D8 size tractor, 30 tonne excavator with rock bucket and ripping tyne.	30 tonne excavator with rock bucket and ripping tyne, some use of hydraulic rock breaker.
Medium to High Strength Rock **	D9-D10 size tractor.	Hydraulic rock breaker.
High to Very High Strength Rock ***	Hydraulic rock breaker, pre-blasting and ripping with a D10-D11 size tractor.	Hydraulic rock breaker.

* the sides of excavations in the alluvial floodplain are likely to be unstable due to the high groundwater table. Trafficability for construction equipment is also likely to be poor particularly after periods of rainfall.

** medium to high strength rock was only encountered in one test pit, TP19. Medium to high strength rock may be present at depth in areas of raised ground.

*** high to very high strength rock was not encountered in the subsurface investigations carried out on site but may be present at depth in areas of raised ground.

5.2 Suitability of Soils and Weathered Rock for Use as Engineered Fill

5.2.1 Residual Soils and Weathered Rock

Residual soils excavated from the more elevated portions of the site will generally be suitable for use as engineered fill. On the basis of the site observations, moisture contents are generally expected to be close to optimum for compaction and the residual soils will not require extensive moisture conditioning. An exception may be residual soils excavated from the lower elevations of the site just above the flood plain. In these locations, groundwater seepage was frequently encountered and soils excavated from these areas are likely to have moisture contents in excess of optimum and will require drying back to make them suitable for compaction.

The definition of the term "weathered rock" covers a broad range of materials ranging from very low strength, extremely to highly weathered material containing a high clay content to durable, high strength quarry products. It will be necessary to carefully match various weathered rock materials to their intended use. More weathered materials may be suitable as general fill while less weathered materials may be suitable for select fill and "CBR" materials. Slightly weathered to fresh, durable rock may be suitable for use as roadbase gravels or other quarry products. Appropriate laboratory testing will be required to ensure that different materials sourced on site are suitable for their intended use. Treatment of weathered rock materials may include (but not necessarily be restricted to) moisture conditioning, addition of cohesive soil materials as "binding" agents and screening to remove larger particles (notionally larger than 250mm but this will depend on the proposed use of the material) prior to compaction.

5.2.2 Alluvial Soils

Clayey and sandy alluvial soils are unlikely to be suitable in their excavated condition due to their high moisture content and will require moisture conditioning (drying out) to make them suitable for compaction. Some of the alluvial clays may have a high organic content or may be acid sulphate soils which would render them unsuitable without appropriate treatment.

5.3 Fill and Cut Batter Stability

5.3.1 Alluvial Soils

Due to the presence of shallow groundwater, excavations in alluvial soils on the flood plains are likely to be unstable unless dewatering measures are implemented.

As a general guideline, temporary batters excavated in very loose to loose sand may be formed no steeper than 26° (1V:2H) for a vertical height no greater than 2.0m, provided that the sand has been effectively de-watered with no visible surface seepage. Temporary batters in medium dense sand may be formed no steeper than 33°(1V:1.5H) for a vertical height no greater than 2.0m, or no steeper than 26° (1V:2H) for a vertical height no greater than 3.0m, provided that the sand has been effectively de-watered with no visible surface seepage. If the excavated batters are to be subject to significant surcharge loads, site-specific geotechnical advice will be required.

For preliminary design purposes, the batter slopes of fill embankments constructed on the alluvial flood plains should not be steeper than 1V:4H.

5.3.2 Other Materials

Where cut and fill batters are unsupported, recommended long term batter slopes are as follows:

Material	Recommended Batter Slope
Residual soils	1V:2H (26°)
Weathered Rock	1V:1H (45°)*
Engineered fill**	1V:2H (26°)

* Batter slopes steeper than 1V:1H may be feasible but will require assessment by an Engineering Geologist at the time of excavation.

** All fill batters should be overfilled, compacted and cut back at the recommended batter slopes.

The above batter slopes are for free-standing batters with a vertical height of not greater than 2m on level or gently sloping areas (slopes of less than 12°). Where batters are excavated with a vertical height of greater than 2m or on slopes of greater than 12°, site-specific geotechnical advice will be required.

5.4 Founding Conditions

5.4.1 Elevated Areas

For the existing natural soil profiles on the elevated areas of the site, footings founded in very stiff clay (typically encountered at 1.0m depth or less) may be designed for an allowable bearing pressure of 150kPa. Higher bearing pressures can be achieved at greater depths – on the basis of the test pits logs, allowable bearing pressures of about 300kPa can be achieved, often at relatively shallow depths, depending on the location.

Footings founded in engineered fill constructed using the residual soil may be designed for an allowable bearing pressure of 100kPa.

Other options for heavier structures include founding the structures on short bored piers taken into weathered rock.

5.4.2 Flood Plain Areas

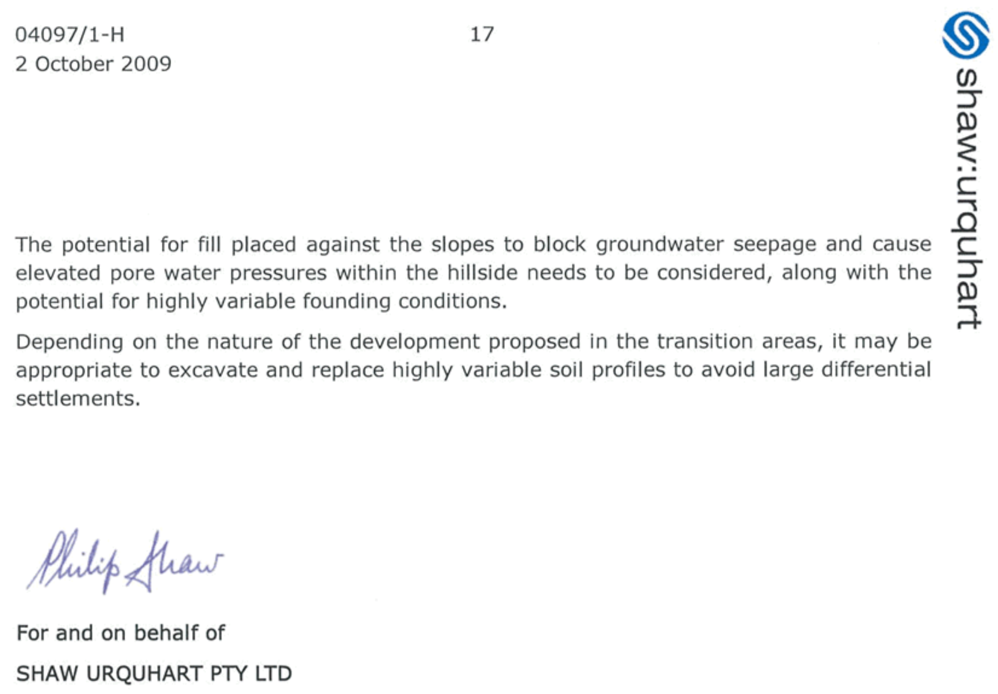
The flood plain areas are expected to be underlain by a variety of alluvial soils ranging from very loose sand and soft clay to stiff alluvial clay. These areas are generally characterised by poor surface trafficability and a shallow groundwater table.

There are a number of engineering constraints to development on the flood plain areas as follows:-

- Near surface soils are generally of low bearing capacity and are unsuitable in their natural condition to support structures.
- Sub-grade conditions for road pavements are poor and may require localised excavation and placement of select subgrade.
- Due to poor surface trafficability, a granular bridging layer may be required to allow access for construction equipment and to facilitate placement and compaction of fill. Depending on the nature of the fill materials, it may be necessary to separate the fill and bridging layer with a geofabric to prevent the migration of fines from the fill into the bridging layer. To be effective, a bridging layer of between 0.6m and 0.8m in thickness is likely to be required.
- Trench excavations or bulk excavations for earthworks will require dewatering and slope stability of the sides of the excavations will be an issue.
- Very loose to loose sands will have low bearing capacity and will be susceptible to settlement under vibrations and additional loading due to filling and/or structures. These can be relatively easily densified by vibratory compaction.
- Soft to firm clays will have low bearing capacity and will undergo primary and secondary consolidation settlement as a result of additional loading due to filling and/or structures. Generally areas underlain by soft to firm clay will require foundation treatment by preloading (surcharging the area by placing additional fill above the final development level). In some circumstances, the duration of foundation treatment can be reduced by the use of vertical (wick) drains. Alternatively the soft to firm clay could be excavated and replaced with engineered fill. Excavations would require dewatering and the replacement material will need to be granular to facilitate compaction in the wet conditions. Even with preloading as described above, areas underlain by soft to firm alluvial clay will be limited to single storey or double storey structures. Higher structures will require piled footings.

5.4.3 Transition Areas

Particular attention needs to be given to the areas where the alluvial soils abut the existing slopes. These areas are likely to contain inter-fingered alluvial soils and colluvial soils from the slopes above (as an example, stiff, colluvial clay soils may overly soft, compressible alluvial clay soils in this area).

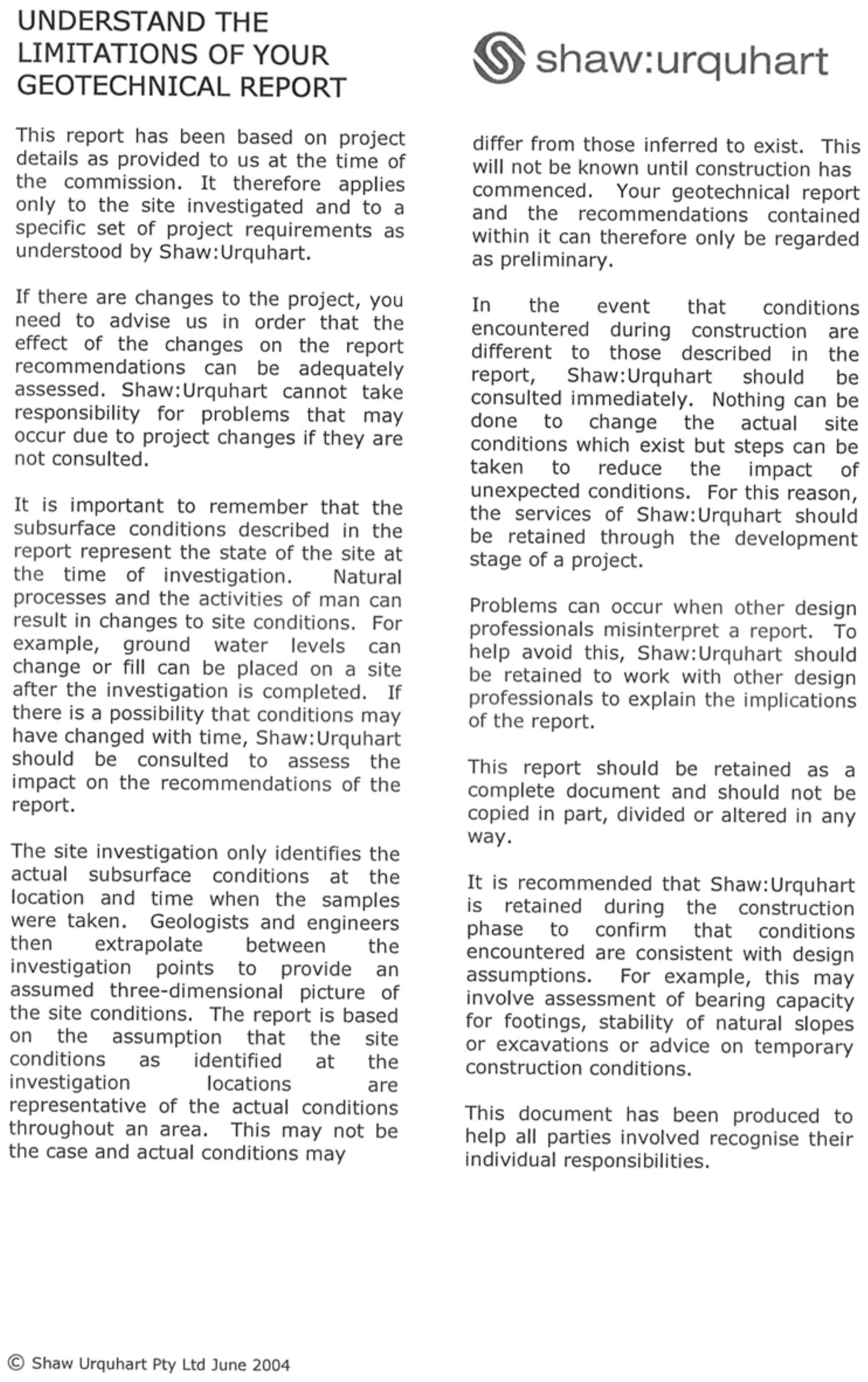


The potential for fill placed against the slopes to block groundwater seepage and cause elevated pore water pressures within the hillside needs to be considered, along with the potential for highly variable founding conditions.

Depending on the nature of the development proposed in the transition areas, it may be appropriate to excavate and replace highly variable soil profiles to avoid large differential settlements.

Philip Shaw

For and on behalf of
SHAW URQUHART PTY LTD



UNDERSTAND THE LIMITATIONS OF YOUR GEOTECHNICAL REPORT

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This report has been based on project details as provided to us at the time of the commission. It therefore applies only to the site investigated and to a specific set of project requirements as understood by Shaw:Urquhart.

If there are changes to the project, you need to advise us in order that the effect of the changes on the report recommendations can be adequately assessed. Shaw:Urquhart cannot take responsibility for problems that may occur due to project changes if they are not consulted.

It is important to remember that the subsurface conditions described in the report represent the state of the site at the time of investigation. Natural processes and the activities of man can result in changes to site conditions. For example, ground water levels can change or fill can be placed on a site after the investigation is completed. If there is a possibility that conditions may have changed with time, Shaw:Urquhart should be consulted to assess the impact on the recommendations of the report.

The site investigation only identifies the actual subsurface conditions at the location and time when the samples were taken. Geologists and engineers then extrapolate between the investigation points to provide an assumed three-dimensional picture of the site conditions. The report is based on the assumption that the site conditions as identified at the investigation locations are representative of the actual conditions throughout an area. This may not be the case and actual conditions may differ from those inferred to exist. This will not be known until construction has commenced. Your geotechnical report and the recommendations contained within it can therefore only be regarded as preliminary.

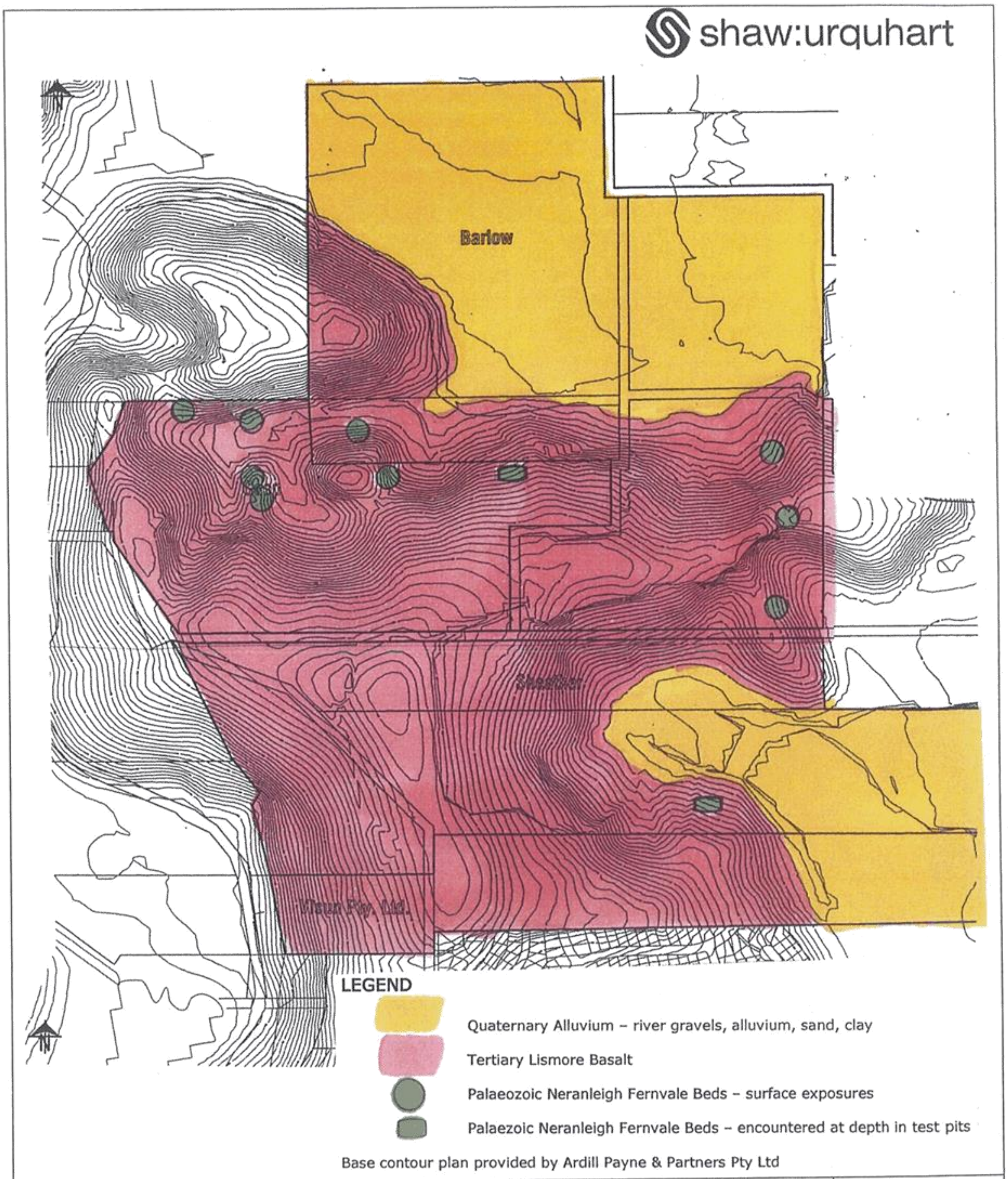
In the event that conditions encountered during construction are different to those described in the report, Shaw:Urquhart should be consulted immediately. Nothing can be done to change the actual site conditions which exist but steps can be taken to reduce the impact of unexpected conditions. For this reason, the services of Shaw:Urquhart should be retained through the development stage of a project.

Problems can occur when other design professionals misinterpret a report. To help avoid this, Shaw:Urquhart should be retained to work with other design professionals to explain the implications of the report.

This report should be retained as a complete document and should not be copied in part, divided or altered in any way.

It is recommended that Shaw:Urquhart is retained during the construction phase to confirm that conditions encountered are consistent with design assumptions. For example, this may involve assessment of bearing capacity for footings, stability of natural slopes or excavations or advice on temporary construction conditions.

This document has been produced to help all parties involved recognise their individual responsibilities.



Base contour plan provided by Ardill Payne & Partners Pty Ltd

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Approved by: PS		
Date: Oct 2009		
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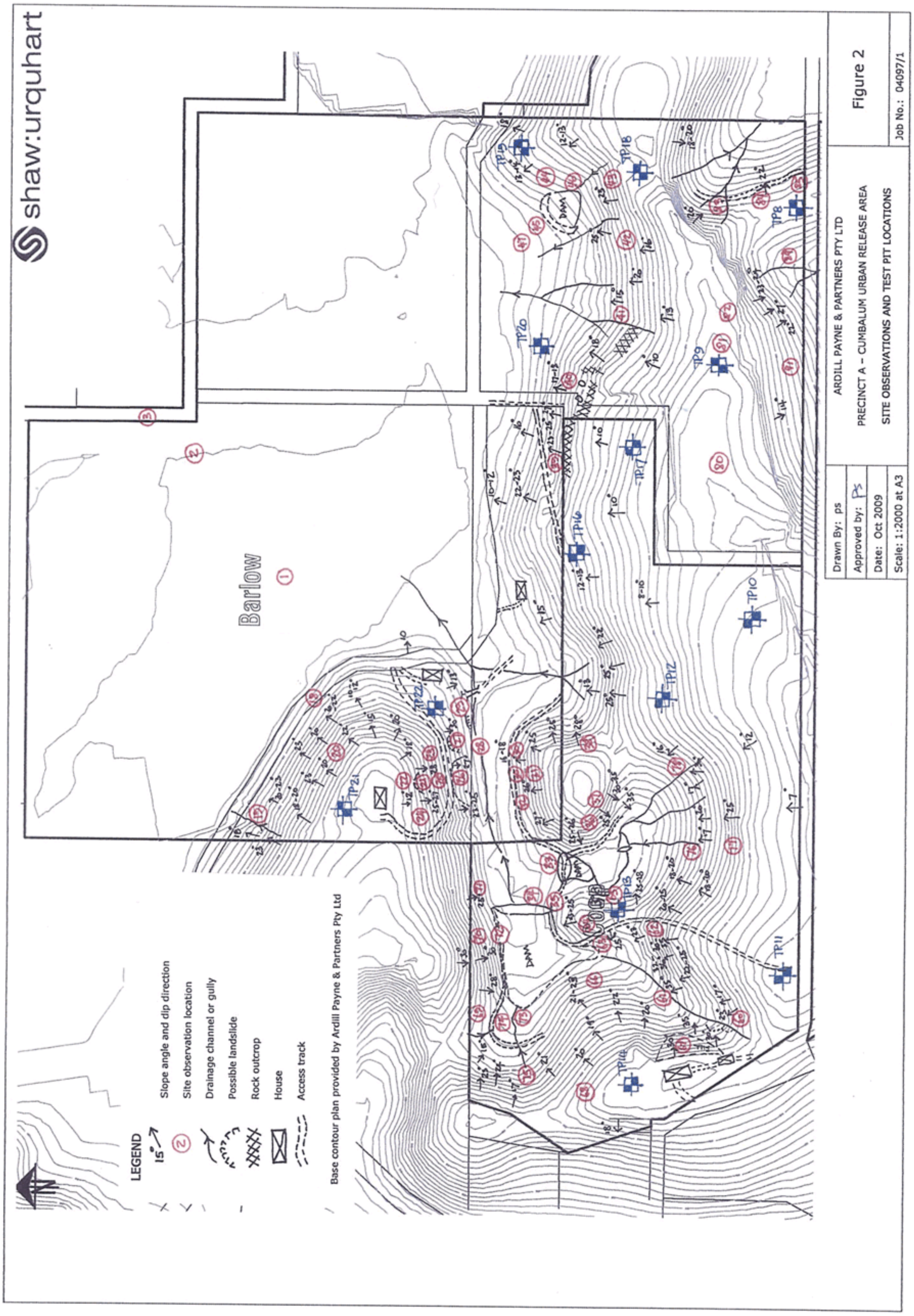
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Barlow
TP8
TP9
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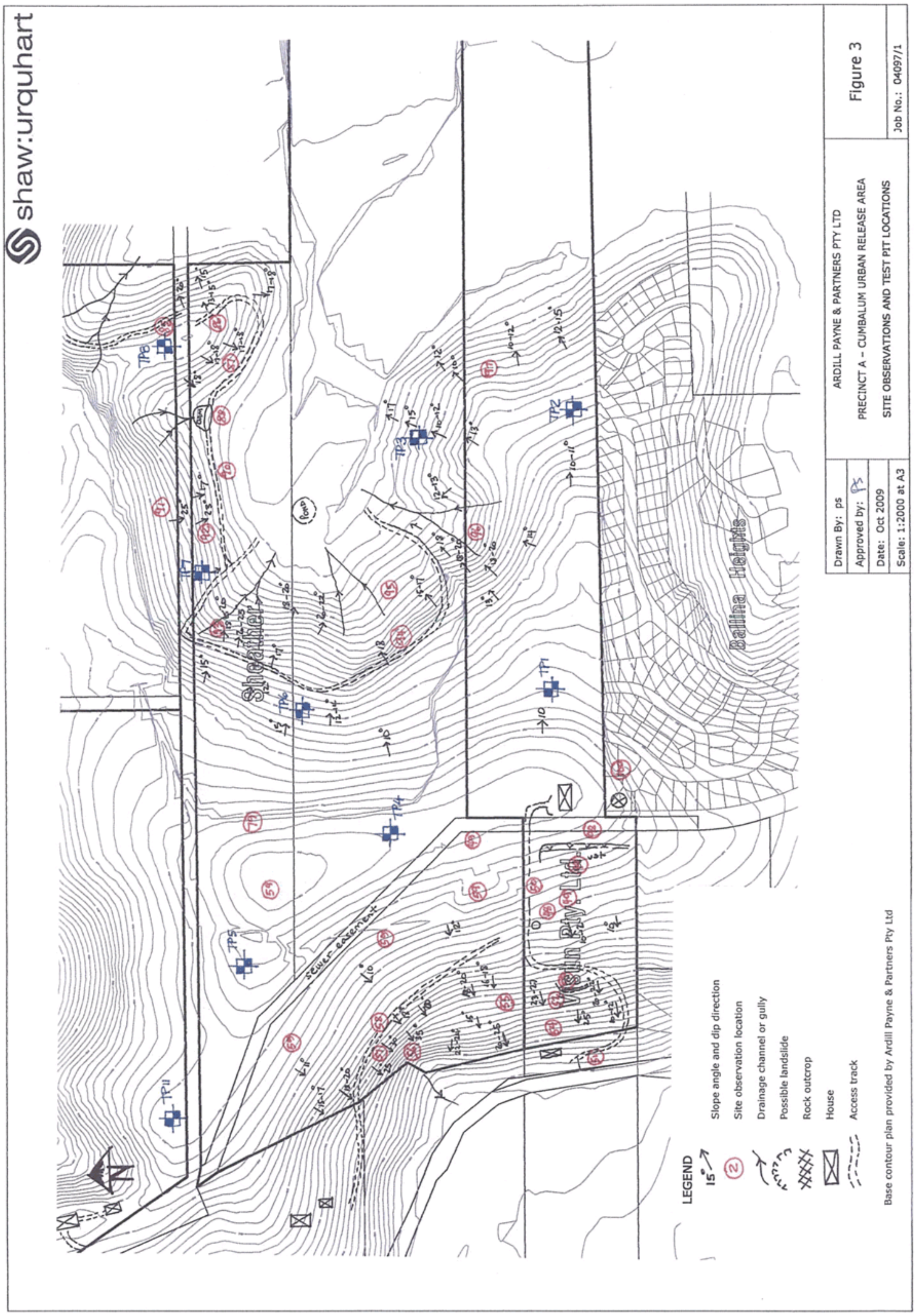
TP20
TP21
TP22
DAM
LEGEND
15° Slope angle and dip direction
② Site observation location
Drainage channel or gully
Possible landslide
Rock outcrop
House
Access track
Base contour plan provided by Ardill Payne & Partners Pty Ltd
Drawn By: ps
Approved by: PS
Date: Oct 2009
Scale: 1:2000 at A3
ARDILL PAYNE & PARTNERS PTY LTD
PRECINCT A – CUMBALUM URBAN RELEASE AREA
SITE OBSERVATIONS AND TEST PIT LOCATIONS
Figure 2
Job No.: 04097/1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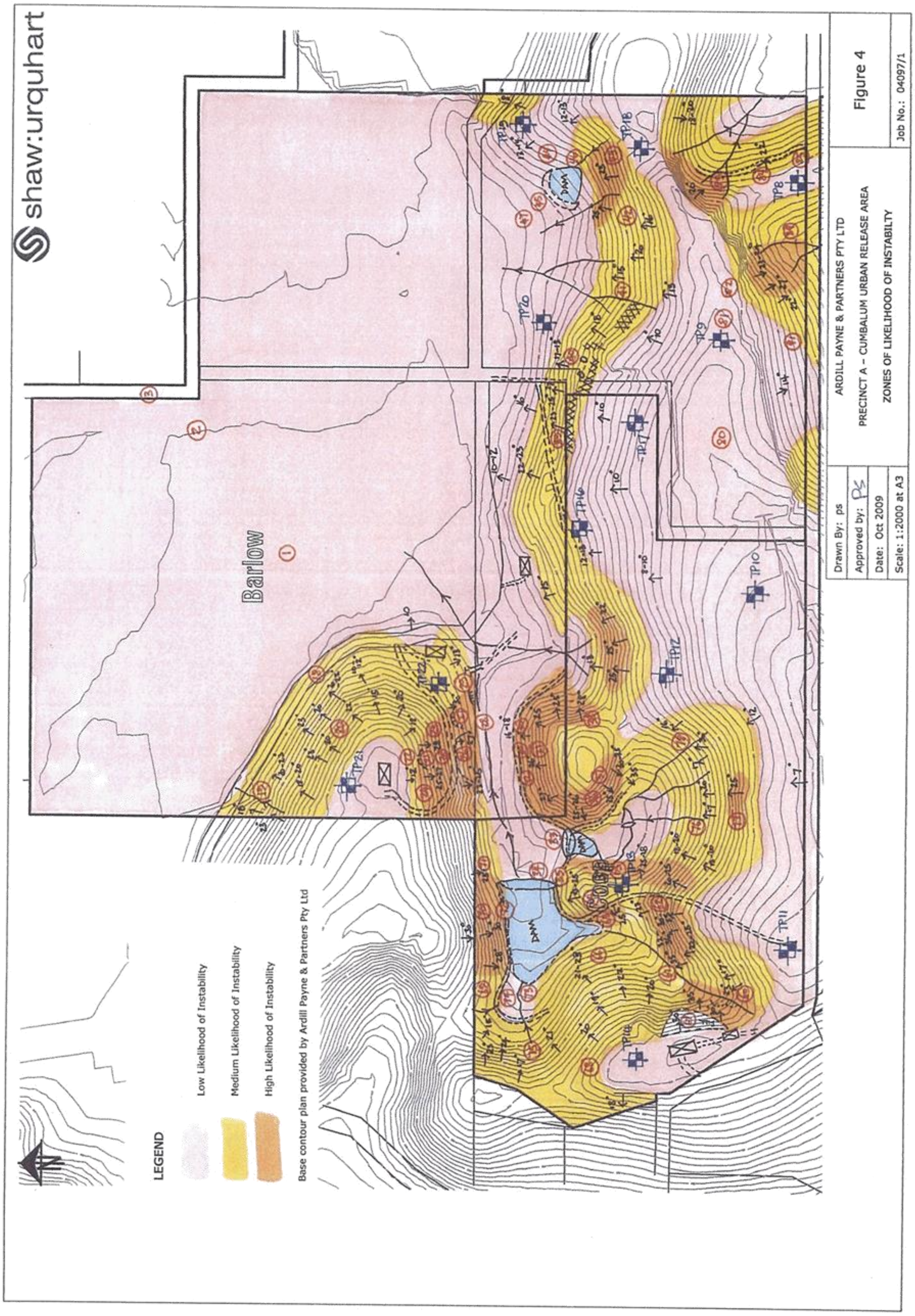
Sheather
Ballina Heights
sewer easement
Pond
Dam
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP11
LEGEND
15° Slope angle and dip direction
② Site observation location
Drainage channel or gully
Possible landslide
Rock outcrop
House
Access track
Base contour plan provided by Ardill Payne & Partners Pty Ltd
Drawn By: ps
Approved by: PS
Date: Oct 2009
Scale: 1:2000 at A3
ARDILL PAYNE & PARTNERS PTY LTD
PRECINCT A – CUMBALUM URBAN RELEASE AREA
SITE OBSERVATIONS AND TEST PIT LOCATIONS
Figure 3
Job No.: 04097/1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Barlow
LEGEND
Low Likelihood of Instability
Medium Likelihood of Instability
High Likelihood of Instability
Base contour plan provided by Ardill Payne & Partners Pty Ltd
Drawn By: ps
Approved by: PS
Date: Oct 2009
Scale: 1:2000 at A3
ARDILL PAYNE & PARTNERS PTY LTD
PRECINCT A – CUMBALUM URBAN RELEASE AREA
ZONES OF LIKELIHOOD OF INSTABILTY
Figure 4
Job No.: 04097/1
TP8
TP9
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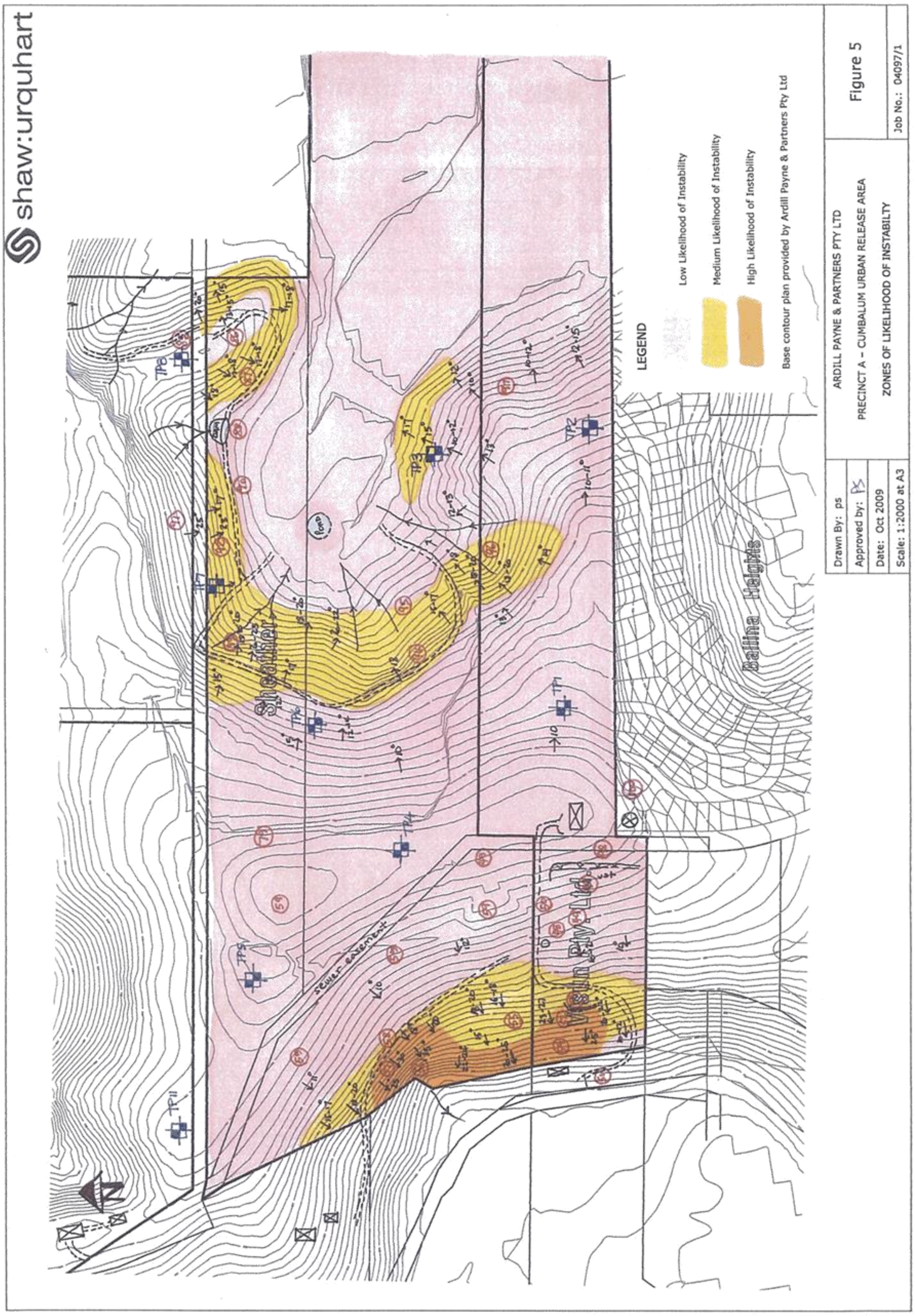
TP11
TP12
TP15
TP16
TP17
TP18
TP19
TP20
TP21
DAM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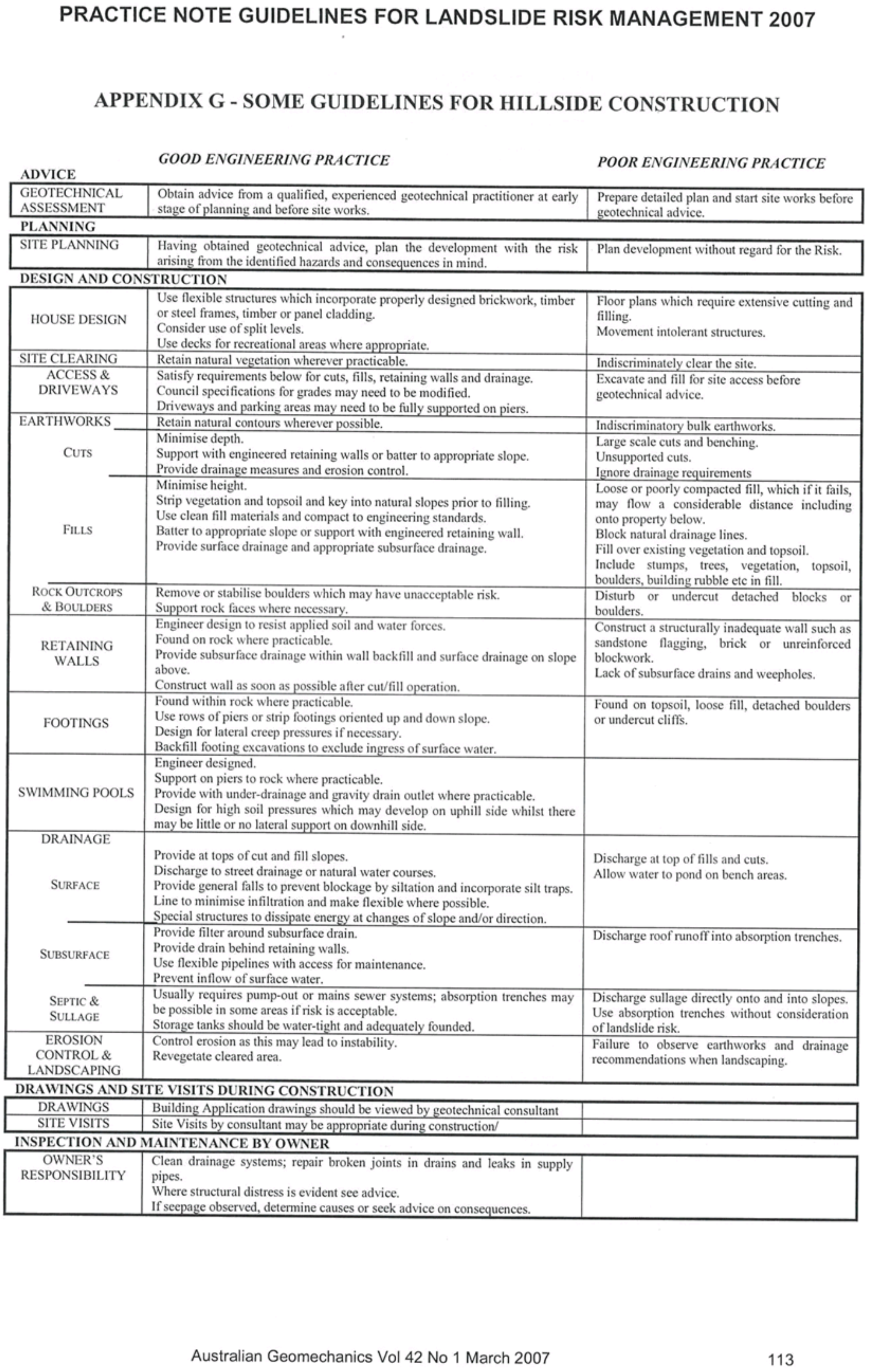
LEGEND
Low Likelihood of Instability
Medium Likelihood of Instability
High Likelihood of Instability
Base contour plan provided by Ardill Payne & Partners Pty Ltd
ARDILL PAYNE & PARTNERS PTY LTD
PRECINCT A – CUMBALUM URBAN RELEASE AREA
ZONES OF LIKELIHOOD OF INSTABILTY
Figure 5
Job No.: 04097/1
Drawn By: ps
Approved by: PS
Date: Oct 2009
Scale: 1:2000 at A3
Ballina Heights
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP11
sewer easement
N

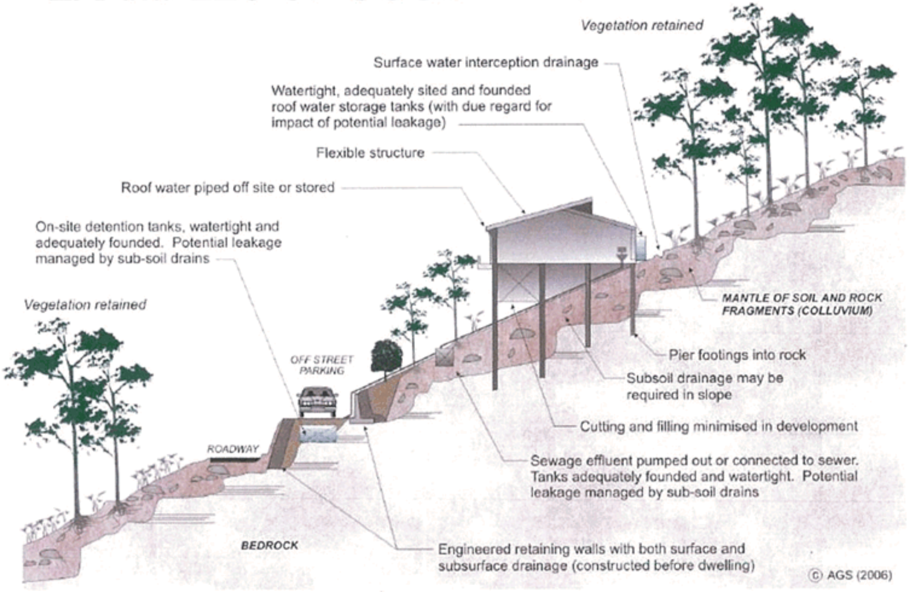


PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

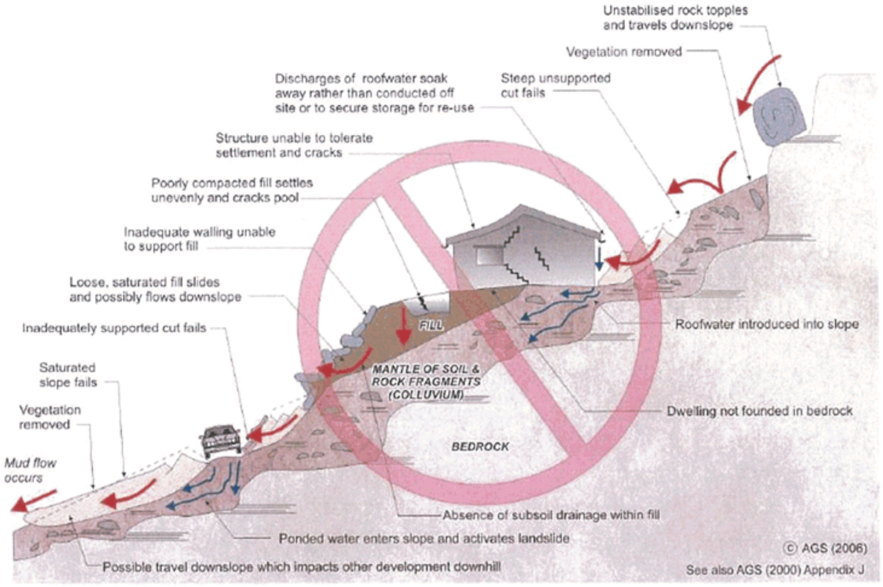
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



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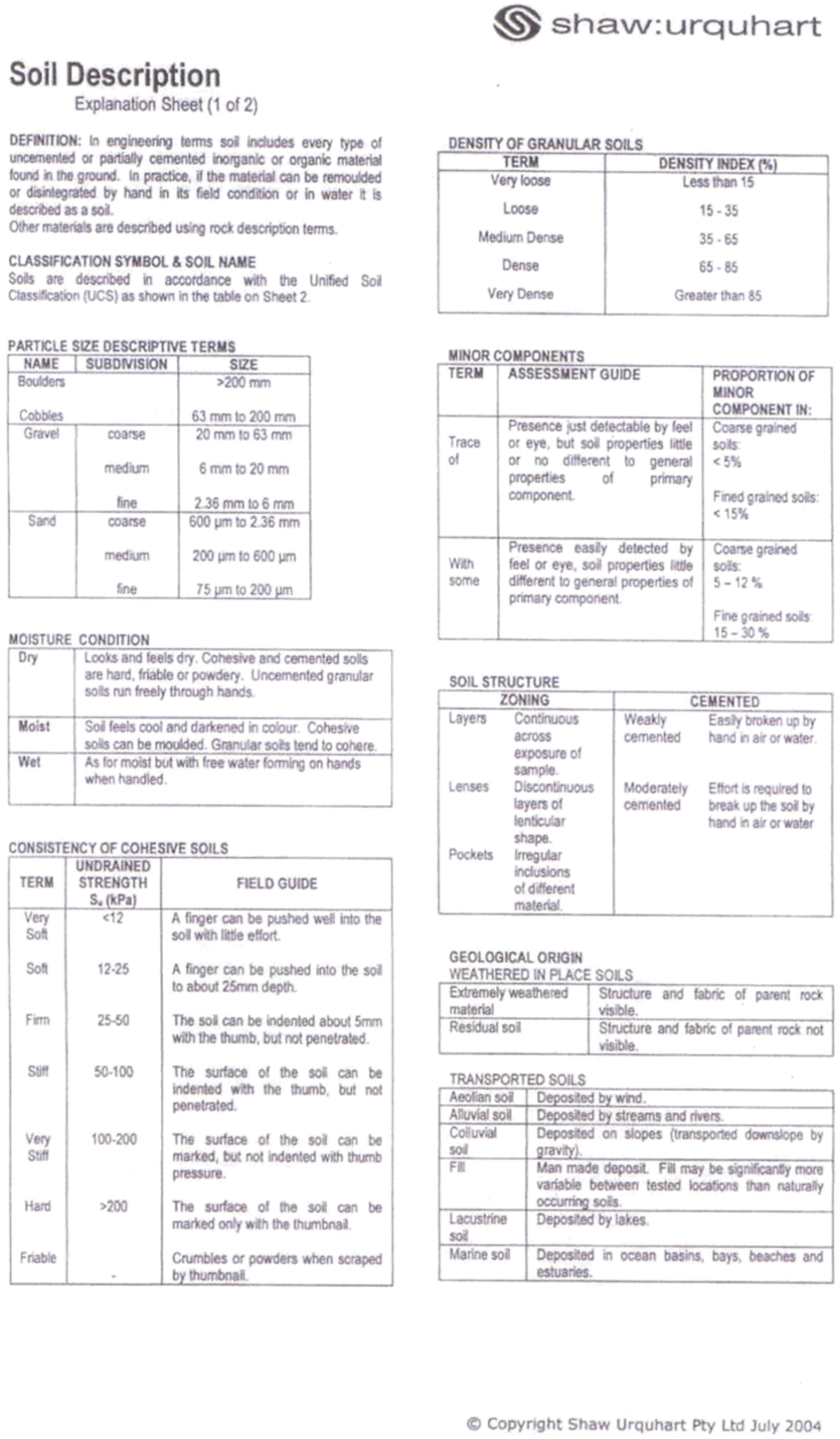
APPENDIX A

ENGINEERING LOGS OF TEST PITS



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Soil Description

Explanation Sheet (1 of 2)

DEFINITION: In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil.
Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH S_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12-25	A finger can be pushed into the soil to about 25mm depth.
Firm	25-50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50-100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100-200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	-	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5% Fined grained soils: < 15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

SOIL STRUCTURE

ZONING		CEMENTED	
Layers	Continuous across exposure of sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water
Pockets	Irregular inclusions of different material.		

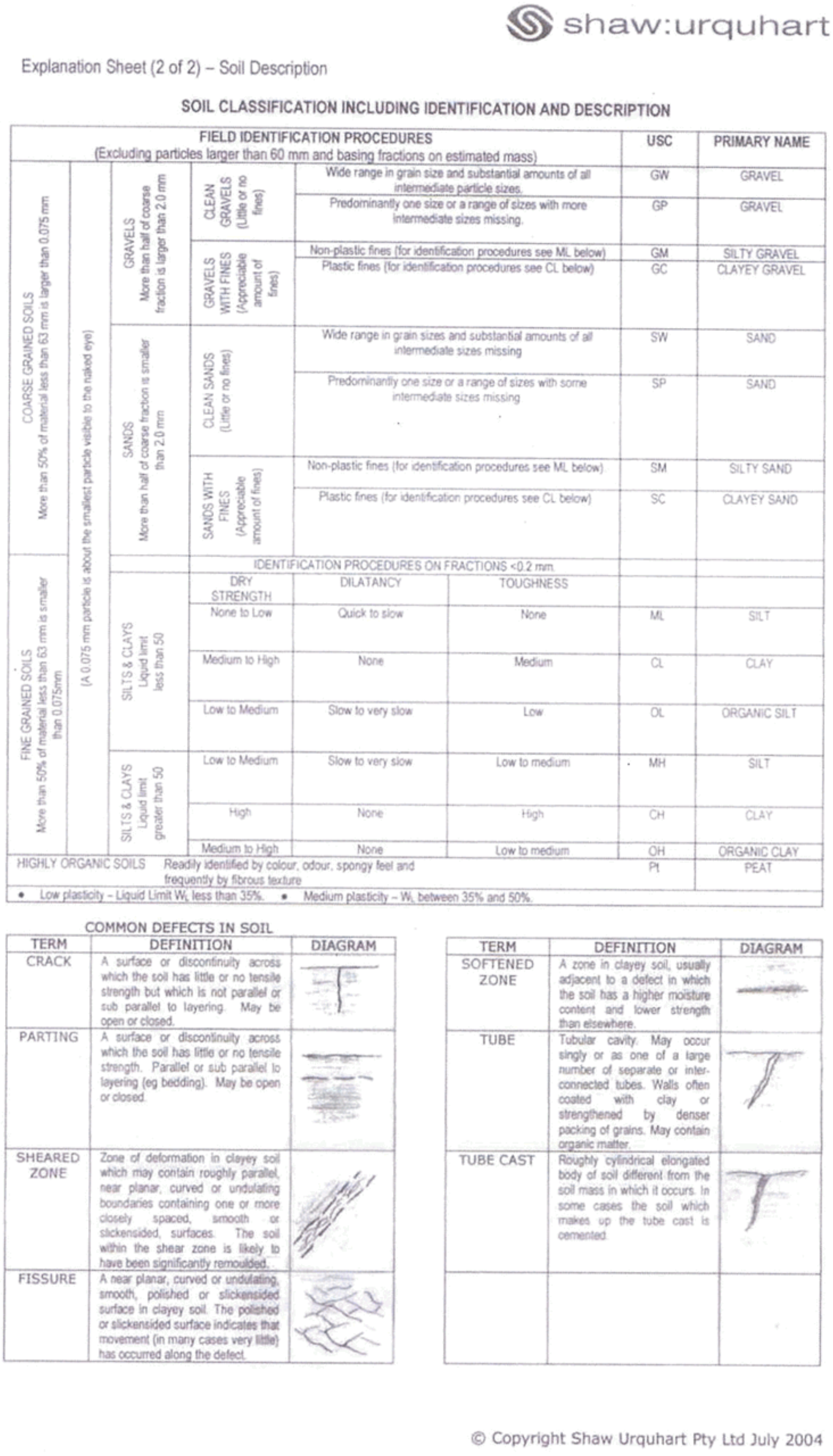
GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.



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Explanation Sheet (2 of 2) – Soil Description

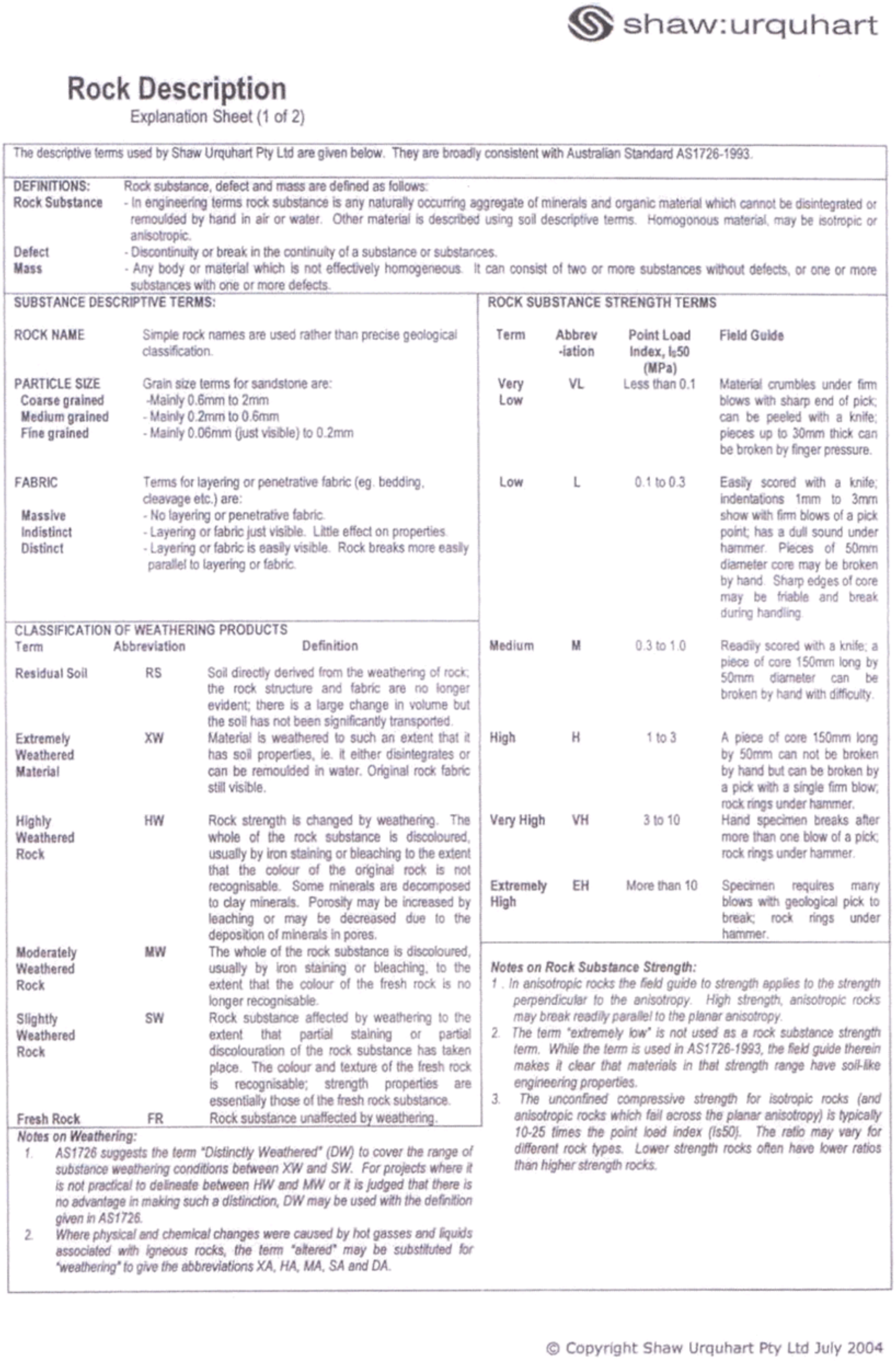
SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.		GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.		GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)		GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)		GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing		SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing		SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)		SM	SILTY SAND
				Plastic fines (for identification procedures see CL below)		SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm				
		SILTS & CLAYS Liquid limit less than 50	DRY STRENGTH	DILATANCY	TOUGHNESS		
			None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to Medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to Medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	PEAT
• Low plasticity – Liquid Limit W_L less than 35%. • Medium plasticity – W_L between 35% and 50%.							

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
CRACK	A surface or discontinuity across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed.	
PARTING	A surface or discontinuity across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
SHEARED ZONE	Zone of deformation in clayey soil which may contain roughly parallel, near planar, curved or undulating boundaries containing one or more closely spaced, smooth or slickensided, surfaces. The soil within the shear zone is likely to have been significantly remoulded.	
FISSURE	A near planar, curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content and lower strength than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter.	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	



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Rock Description

Explanation Sheet (1 of 2)

The descriptive terms used by Shaw Urquhart Pty Ltd are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS:	Rock substance, defect and mass are defined as follows:
Rock Substance	- In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Homogonous material, may be isotropic or anisotropic.
Defect	- Discontinuity or break in the continuity of a substance or substances.
Mass	- Any body or material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	-Mainly 0.6mm to 2mm
Medium grained	- Mainly 0.2mm to 0.6mm
Fine grained	- Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering or penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	- No layering or penetrative fabric.
Indistinct	- Layering or fabric just visible. Little effect on properties.
Distinct	- Layering or fabric is easily visible. Rock breaks more easily parallel to layering or fabric.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev -iation	Point Load Index, I_s50 (MPa)	Field Guide
Very Low	VL	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	L	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm blows of a pick point; has a dull sound under hammer. Pieces of 50mm diameter core may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	EH	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1 . *In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength, anisotropic rocks may break readily parallel to the planar anisotropy.*

2. *The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range have soil-like engineering properties.*

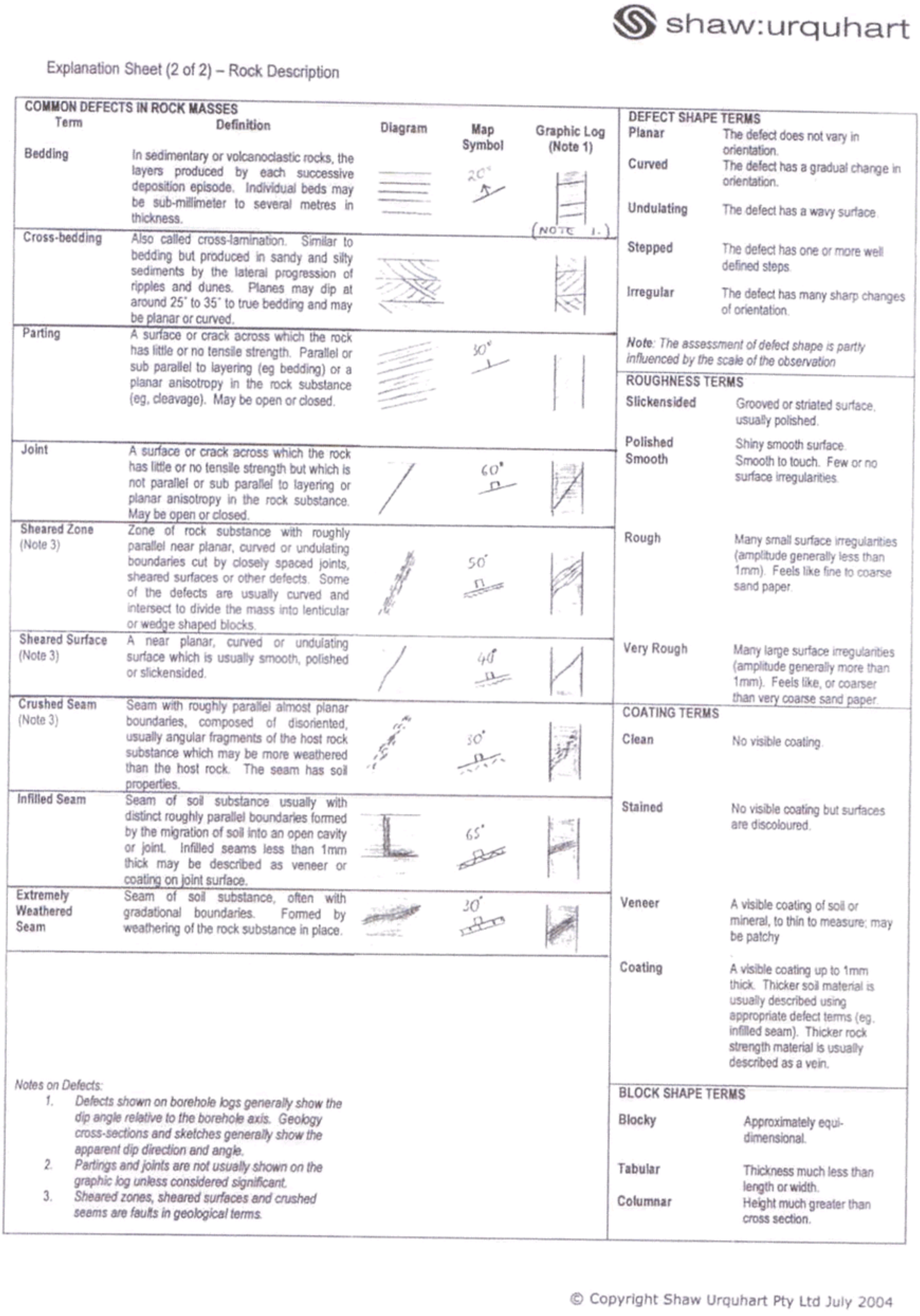
3. *The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fail across the planar anisotropy) is typically 10-25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.*

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	RS	Soil directly derived from the weathering of rock; the rock structure and fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	XW	Material is weathered to such an extent that it has soil properties, ie. it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	HW	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	SW	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	FR	Rock substance unaffected by weathering.

Notes on Weathering:

1. *AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.*
2. *Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.*



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Explanation Sheet (2 of 2) – Rock Description

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Bedding	In sedimentary or volcanoclastic rocks, the layers produced by each successive deposition episode. Individual beds may be sub-millimeter to several metres in thickness.		20°	(NOTE 1.)
Cross-bedding	Also called cross-lamination. Similar to bedding but produced in sandy and silty sediments by the lateral progression of ripples and dunes. Planes may dip at around 25° to 35° to true bedding and may be planar or curved.			
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.		30°	
Joint	A surface or crack across which the rock has little or no tensile strength but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.		60°	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.		50°	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.		40°	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.		30°	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint. Infilled seams less than 1mm thick may be described as veneer or coating on joint surface.		65°	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formed by weathering of the rock substance in place.		30°	

Notes on Defects:

1. *Defects shown on borehole logs generally show the dip angle relative to the borehole axis. Geology cross-sections and sketches generally show the apparent dip direction and angle.*
2. *Partings and joints are not usually shown on the graphic log unless considered significant.*
3. *Sheared zones, sheared surfaces and crushed seams are faults in geological terms.*

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation.
Curved	The defect has a gradual change in orientation.
Undulating	The defect has a wavy surface.
Stepped	The defect has one or more well defined steps.
Irregular	The defect has many sharp changes of orientation.

Note: The assessment of defect shape is partly influenced by the scale of the observation

ROUGHNESS TERMS

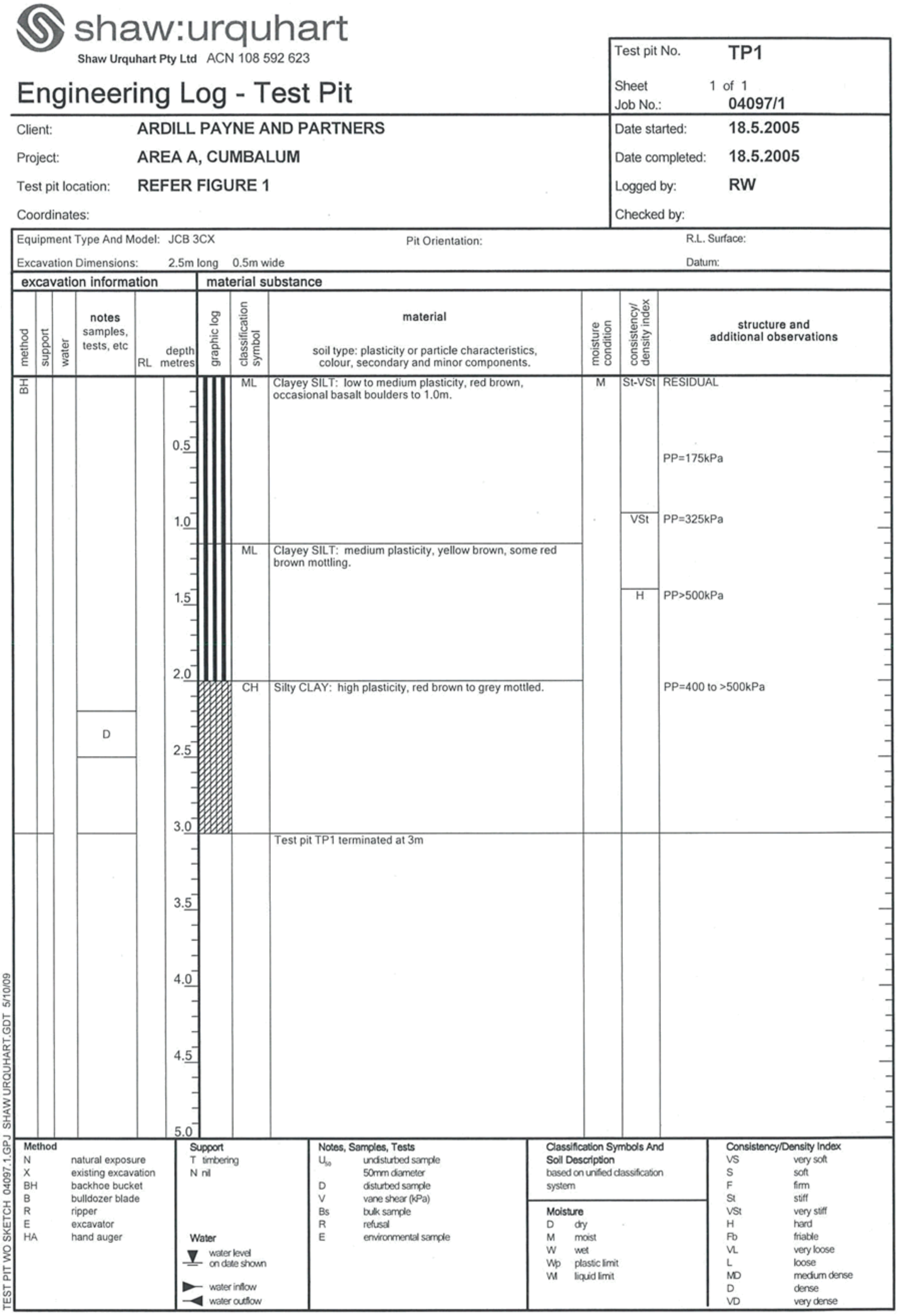
Slickensided	Grooved or striated surface, usually polished.
Polished	Shiny smooth surface.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating.
Stained	No visible coating but surfaces are discoloured.
Veneer	A visible coating of soil or mineral, to thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equi-dimensional.
Tabular	Thickness much less than length or width.
Columnar	Height much greater than cross section.



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Engineering Log - Test Pit

Test pit No.	TP1
Sheet	1 of 1
Job No.:	04097/1
Client:	ARDILL PAYNE AND PARTNERS
Project:	AREA A, CUMBALUM
Test pit location:	REFER FIGURE 1
Coordinates:	
Date started:	18.5.2005
Date completed:	18.5.2005
Logged by:	RW
Checked by:	
Equipment Type And Model:	JCB 3CX
Pit Orientation:	
R.L. Surface:	
Excavation Dimensions:	2.5m long 0.5m wide
Datum:	

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH					0.0	▮	ML	Clayey SILT: low to medium plasticity, red brown, occasional basalt boulders to 1.0m.	M	St-VSt	RESIDUAL
					0.5						PP=175kPa
					1.0					VSt	PP=325kPa
					1.1	▮	ML	Clayey SILT: medium plasticity, yellow brown, some red brown mottling.			
					1.5					H	PP>500kPa
					2.0	▨	CH	Silty CLAY: high plasticity, red brown to grey mottled.			PP=400 to >500kPa
			D		2.5						
					3.0			Test pit TP1 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HA hand auger

Support
- T timbering
- N nil

Water
- ▼ water level on date shown
- ► water inflow
- ◄ water outflow

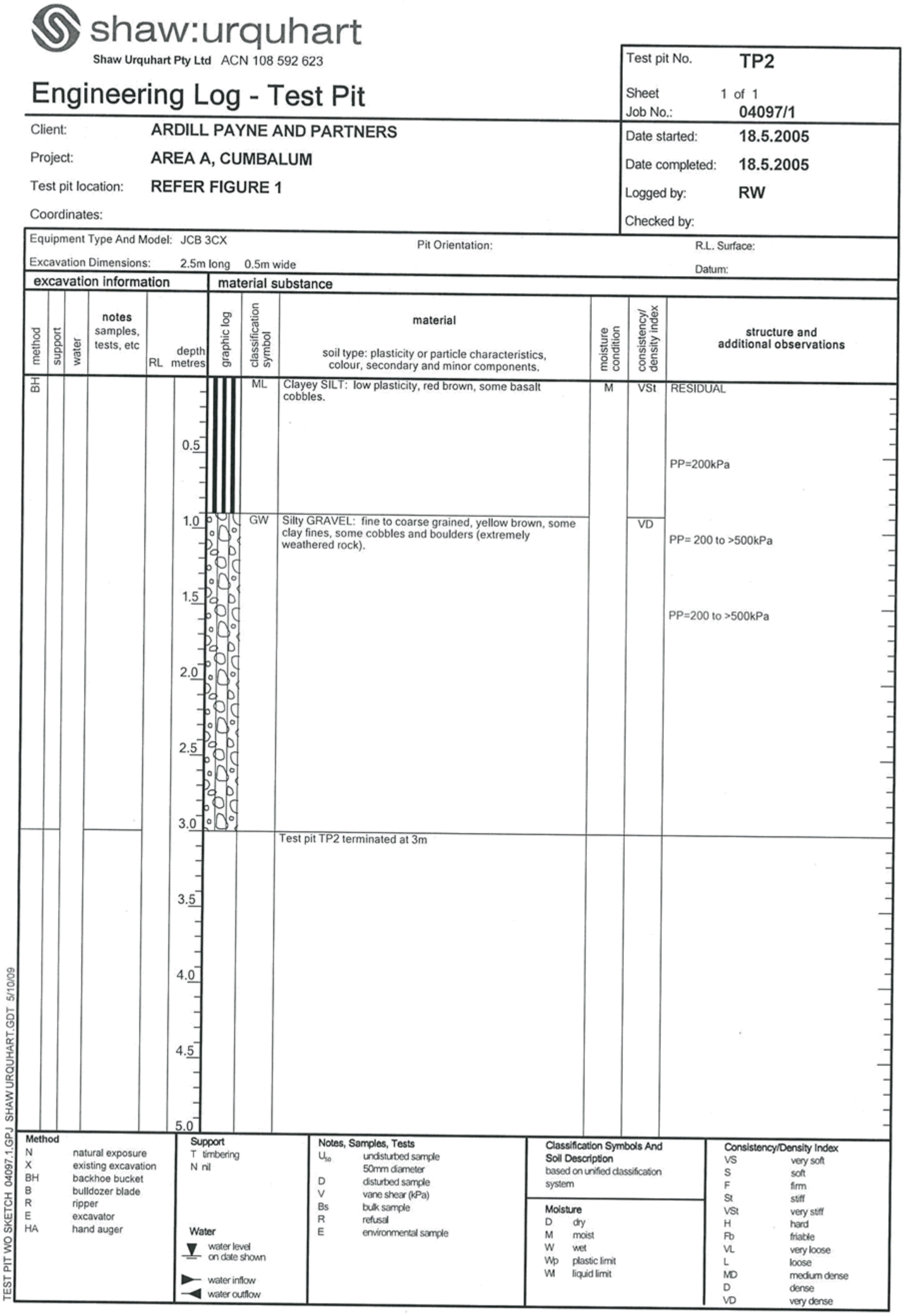
Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

Consistency/Density Index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP2**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	

Equipment Type And Model: JCB 3CX

Pit Orientation:

R.L. Surface:

Excavation Dimensions: 2.5m long 0.5m wide

Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH					0.5		ML	Clayey SILT: low plasticity, red brown, some basalt cobbles.	M	VSt	RESIDUAL PP=200kPa
					1.0 1.5 2.0 2.5		GW	Silty GRAVEL: fine to coarse grained, yellow brown, some clay fines, some cobbles and boulders (extremely weathered rock).		VD	PP= 200 to >500kPa PP=200 to >500kPa
					3.0 3.5 4.0 4.5 5.0			Test pit TP2 terminated at 3m			

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering

N nil

Water

▼ water level on date shown

► water inflow

◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

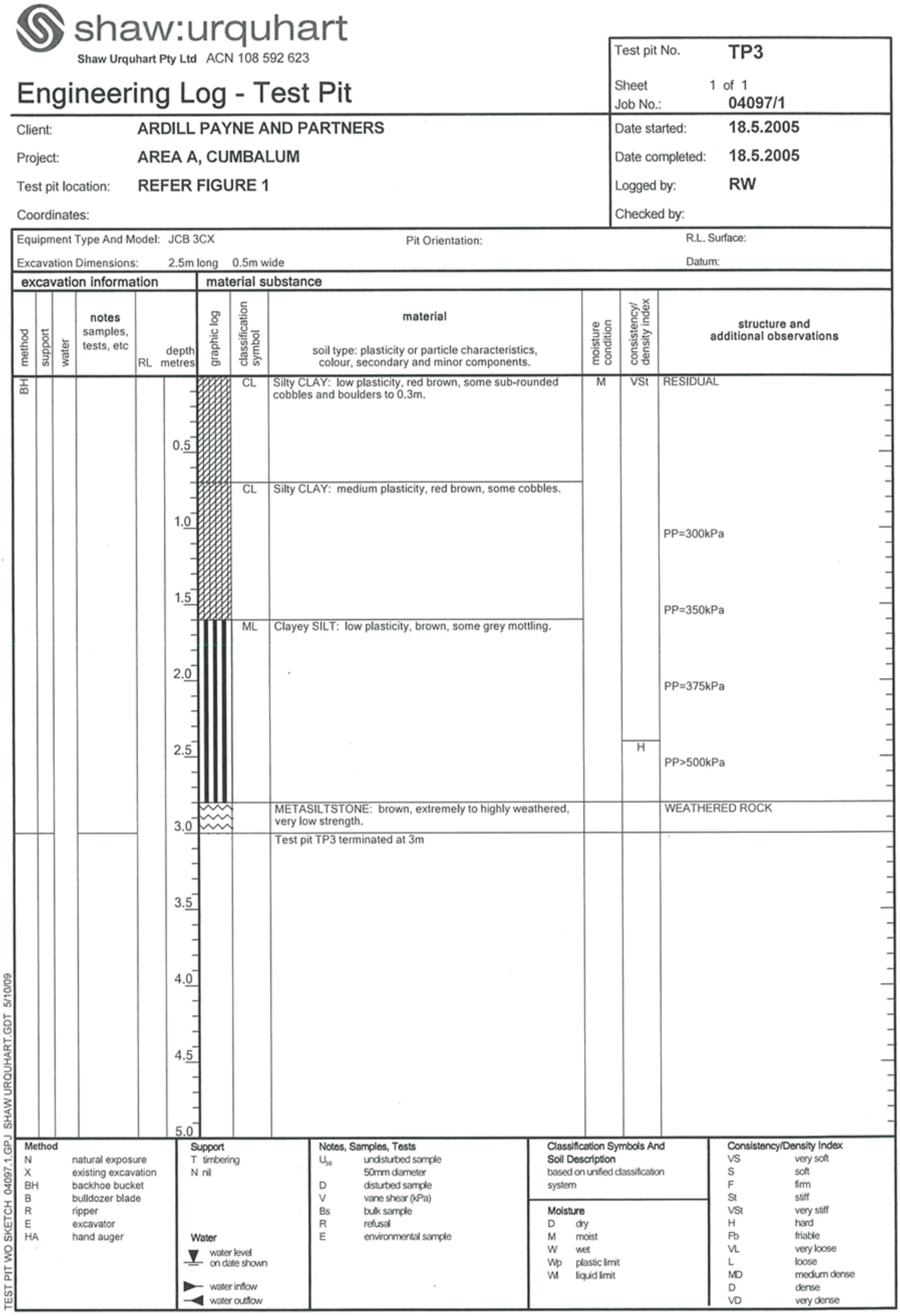
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No. **TP3**
Sheet 1 of 1
Job No.: **04097/1**

Client: **ARDILL PAYNE AND PARTNERS**
Project: **AREA A, CUMBALUM**
Test pit location: **REFER FIGURE 1**
Coordinates:

Date started: **18.5.2005**
Date completed: **18.5.2005**
Logged by: **RW**
Checked by:

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							CL	Silty CLAY: low plasticity, red brown, some sub-rounded cobbles and boulders to 0.3m.	M	VSt	RESIDUAL
							CL	Silty CLAY: medium plasticity, red brown, some cobbles.			PP=300kPa
											PP=350kPa
							ML	Clayey SILT: low plasticity, brown, some grey mottling.			PP=375kPa
										H	PP>500kPa
								METASILTSTONE: brown, extremely to highly weathered, very low strength.			WEATHERED ROCK
								Test pit TP3 terminated at 3m			

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering
N nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

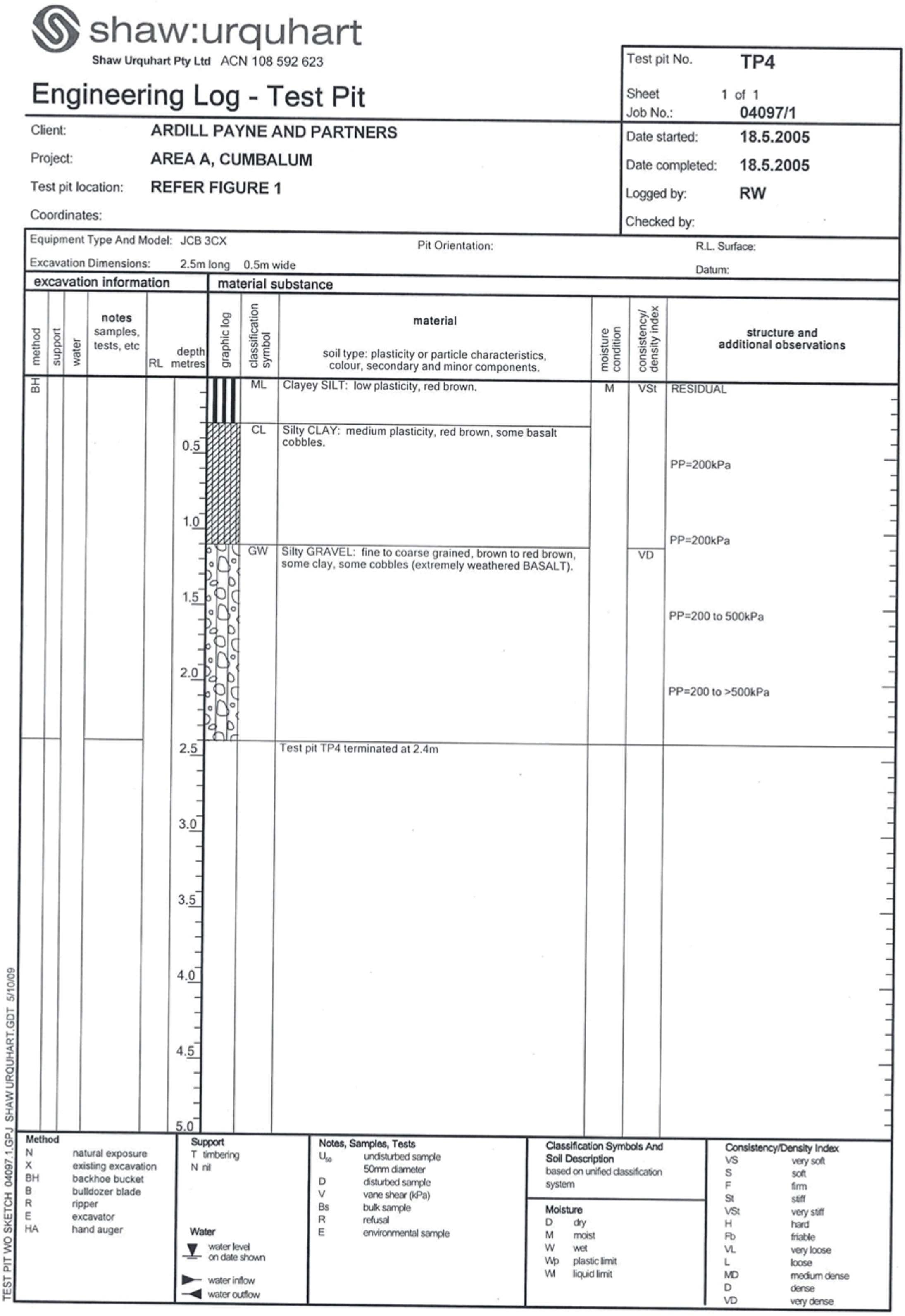
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097_1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP4**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	
Equipment Type And Model:	JCB 3CX
Excavation Dimensions:	2.5m long 0.5m wide
Pit Orientation:	
R.L. Surface:	
Datum:	

excavation information						material substance					
method	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	**structure and additional observations**
BH							ML	Clayey SILT: low plasticity, red brown.	M	VSt	RESIDUAL
					0.5		CL	Silty CLAY: medium plasticity, red brown, some basalt cobbles.			PP=200kPa
					1.0						PP=200kPa
							GW	Silty GRAVEL: fine to coarse grained, brown to red brown, some clay, some cobbles (extremely weathered BASALT).		VD	
					1.5						PP=200 to 500kPa
					2.0						PP=200 to >500kPa
					2.5			Test pit TP4 terminated at 2.4m			
					3.0						
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

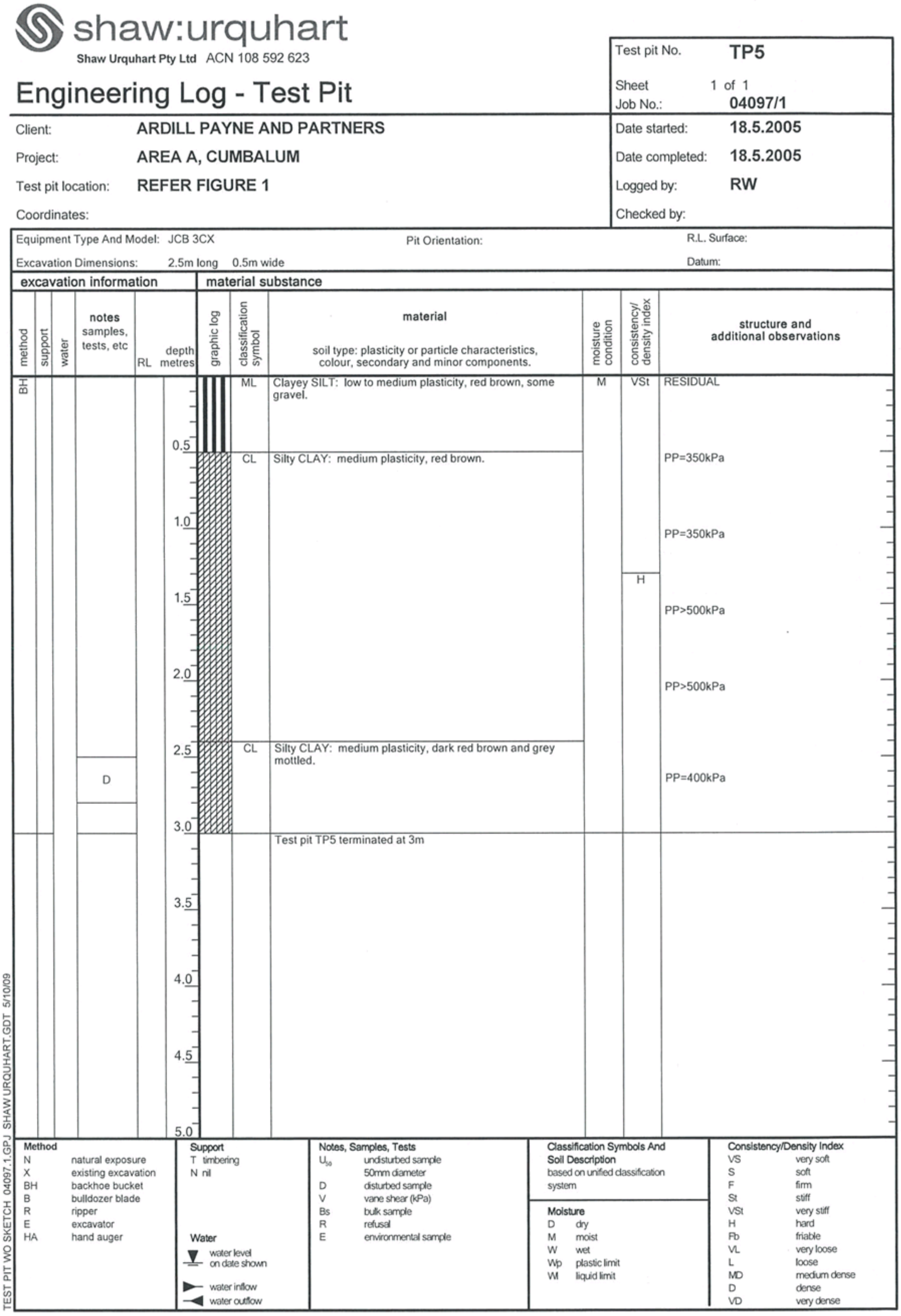
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Client:	ARDILL PAYNE AND PARTNERS	Test pit No.	TP5
Project:	AREA A, CUMBALUM	Sheet	1 of 1
Test pit location:	REFER FIGURE 1	Job No.:	04097/1
Coordinates:		Date started:	18.5.2005
		Date completed:	18.5.2005
		Logged by:	RW
		Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low to medium plasticity, red brown, some gravel.	M	VSt	RESIDUAL
					0.5		CL	Silty CLAY: medium plasticity, red brown.			PP=350kPa
					1.0						PP=350kPa
										H	
					1.5						PP>500kPa
					2.0						PP>500kPa
					2.5		CL	Silty CLAY: medium plasticity, dark red brown and grey mottled.			
			D								PP=400kPa
					3.0			Test pit TP5 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HA hand auger

Support
- T timbering
- N nil

Water
- ▼ water level on date shown
- ► water inflow
- ◄ water outflow

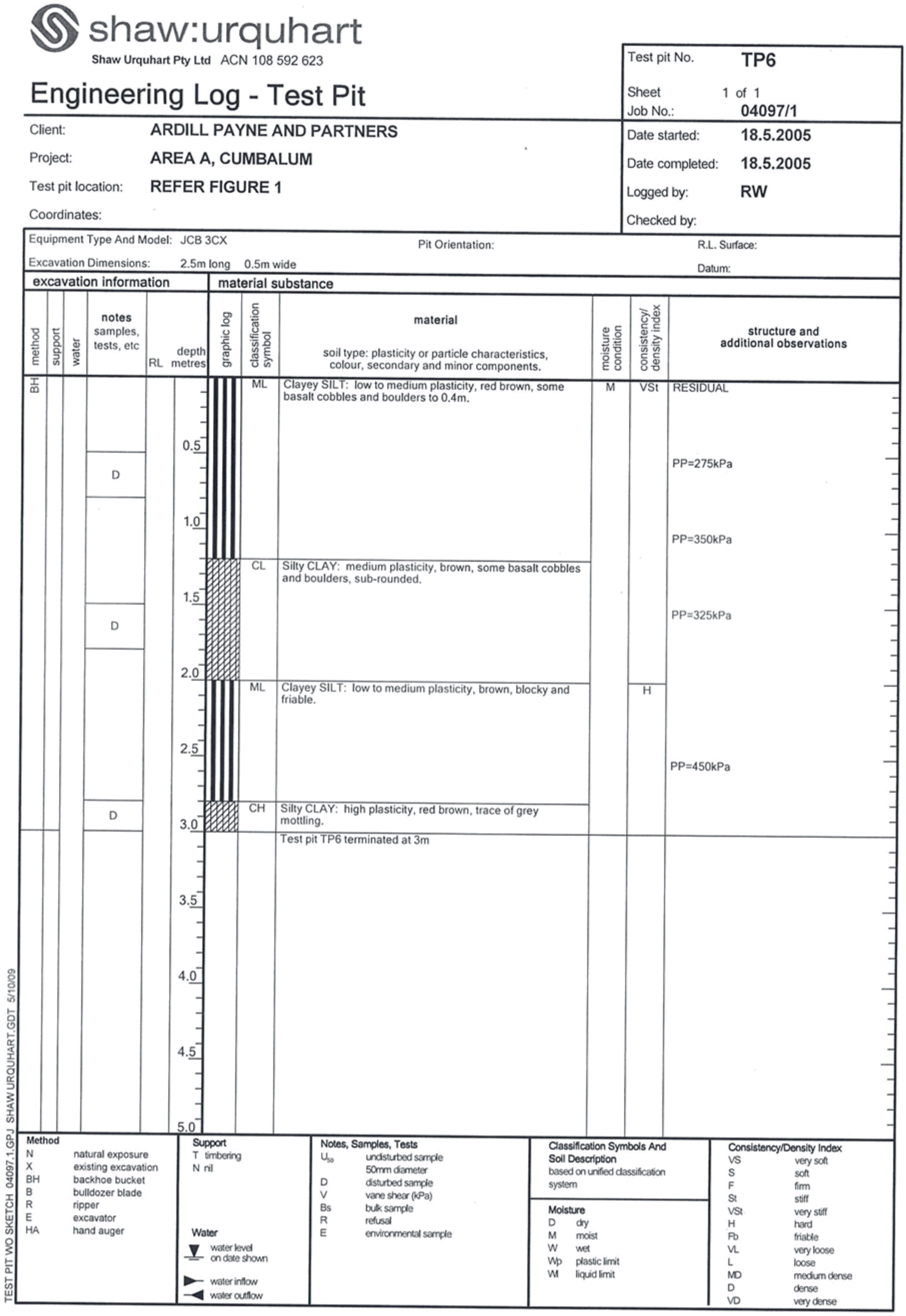
Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

Consistency/Density Index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.: TP6
Sheet 1 of 1
Job No.: 04097/1

Client: ARDILL PAYNE AND PARTNERS
Project: AREA A, CUMBALUM
Test pit location: REFER FIGURE 1
Coordinates:

Date started: 18.5.2005
Date completed: 18.5.2005
Logged by: RW
Checked by:

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH						▮	ML	Clayey SILT: low to medium plasticity, red brown, some basalt cobbles and boulders to 0.4m.	M	VSt	RESIDUAL
			D		0.5						PP=275kPa
					1.0						PP=350kPa
						▨	CL	Silty CLAY: medium plasticity, brown, some basalt cobbles and boulders, sub-rounded.			
			D		1.5						PP=325kPa
					2.0	▮	ML	Clayey SILT: low to medium plasticity, brown, blocky and friable.		H	
					2.5						PP=450kPa
			D			▨	CH	Silty CLAY: high plasticity, red brown, trace of grey mottling.			
					3.0			Test pit TP6 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering
N nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

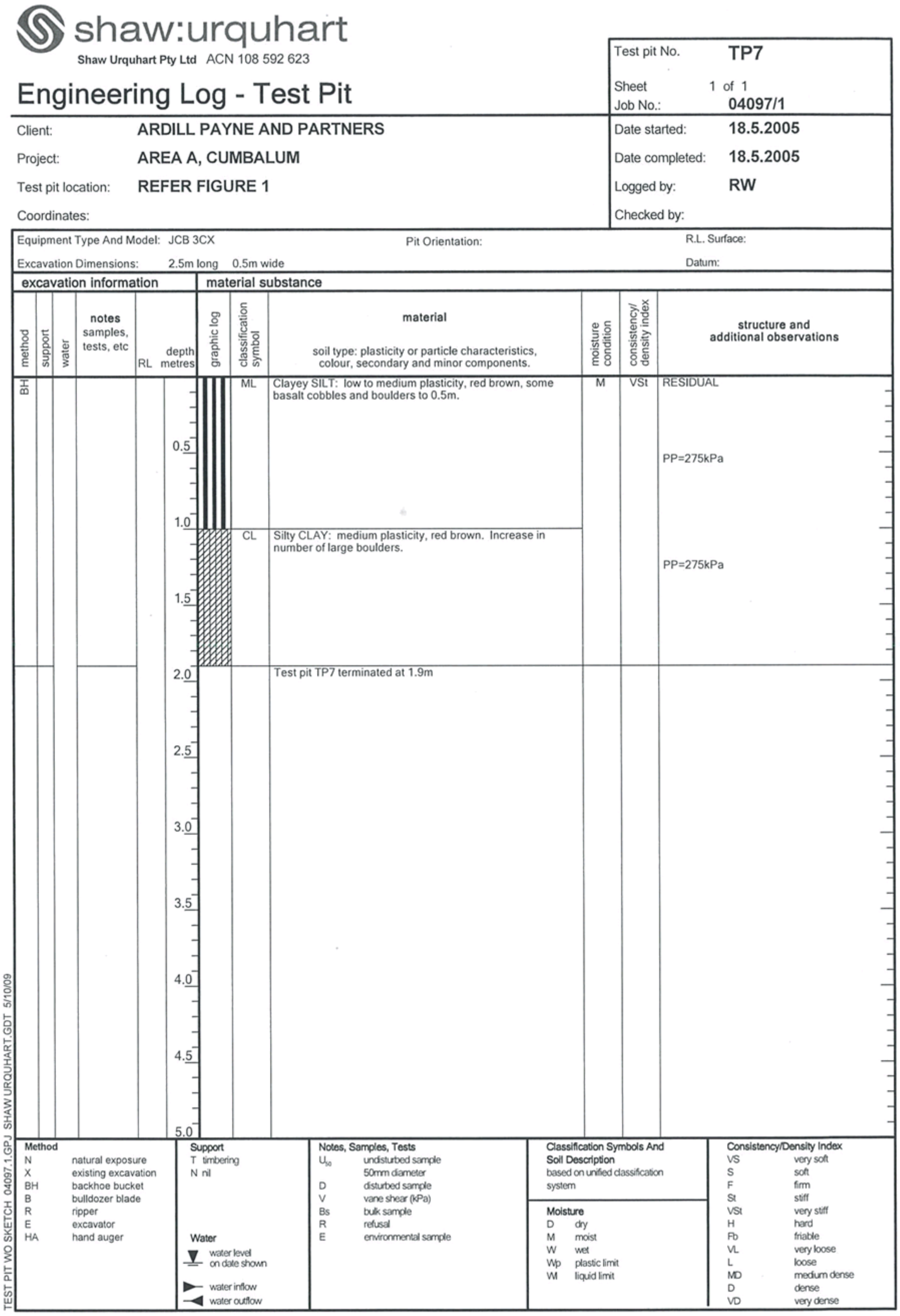
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Client:	ARDILL PAYNE AND PARTNERS	Test pit No.	TP7
Project:	AREA A, CUMBALUM	Sheet	1 of 1
Test pit location:	REFER FIGURE 1	Job No.:	04097/1
Coordinates:		Date started:	18.5.2005
		Date completed:	18.5.2005
		Logged by:	RW
		Checked by:	

Equipment Type And Model: JCB 3CX

Pit Orientation:

R.L. Surface:

Excavation Dimensions: 2.5m long 0.5m wide

Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low to medium plasticity, red brown, some basalt cobbles and boulders to 0.5m.	M	VSt	RESIDUAL
					0.5						PP=275kPa
					1.0		CL	Silty CLAY: medium plasticity, red brown. Increase in number of large boulders.			PP=275kPa
					1.5						
					2.0			Test pit TP7 terminated at 1.9m			
					2.5						
					3.0						
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering
N nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

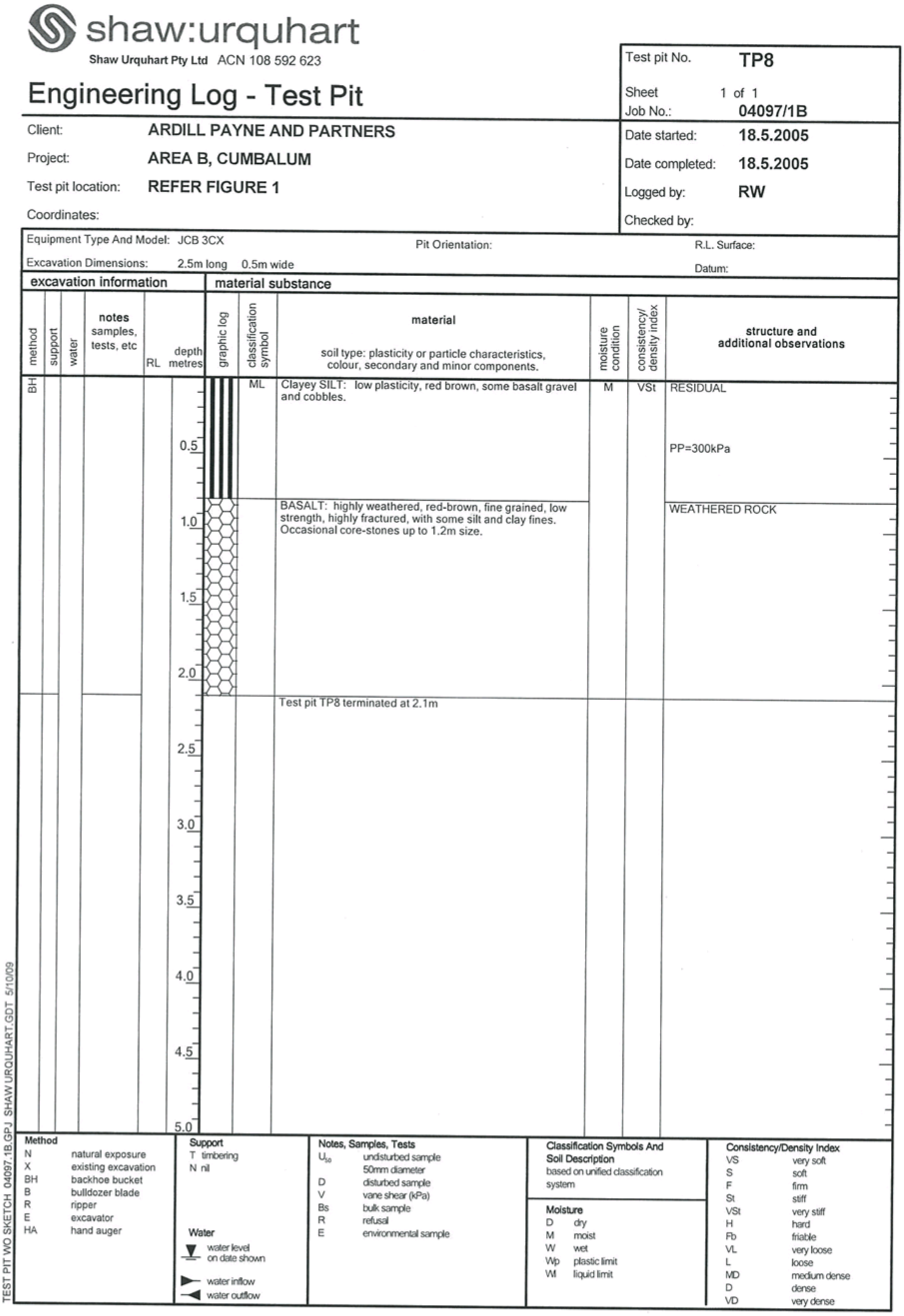
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP8**
Sheet	1 of 1
Job No.:	**04097/1B**
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	

Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA B, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	

Equipment Type And Model:	JCB 3CX
Excavation Dimensions:	2.5m long 0.5m wide
Pit Orientation:	
R.L. Surface:	
Datum:	

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH					0.5	▥	ML	Clayey SILT: low plasticity, red brown, some basalt gravel and cobbles.	M	VSt	RESIDUAL PP=300kPa
					1.0 1.5 2.0	⬡		BASALT: highly weathered, red-brown, fine grained, low strength, highly fractured, with some silt and clay fines. Occasional core-stones up to 1.2m size.			WEATHERED ROCK
					2.5 3.0 3.5 4.0 4.5 5.0			Test pit TP8 terminated at 2.1m			

Method
N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support
T	timbering
N	nil

Water
▼	water level on date shown
►	water inflow
◄	water outflow

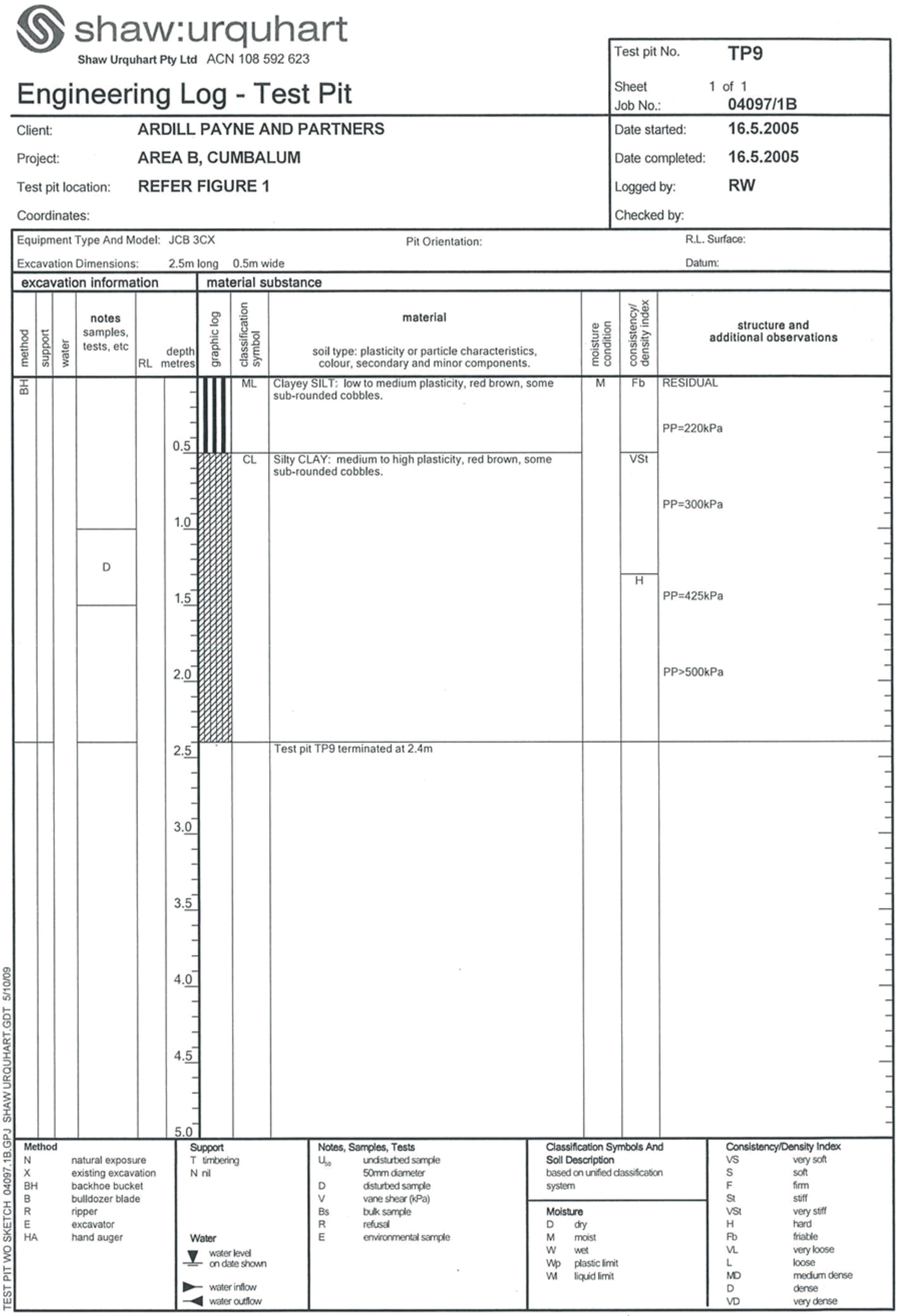
Notes, Samples, Tests
U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index
VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP9**
Sheet	1 of 1
Job No.:	**04097/1B**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA B, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**16.5.2005**
Date completed:	**16.5.2005**
Logged by:	**RW**
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low to medium plasticity, red brown, some sub-rounded cobbles.	M	Fb	RESIDUAL PP=220kPa
					0.5		CL	Silty CLAY: medium to high plasticity, red brown, some sub-rounded cobbles.		VSt	PP=300kPa
			D		1.0					H	PP=425kPa
					1.5						
					2.0						PP>500kPa
					2.5			Test pit TP9 terminated at 2.4m			
					3.0						
					3.5						
					4.0						
					4.5						
					5.0						

Method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HA hand auger

Support
T timbering
N nil

Water
▼ water level on date shown
► water inflow
◄ water outflow

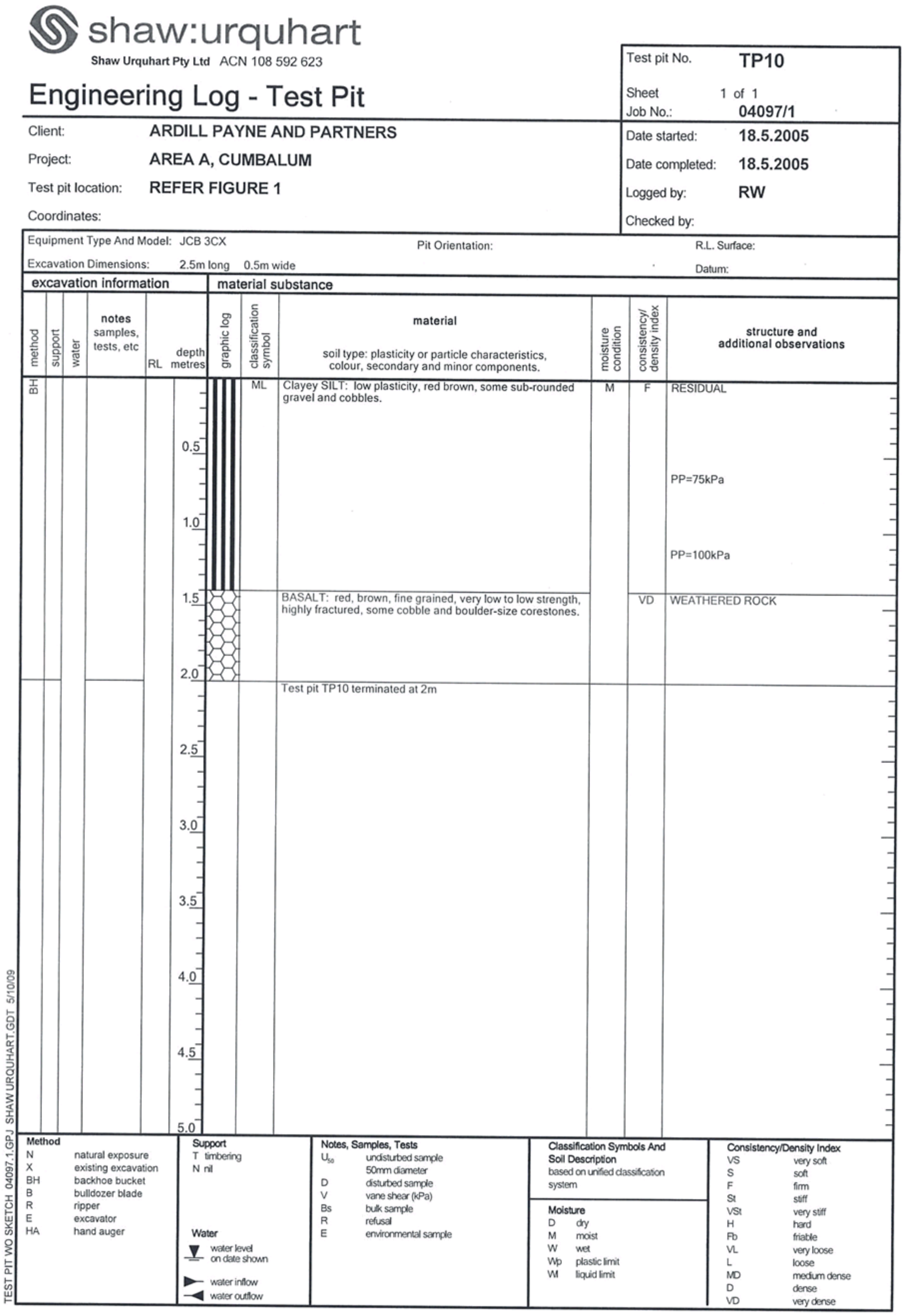
Notes, Samples, Tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
R refusal
E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

Consistency/Density Index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP10**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	
Equipment Type And Model:	JCB 3CX
Excavation Dimensions:	2.5m long 0.5m wide
Pit Orientation:	
R.L. Surface:	
Datum:	

excavation information						material substance					
method	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	**structure and additional observations**
BH					0.5 1.0		ML	Clayey SILT: low plasticity, red brown, some sub-rounded gravel and cobbles.	M	F	RESIDUAL PP=75kPa PP=100kPa
					1.5 2.0			BASALT: red, brown, fine grained, very low to low strength, highly fractured, some cobble and boulder-size corestones.		VD	WEATHERED ROCK
					2.5 3.0 3.5 4.0 4.5 5.0			Test pit TP10 terminated at 2m			

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering

N nil

Water

▼ water level on date shown

▶ water inflow

◀ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

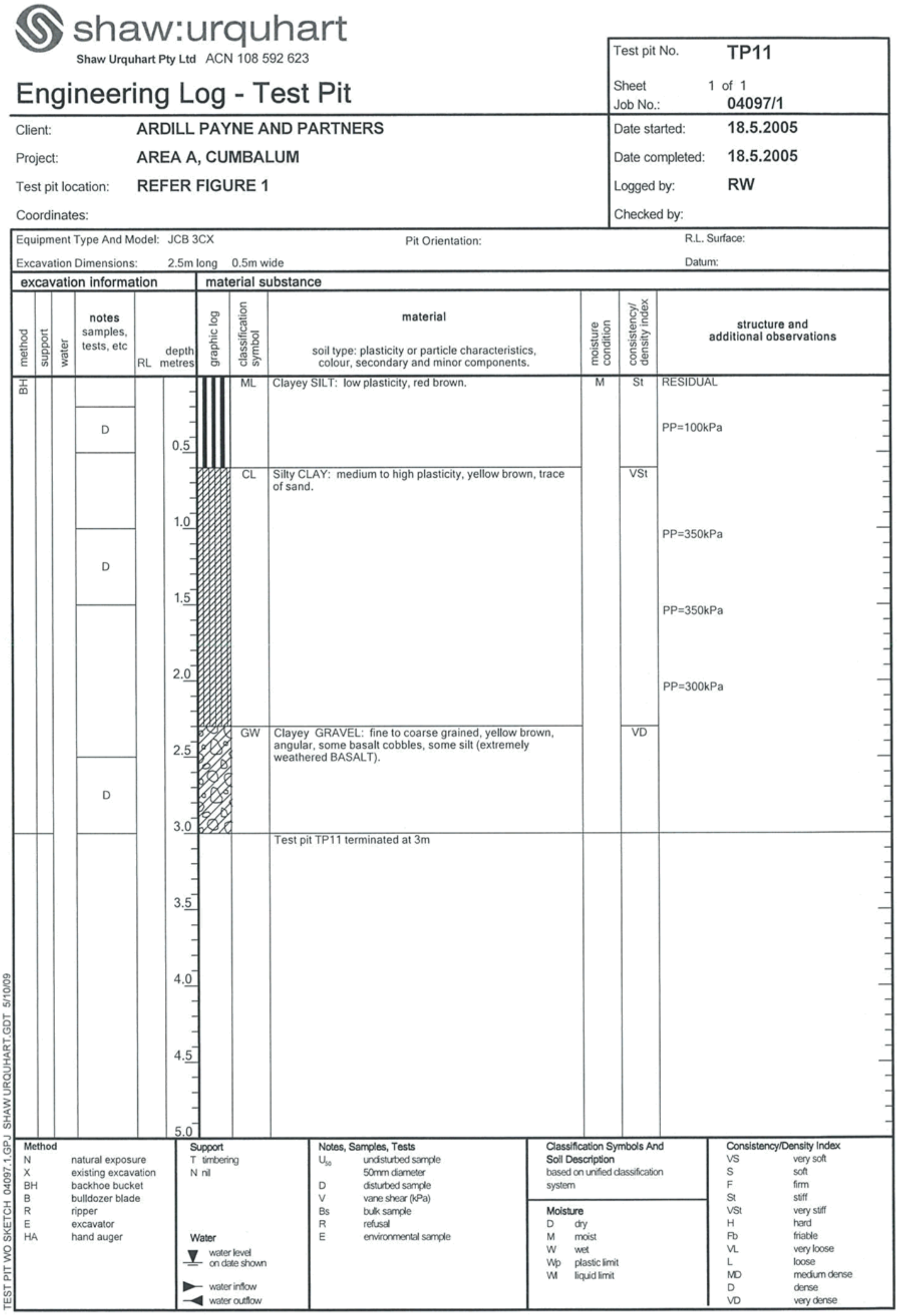
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.: **TP11**

Sheet 1 of 1

Job No.: **04097/1**

Client: **ARDILL PAYNE AND PARTNERS**

Project: **AREA A, CUMBALUM**

Test pit location: **REFER FIGURE 1**

Coordinates:

Date started: **18.5.2005**

Date completed: **18.5.2005**

Logged by: **RW**

Checked by:

Equipment Type And Model: JCB 3CX

Pit Orientation:

R.L. Surface:

Excavation Dimensions: 2.5m long 0.5m wide

Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low plasticity, red brown.	M	St	RESIDUAL
			D								PP=100kPa
					0.5						
							CL	Silty CLAY: medium to high plasticity, yellow brown, trace of sand.		VSt	
					1.0						PP=350kPa
			D								
					1.5						PP=350kPa
					2.0						PP=300kPa
							GW	Clayey GRAVEL: fine to coarse grained, yellow brown, angular, some basalt cobbles, some silt (extremely weathered BASALT).		VD	
					2.5						
			D								
					3.0			Test pit TP11 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HA hand auger

Support
- T timbering
- N nil

Water
- ▼ water level on date shown
- ► water inflow
- ◄ water outflow

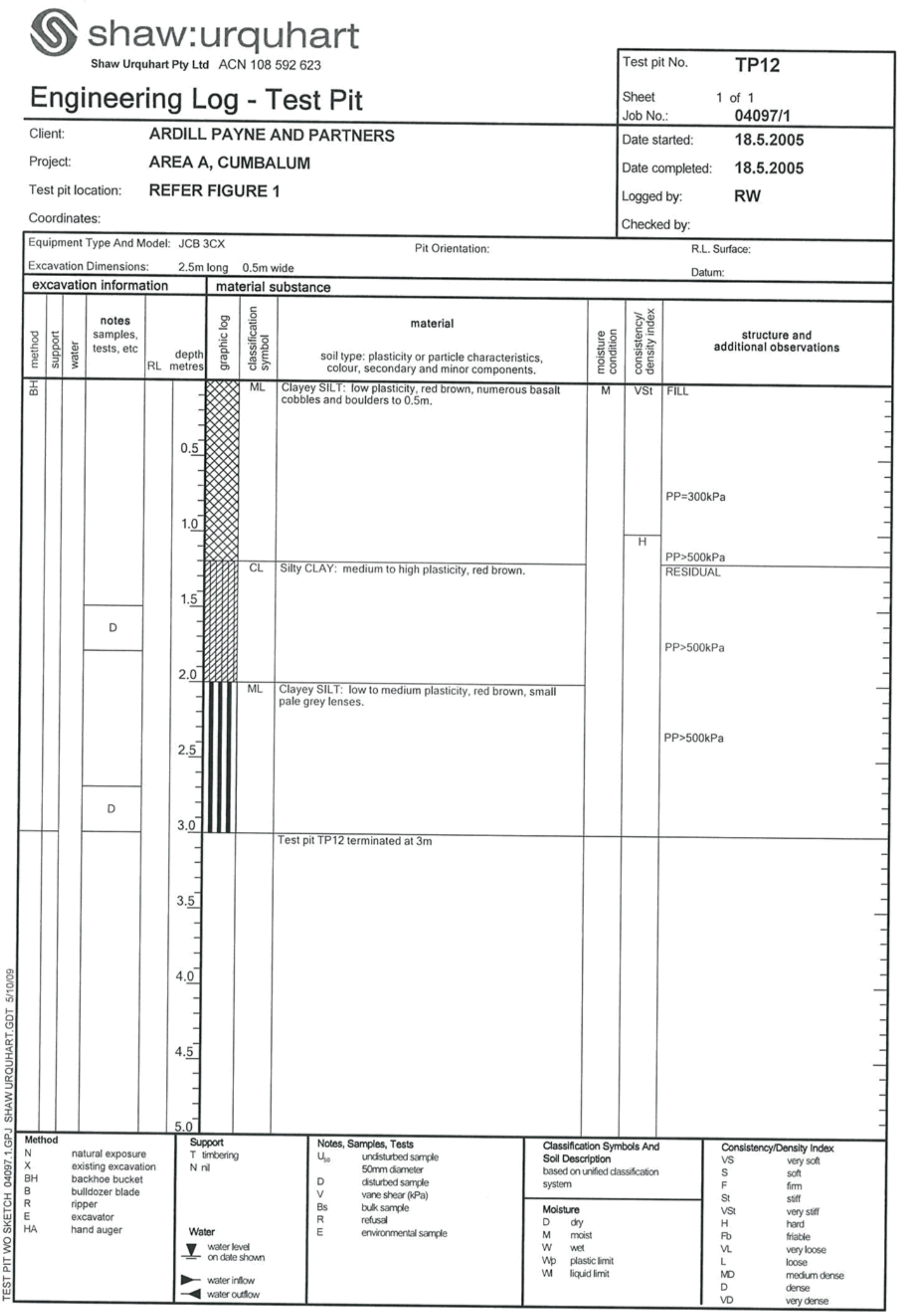
Notes, Samples, Tests
- U_{50} undisturbed sample 50mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- R refusal
- E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

Consistency/Density Index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP12**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	
Equipment Type And Model:	JCB 3CX
Excavation Dimensions:	2.5m long 0.5m wide
Pit Orientation:	
R.L. Surface:	
Datum:	

excavation information						material substance					
method	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	**structure and additional observations**
BH						▩	ML	Clayey SILT: low plasticity, red brown, numerous basalt cobbles and boulders to 0.5m.	M	VSt	FILL
					0.5						
											PP=300kPa
					1.0						
										H	
											PP>500kPa
						▥	CL	Silty CLAY: medium to high plasticity, red brown.			RESIDUAL
					1.5						
			D								
											PP>500kPa
					2.0	▮	ML	Clayey SILT: low to medium plasticity, red brown, small pale grey lenses.			
											PP>500kPa
					2.5						
			D								
					3.0			Test pit TP12 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼	water level on date shown
►	water inflow
◄	water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

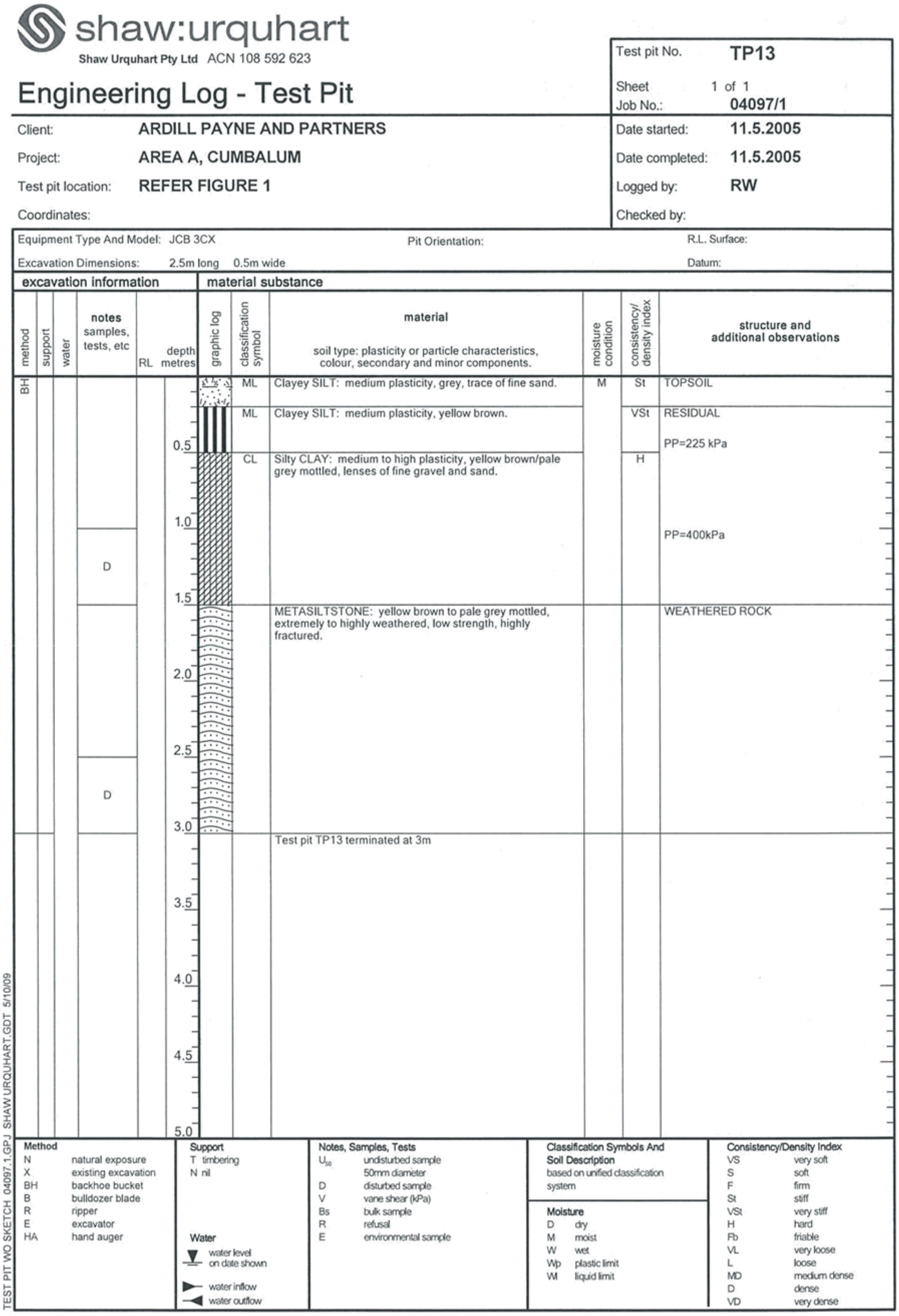
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	TP13
Sheet	1 of 1
Job No.:	04097/1
Client:	ARDILL PAYNE AND PARTNERS
Project:	AREA A, CUMBALUM
Test pit location:	REFER FIGURE 1
Coordinates:	
Date started:	11.5.2005
Date completed:	11.5.2005
Logged by:	RW
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: medium plasticity, grey, trace of fine sand.	M	St	TOPSOIL
							ML	Clayey SILT: medium plasticity, yellow brown.		VSt	RESIDUAL PP=225 kPa
					0.5		CL	Silty CLAY: medium to high plasticity, yellow brown/pale grey mottled, lenses of fine gravel and sand.		H	
			D		1.0						PP=400kPa
					1.5			METASILTSTONE: yellow brown to pale grey mottled, extremely to highly weathered, low strength, highly fractured.			WEATHERED ROCK
					2.0						
			D		2.5						
					3.0			Test pit TP13 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering
N nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

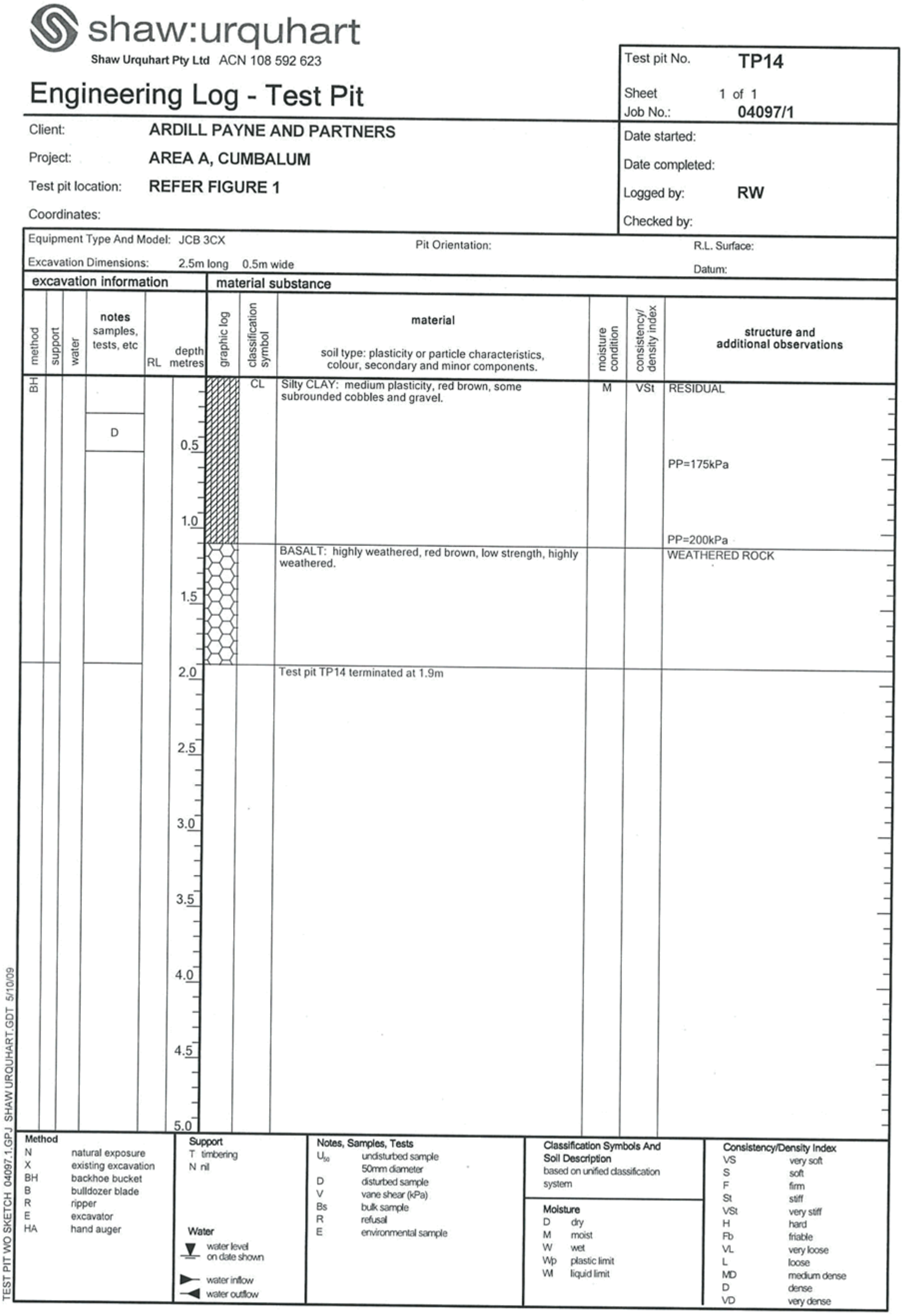
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP14**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	
Date completed:	
Logged by:	**RW**
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							CL	Silty CLAY: medium plasticity, red brown, some subrounded cobbles and gravel.	M	VSt	RESIDUAL
			D		0.5						PP=175kPa
					1.0						PP=200kPa
					1.5			BASALT: highly weathered, red brown, low strength, highly weathered.			WEATHERED ROCK
					2.0			Test pit TP14 terminated at 1.9m			
					2.5						
					3.0						
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼	water level on date shown
►	water inflow
◄	water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

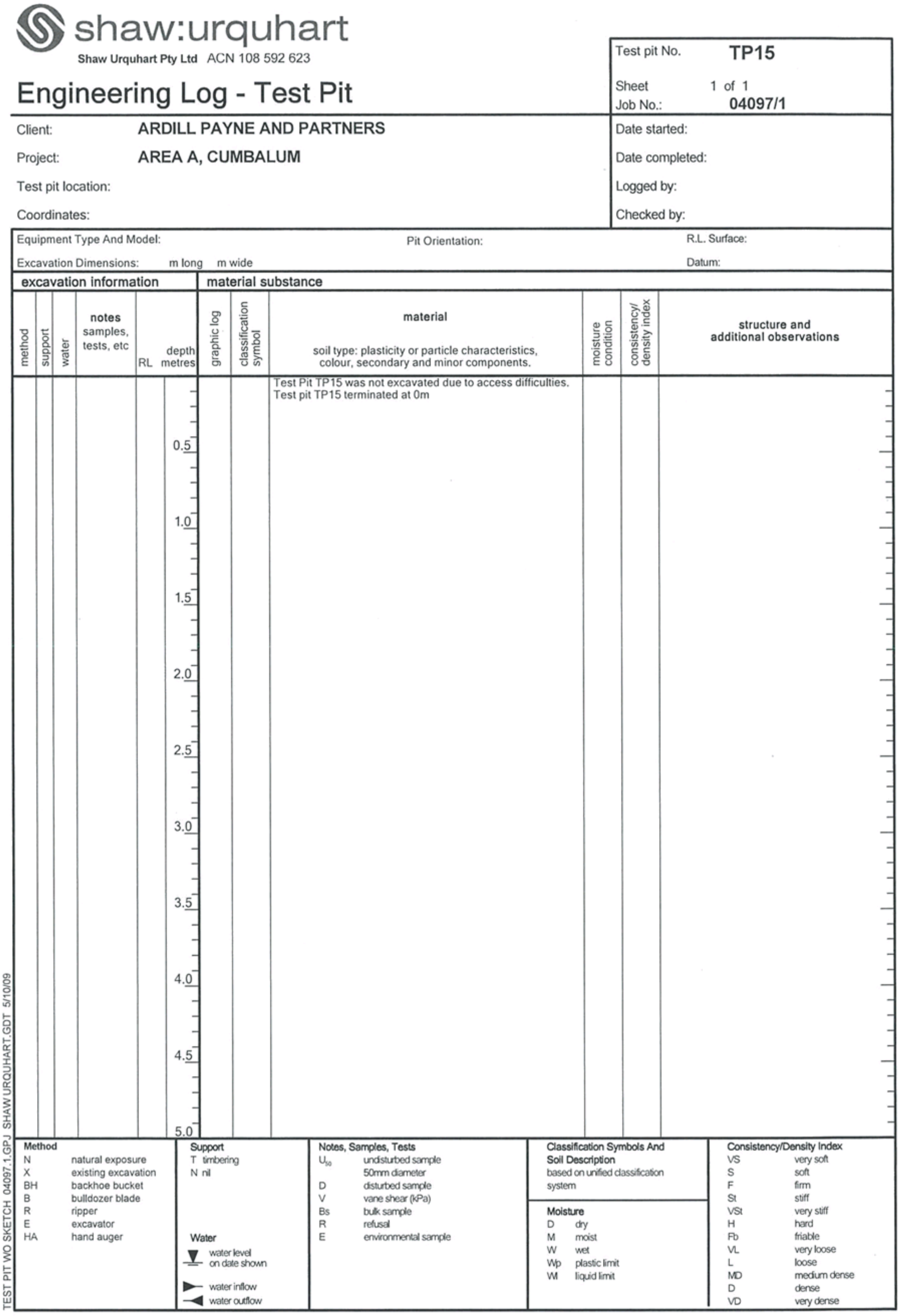
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No. **TP15**
Sheet 1 of 1
Job No.: **04097/1**

Client: **ARDILL PAYNE AND PARTNERS**
Project: **AREA A, CUMBALUM**
Test pit location:
Coordinates:

Date started:
Date completed:
Logged by:
Checked by:

Equipment Type And Model:
Pit Orientation:
R.L. Surface:
Excavation Dimensions: m long m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
								Test Pit TP15 was not excavated due to access difficulties. Test pit TP15 terminated at 0m			
					0.5						
					1.0						
					1.5						
					2.0						
					2.5						
					3.0						
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼	water level on date shown
►	water inflow
◄	water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

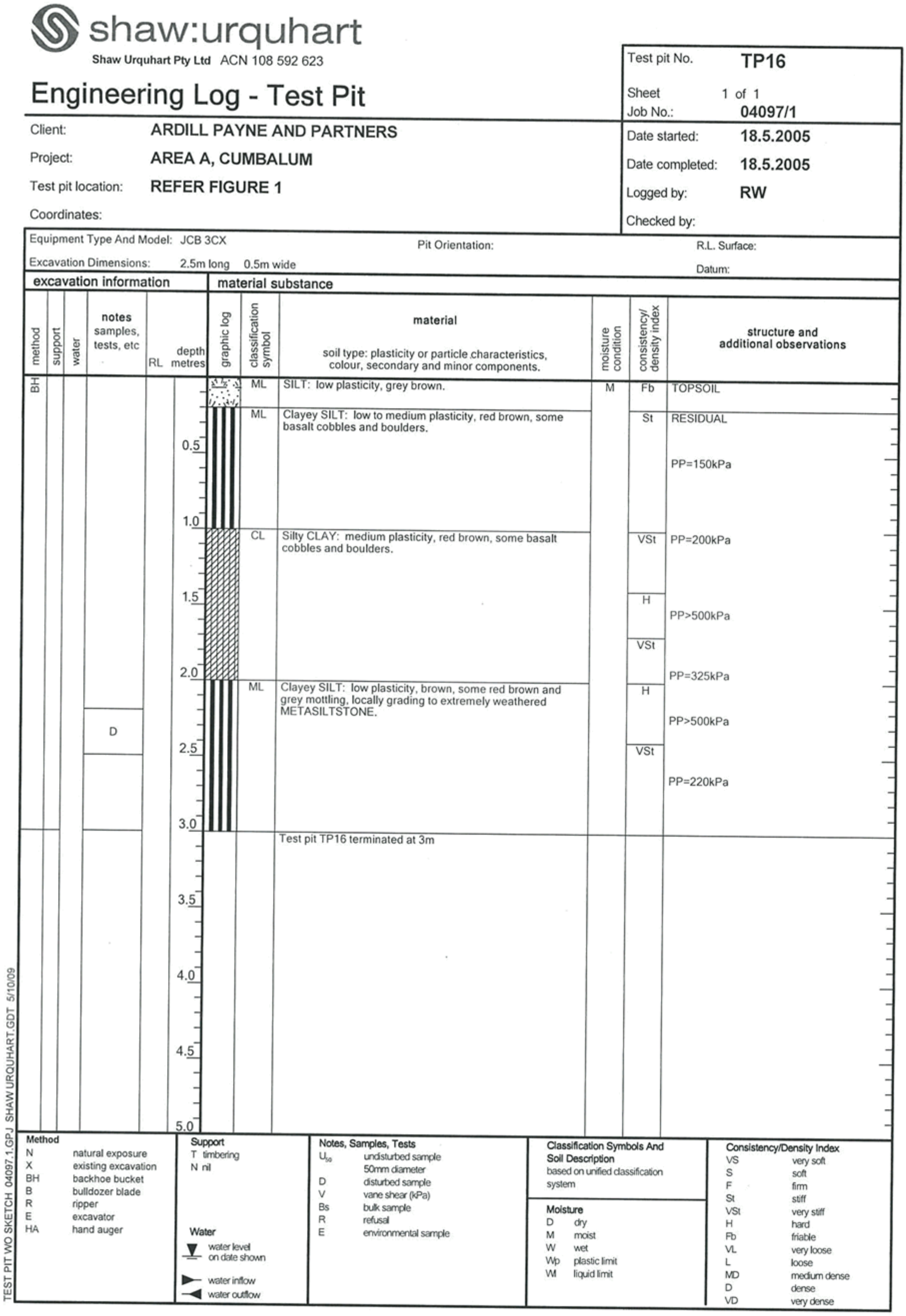
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	TP16
Sheet	1 of 1
Job No.:	04097/1
Client:	ARDILL PAYNE AND PARTNERS
Project:	AREA A, CUMBALUM
Test pit location:	REFER FIGURE 1
Coordinates:	
Date started:	18.5.2005
Date completed:	18.5.2005
Logged by:	RW
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	SILT: low plasticity, grey brown.	M	Fb	TOPSOIL
					0.5 1.0		ML	Clayey SILT: low to medium plasticity, red brown, some basalt cobbles and boulders.		St	RESIDUAL PP=150kPa
					1.5 2.0		CL	Silty CLAY: medium plasticity, red brown, some basalt cobbles and boulders.		VSt H VSt	PP=200kPa PP>500kPa PP=325kPa
			D		2.5 3.0		ML	Clayey SILT: low plasticity, brown, some red brown and grey mottling, locally grading to extremely weathered METASILTSTONE.		H VSt	PP>500kPa PP=220kPa
					3.5 4.0 4.5 5.0			Test pit TP16 terminated at 3m			

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼ water level on date shown
► water inflow
◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

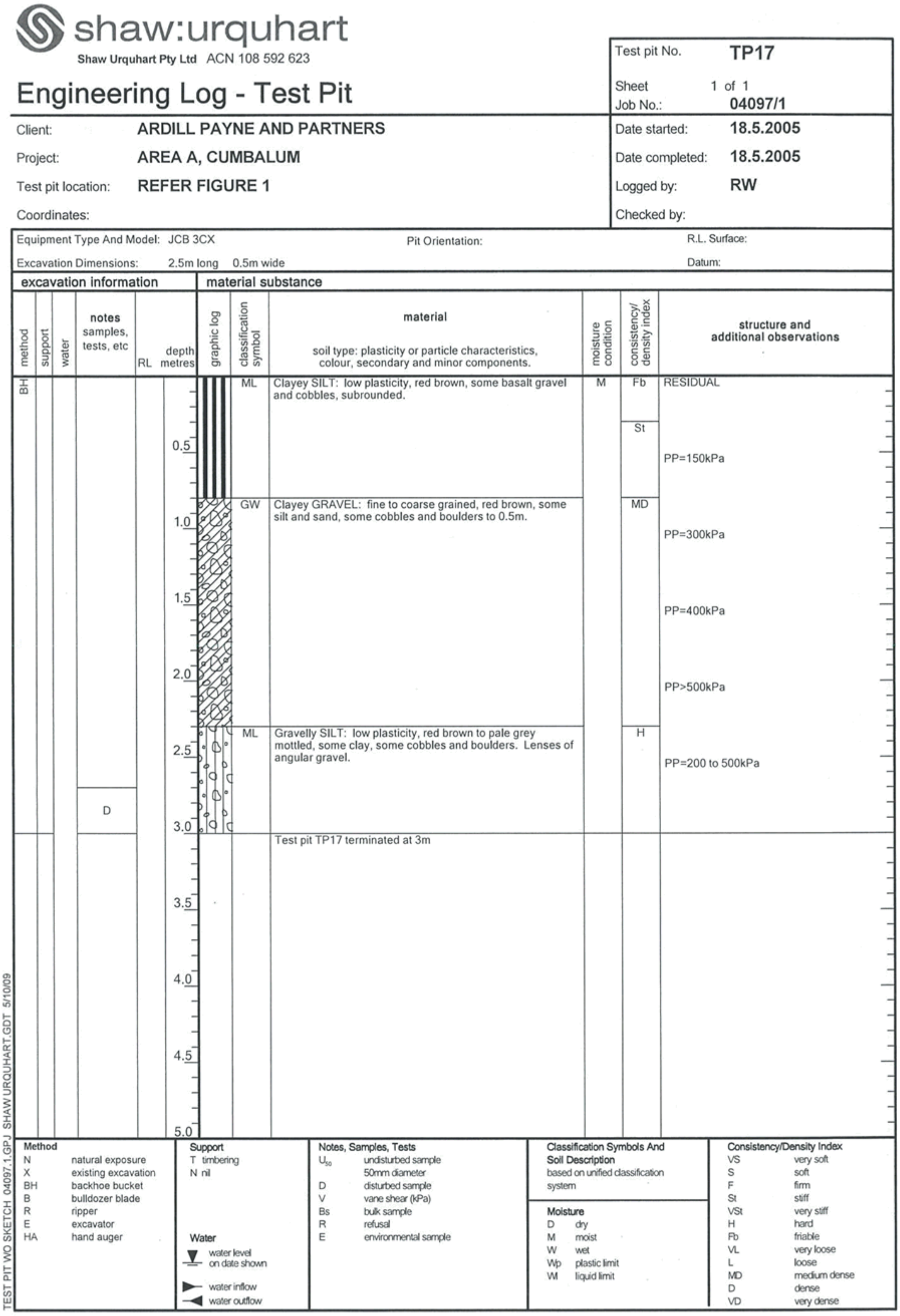
Classification Symbols And Soil Description
based on unified classification system

Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense



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Engineering Log - Test Pit

Test pit No.	**TP17**
Sheet	1 of 1
Job No.:	**04097/1**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA A, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**18.5.2005**
Date completed:	**18.5.2005**
Logged by:	**RW**
Checked by:	
Equipment Type And Model:	JCB 3CX
Excavation Dimensions:	2.5m long 0.5m wide
Pit Orientation:	
R.L. Surface:	
Datum:	

excavation information						material substance					
method	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	**structure and additional observations**
BH							ML	Clayey SILT: low plasticity, red brown, some basalt gravel and cobbles, subrounded.	M	Fb	RESIDUAL
										St	
					0.5						PP=150kPa
							GW	Clayey GRAVEL: fine to coarse grained, red brown, some silt and sand, some cobbles and boulders to 0.5m.		MD	
					1.0						PP=300kPa
					1.5						PP=400kPa
					2.0						PP>500kPa
							ML	Gravelly SILT: low plasticity, red brown to pale grey mottled, some clay, some cobbles and boulders. Lenses of angular gravel.		H	
					2.5						PP=200 to 500kPa
			D								
					3.0			Test pit TP17 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HA hand auger

Support
T timbering
N nil

Water
▼ water level on date shown
► water inflow
◄ water outflow

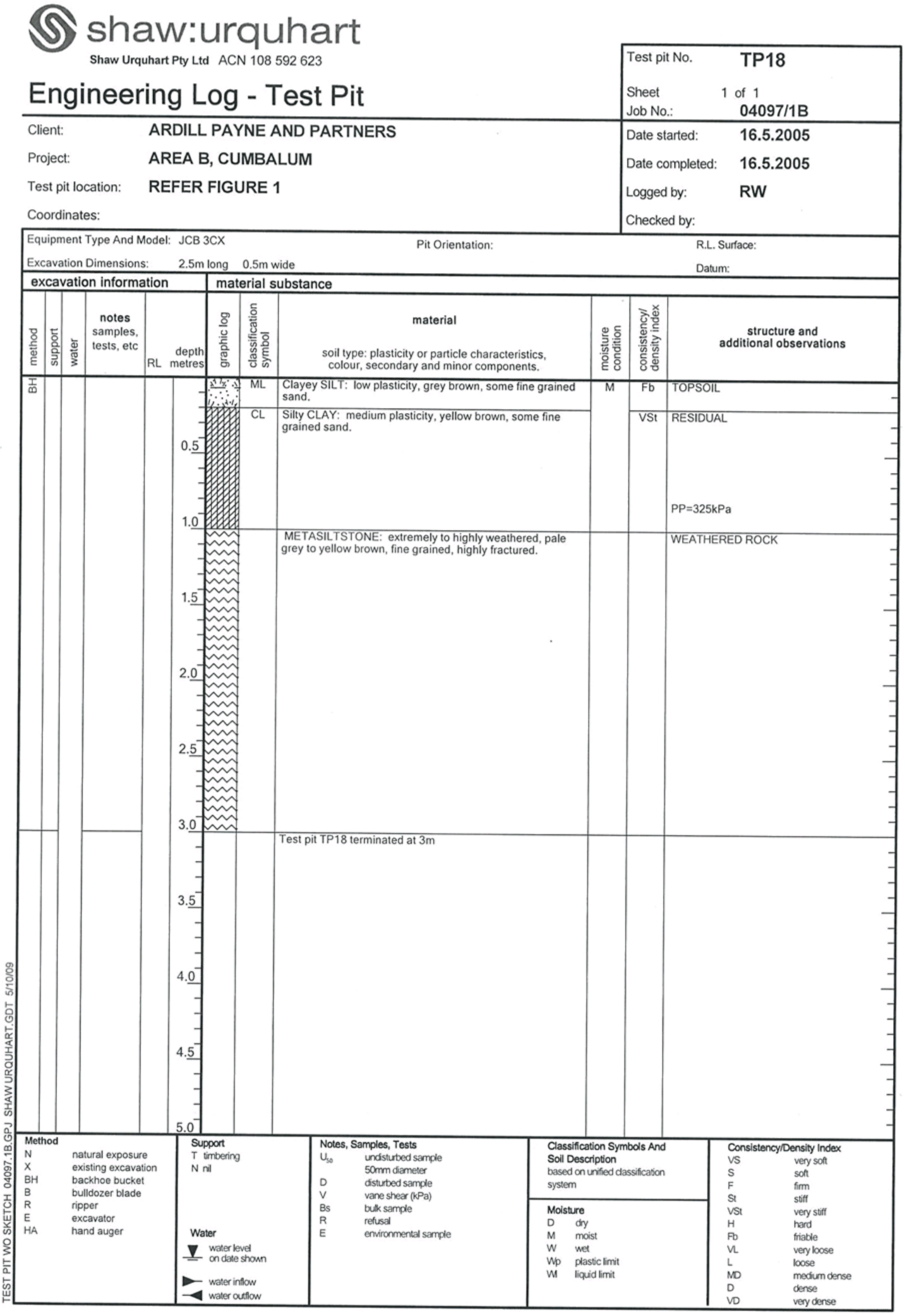
Notes, Samples, Tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
R refusal
E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

Consistency/Density Index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TEST PIT WO SKETCH 04097.1.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	**TP18**
Sheet	1 of 1
Job No.:	**04097/1B**
Client:	**ARDILL PAYNE AND PARTNERS**
Project:	**AREA B, CUMBALUM**
Test pit location:	**REFER FIGURE 1**
Coordinates:	
Date started:	**16.5.2005**
Date completed:	**16.5.2005**
Logged by:	**RW**
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low plasticity, grey brown, some fine grained sand.	M	Fb	TOPSOIL
					0.5		CL	Silty CLAY: medium plasticity, yellow brown, some fine grained sand.		VSt	RESIDUAL PP=325kPa
					1.0 1.5 2.0 2.5			METASILTSTONE: extremely to highly weathered, pale grey to yellow brown, fine grained, highly fractured.			WEATHERED ROCK
					3.0 3.5 4.0 4.5 5.0			Test pit TP18 terminated at 3m			

Method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HA hand auger

Support
T timbering
N nil

Water
water level on date shown
water inflow
water outflow

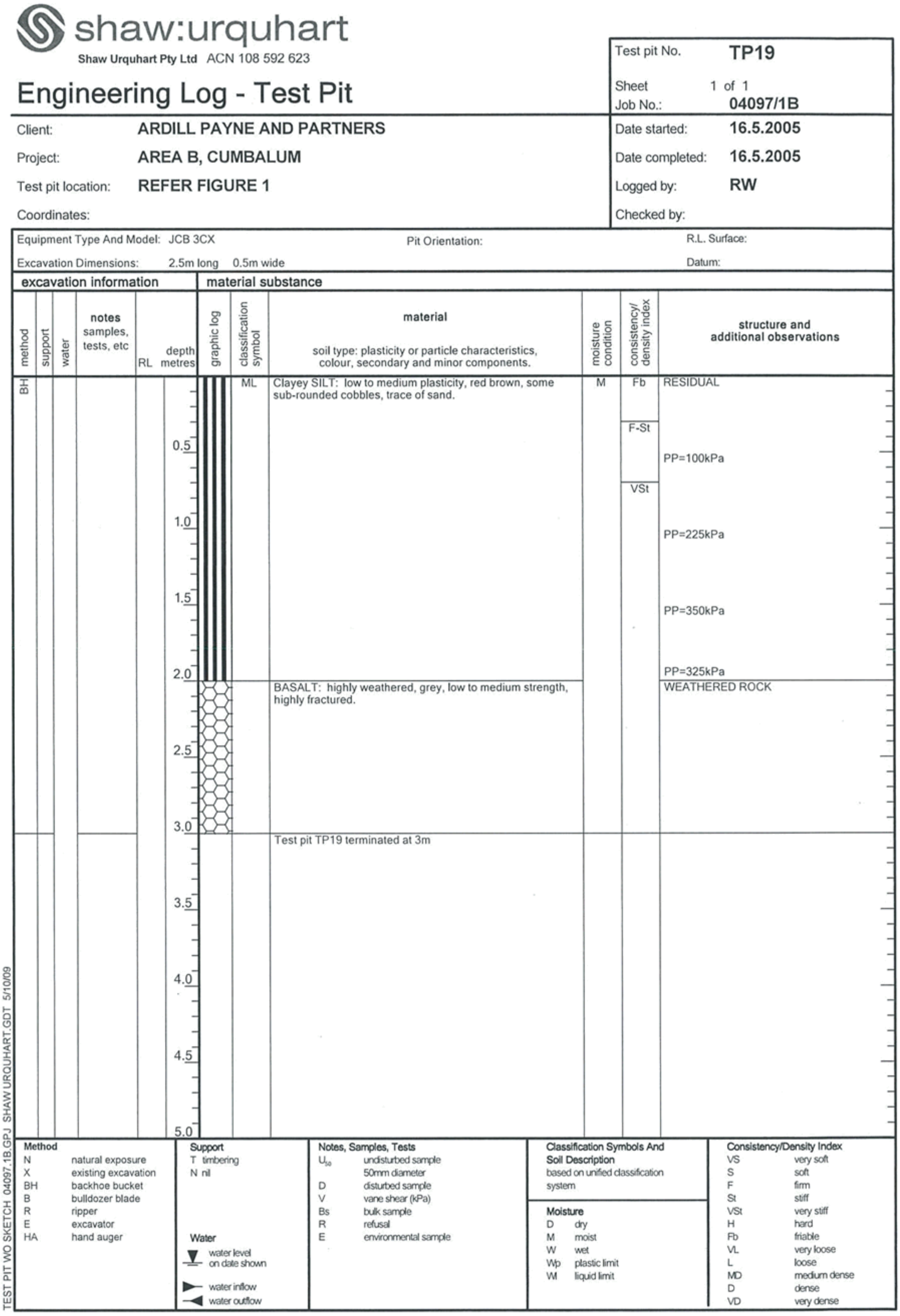
Notes, Samples, Tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
R refusal
E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

Consistency/Density Index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No. **TP19**

Sheet 1 of 1

Job No.: **04097/1B**

Client: **ARDILL PAYNE AND PARTNERS**

Project: **AREA B, CUMBALUM**

Test pit location: **REFER FIGURE 1**

Coordinates:

Date started: **16.5.2005**

Date completed: **16.5.2005**

Logged by: **RW**

Checked by:

Equipment Type And Model: JCB 3CX

Pit Orientation:

R.L. Surface:

Excavation Dimensions: 2.5m long 0.5m wide

Datum:

excavation information						material substance					
method	support	water	**notes** samples, tests, etc	RL	depth metres	graphic log	classification symbol	**material** soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	**structure and additional observations**
BH							ML	Clayey SILT: low to medium plasticity, red brown, some sub-rounded cobbles, trace of sand.	M	Fb	RESIDUAL
					0.5					F-St	PP=100kPa
					1.0					VSt	PP=225kPa
					1.5						PP=350kPa
					2.0						PP=325kPa
								BASALT: highly weathered, grey, low to medium strength, highly fractured.			WEATHERED ROCK
					2.5						
					3.0			Test pit TP19 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T timbering

N nil

Water

▼ water level on date shown

► water inflow

◄ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

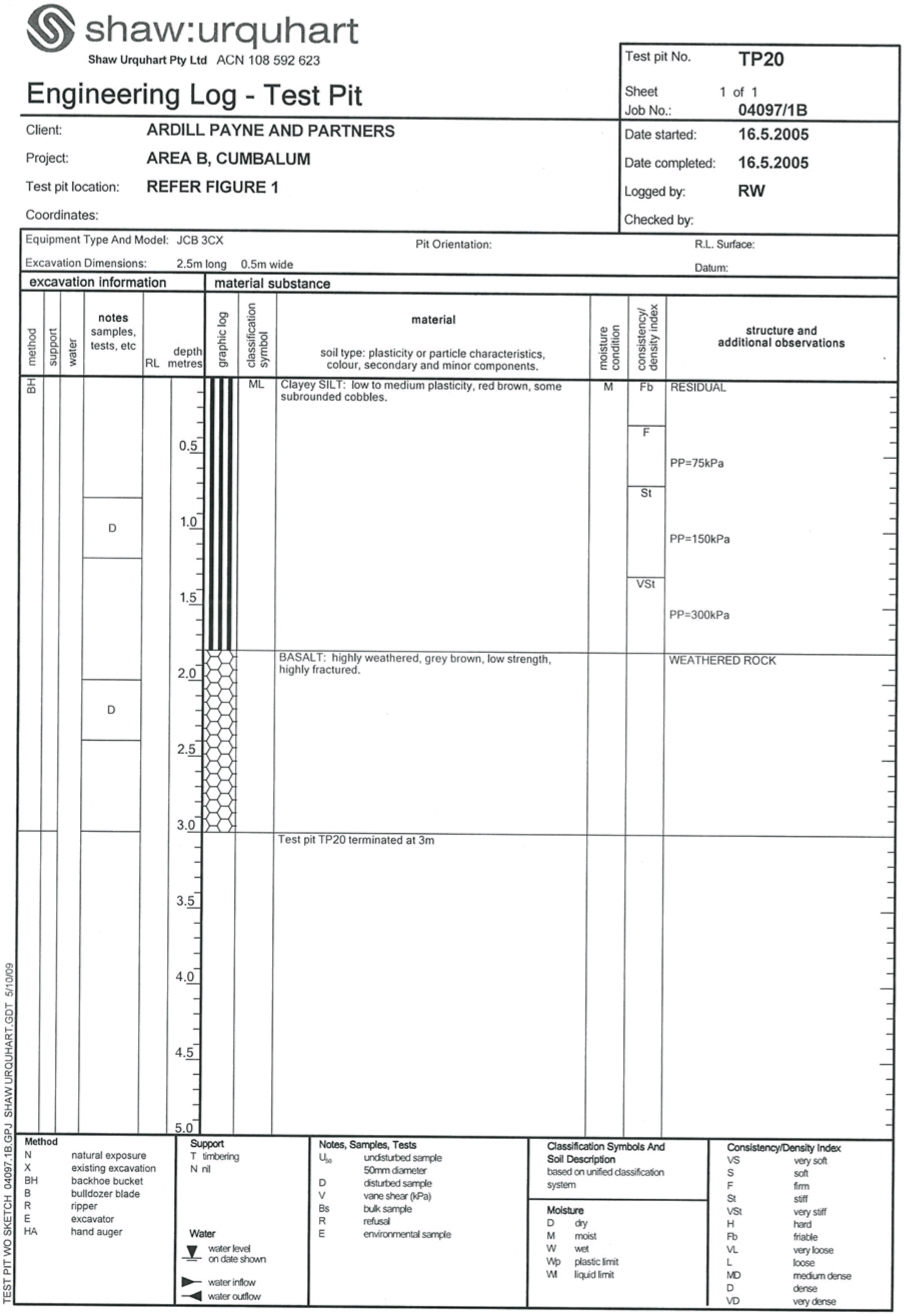
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Client:	ARDILL PAYNE AND PARTNERS	Test pit No.	TP20
		Sheet	1 of 1
		Job No.:	04097/1B
Project:	AREA B, CUMBALUM	Date started:	16.5.2005
Test pit location:	REFER FIGURE 1	Date completed:	16.5.2005
		Logged by:	RW
Coordinates:		Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: low to medium plasticity, red brown, some subrounded cobbles.	M	Fb	RESIDUAL
					0.5					F	PP=75kPa
										St	
			D		1.0						PP=150kPa
										VSt	
					1.5						PP=300kPa
								BASALT: highly weathered, grey brown, low strength, highly fractured.			WEATHERED ROCK
					2.0						
			D								
					2.5						
					3.0						
								Test pit TP20 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support
T timbering
N nil

Water
▼ water level on date shown
▶ water inflow
◀ water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description
based on unified classification system

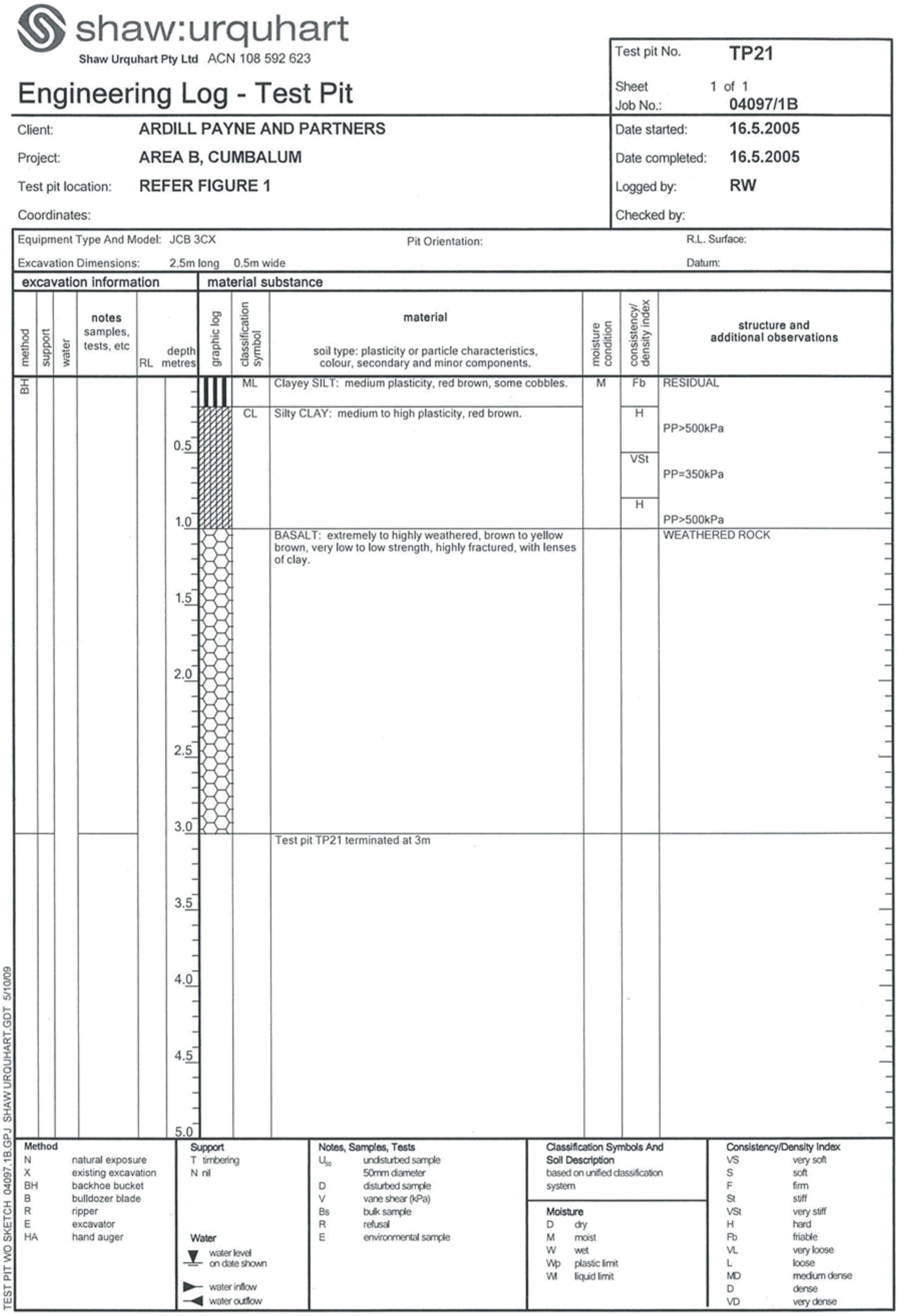
Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	TP21
Sheet	1 of 1
Job No.:	04097/1B
Client:	ARDILL PAYNE AND PARTNERS
Project:	AREA B, CUMBALUM
Test pit location:	REFER FIGURE 1
Coordinates:	
Date started:	16.5.2005
Date completed:	16.5.2005
Logged by:	RW
Checked by:	

Equipment Type And Model: JCB 3CX
Pit Orientation:
R.L. Surface:
Excavation Dimensions: 2.5m long 0.5m wide
Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
BH							ML	Clayey SILT: medium plasticity, red brown, some cobbles.	M	Fb	RESIDUAL
							CL	Silty CLAY: medium to high plasticity, red brown.		H	PP>500kPa
					0.5					VSt	PP=350kPa
										H	PP>500kPa
					1.0			BASALT: extremely to highly weathered, brown to yellow brown, very low to low strength, highly fractured, with lenses of clay.			WEATHERED ROCK
					1.5						
					2.0						
					2.5						
					3.0			Test pit TP21 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HA hand auger

Support
T timbering
N nil

Water
▼ water level on date shown
► water inflow
◄ water outflow

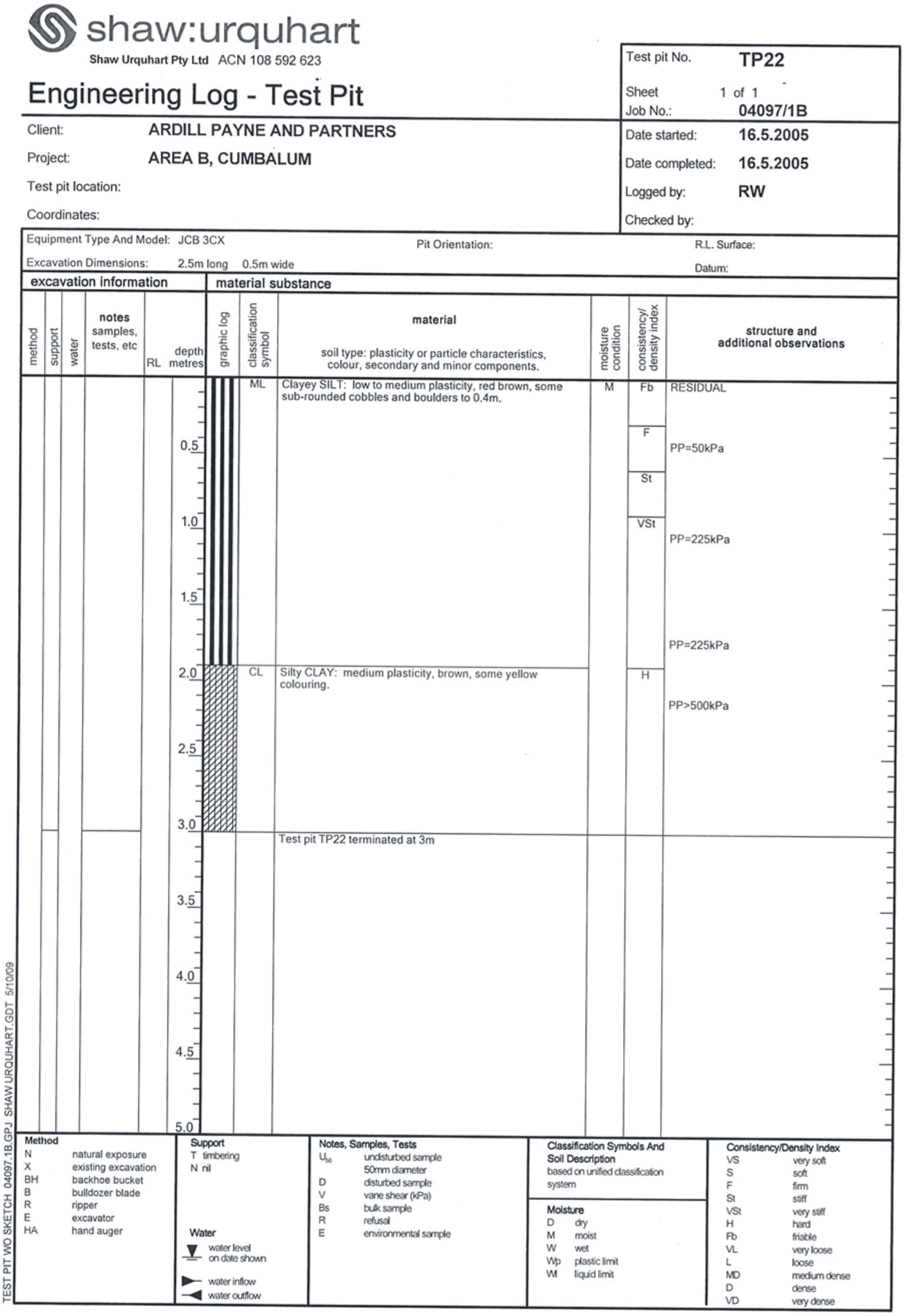
Notes, Samples, Tests
U_{50} undisturbed sample 50mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
R refusal
E environmental sample

Classification Symbols And Soil Description
based on unified classification system

Moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

Consistency/Density Index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09



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Engineering Log - Test Pit

Test pit No.	TP22
Sheet	1 of 1
Job No.:	04097/1B
Date started:	16.5.2005
Date completed:	16.5.2005
Logged by:	RW
Checked by:	

Client: ARDILL PAYNE AND PARTNERS

Project: AREA B, CUMBALUM

Test pit location:

Coordinates:

Equipment Type And Model: JCB 3CX

Pit Orientation:

R.L. Surface:

Excavation Dimensions: 2.5m long 0.5m wide

Datum:

excavation information						material substance					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	structure and additional observations
							ML	Clayey SILT: low to medium plasticity, red brown, some sub-rounded cobbles and boulders to 0.4m.	M	Fb	RESIDUAL
										F	PP=50kPa
					0.5						
										St	
					1.0					VSt	PP=225kPa
					1.5						
											PP=225kPa
					2.0		CL	Silty CLAY: medium plasticity, brown, some yellow colouring.		H	PP>500kPa
					2.5						
					3.0			Test pit TP22 terminated at 3m			
					3.5						
					4.0						
					4.5						
					5.0						

Method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator
HA	hand auger

Support

T	timbering
N	nil

Water

▼	water level on date shown
►	water inflow
◄	water outflow

Notes, Samples, Tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
R	refusal
E	environmental sample

Classification Symbols And Soil Description

based on unified classification system

Moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

Consistency/Density Index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TEST PIT WO SKETCH 04097.1B.GPJ SHAW URQUHART.GDT 5/10/09

04097/1-H
2 October 2009

APPENDIX B

SITE OBSERVATION NOTES

04097/1-H
2 October 2009

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Site Observation Notes

For locations of notes see Figures 2 and 3

1. Broad area of low-lying marshy paddock with surface water at the time of the site visit.

2. Area of slightly higher, drier ground with scattered, mature trees.

3. Unsealed access road.

18. Up to approximately 2m of red-brown to brown colluvial soils exposed in the road cutting on the south side of Sandy Flat Road.

19. Pile of basalt boulders in a drainage channel.

20. Broad area of open, grassed paddock, slightly hummocky slopes falling to the north east with slopes angles of typically 16° to 20°, locally 25°.

21. Erosion scar/small landslide around 10m across. Looks like an old track terrace with fill on the down-slope side which has slumped. The area is in the drainage path of the rainwater tank overflow pipe from the adjacent house.

22. Old cut and fill terrace with 25° slopes on down-slope side (possible old access track.

23. Old cut and fill terrace with 25° to 27° slopes on down-slope side (possible old access track.

24. Unlined V-shaped cut-off drain, draining to the east.

25. Area of trees and boulders on up-slope side of access driveway. The cut batter on the up-slope side of the driveway is around 1.3m to 1.5m high formed at 35° to 45°, exposing red-brown clay soils.

26. Broad, bowl-shaped area of steeper slopes of around 23° to 25°.

27. Possible, small to medium size shallow landslide, approximately 15m wide by 20m long with an average slope angle of around 22° to 25°.

28. Broad, swampy area with running water, draining eastwards.

29. Steep, treed and overgrown creek bank, slope angles of typically 28° to 30°. Possible fill on down-slopes side of access track, more likely to be a landslide caused by undercutting of the creek bank.

30. Broad erosion scar exposing brown to red-brown silty clay with basalt fragments.

31. Broad area of densely treed, heavily overgrown, steep slopes and slope angles of typically 25° to 27°.

32. Erosion scar exposure of grey-brown silty clay with metasiltstone fragments.

33. Small farm dam embankment around 2m high and retained pond.

34. Large farm dam, around 80m long and 3.5m high. The downstream face has been formed at around 40° to 45°.

35. Exposure of extremely to highly weathered metasiltstone in access track cutting.

36. Exposure of red-brown silty clay as soil scarring and shallow slumping.

37. Zone of very steep slopes with terracing, and shallow soil slumping and shallow small to medium size slips

38. Exposure of approx. 0.3m to 0.4m of silty clay soil overlying extremely to highly weathered metasiltstone. Immediately down-slope are very steep, terraced slopes.

39. 80m long outcrop of slightly weathered, very high strength basalt, around 2.5m to 3m high. The basalt is strongly jointed in a hexagonal, columnar pattern.

40: Two very small farm dams gouged out of the underlying residual soils and weathered basalt. The easternmost of the two dams is leaking through the base of the embankment.

41. Large pile of basalt boulders in drainage channel.

42. Open, wooded area with piles of basalt boulders.

43. Densely wooded gully.

44. Area of open, grassed paddock.

45. Medium-size farm dam with a 2.5m to 3.5m high embankment.

46. Exposure of gravelly silty clay with fragments of metasiltstone.

47. Two pegged concrete manholes (water supply?).

48. Disused concrete water tank.

49. Broad area of moderate slopes with grass and weed cover, dips west at around 10° to 12°.

50. Sealed access road/driveway.

51. Overgrown area with moderate to steep slopes, 15° to 20°, several cut and fill benches, including access road.

52. Overgrown area with steep slopes. Zone of strong surface groundwater seepage down-slope of old house platform at Site Observation Location 53.

53. Old house platform and dry stone wall.

54. Steep slopes 25° to 28° in pine tree grove to east of existing house.

55. Area of steep slopes, overgrown with lantana and long grass. Slopes typically 18°to 20° with numerous surface boulders.

56. Steep-sided drainage gully, roughly U-shaped in cross-section, heavily treed, slopes of 30° to 35° with numerous surface boulders. There is some terracing and possible soil slumping.

57. Small, lean-to covering a groundwater spring adjacent to the access track.

58. Access track with groundwater seepage on up-slope side.

59. Broad, gently to moderately sloping paddock on ridge crest and upper to middle slopes.

60. Steep-sided, incised gully with three small, localised landslips on western side. Slopes of 25° to 35°.

61. Incised drainage gully with numerous surface boulders and dense tree cover, side slopes of 25° to 35°.

62. Broad area of surface soil scarring and erosion, around 15m by 10m, with exposure of red-brown silty clay.

63. Incised, eroded gully with dense tree cover and numerous basalt boulders.

64. Exposure of yellow brown silty clay with metasiltstone fragments in access rack cutting.

65. Very steep,, near vertical eroded creek bank on curve in creek channel, around 5m high with 60° to 80° slopes and dense tree cover.

66. Copse of mature trees, slopes of 23° to 25°, surface boulders.

67. 30° fill batter on eastern edge of house platform.

68. Broad area of open, grassed paddock, slopes of 5° to 15°.

69. Fragments of metasiltstone in soil exposed on ground surface.

70. Small landslide or shallow slumping in drainage gully. The area of soil movement is around 10m wide by 15 m long on very steep slopes of 30°, with terracing along contours.

71. Densely wooded area with terracing and very steep slopes of 28° to 30°. Red brown clay soils with surface boulders.

72. Steep cut batter on north side of dam, formed at around 35° to 60° with exposure of extremely to highly weathered metasiltstone. Foliation planes dip 280°-290°/60°-70°.

73. Steep-sided drainage gully with numerous surface basalt boulders.

74. Area of surface groundwater seepage in drainage gully.

75. S.V peg and manhole (water pipe).

76. Broad area of moderate to steep slopes, dense woodland with a large number of surface boulders. Slopes typically 18° to 20°, but crossed by two, steep-sided drainage gullies with side slopes of 25° to 30° increasing to 30° to 35° at heads of gullies.

77. Large windrow of basalt boulders on up-slope side of wooded area.

78. Incised drainage gully with steep sides of around 25° to 30° and numerous basalt boulders.

79. White concrete water tank.

80. Broad area of open, grassed paddock scattered trees and gentle slopes.

81. Three distinct piles of basalt boulders on crest of ridge.

82. Dense copse of trees, around 60m by 80m on approximately 10° slopes falling to the south.

83. Moderate to steep slopes, grassed and with scattered trees, incised drainage gullies and slopes of around 20° to 23°.

84. Exposure of pale grey clay soil with metasandstone and greywacke gravel and cobbles.

85. Large mound of red-brown clay with basalt cobbles.

86. Area of long grass and paddock with slopes of 18° to 20°.

87. Exposure of red-brown clay with basalt gravel and cobbles on up-slope cut on access track

88. Small farm dam, around 20m long and 2m high.

89. Two, steep-sided drainage gullies with eroded banks with slopes of 30° to 40°, heavily overgrown, densely vegetated, with numerous surface basalt boulders.

90. Two distinct soil scars, exposing red-brown silty clay with basalt gravel.

91. Copse of moderately dense tree cover, thick undergrowth and basalt boulders. Slopes fall to the south and south east at around 18° to 22°.

92. Sub-crop and boulders of weathered basalt, slopes of approx. 18° to 22°

93. Large copse of dense trees around incised drainage gully, slopes of 18° to 20°. Numerous surface basalt boulders, vegetation mainly camphor laurel and lantana.

94. Large copse of dense trees with numerous basalt boulders slopes of 17° to 20°. An old access track cuts through the copse.

95. Large dense copse of trees, thick undergrowth, numerous surface basalt boulders, slopes of typically 18° to 20°, increasing to 25° to 27°adjacent to the incised gully.

96. Open area of moderately steep, hummocky ground with slopes of 17° to 18°, scattered lantana cover, numerous surface boulders, occasional exposure of red-brown clay.

97. Broad area of moderately-sloping, open paddock, slopes fall to the east at around 10° to 15°, typically 12°, well grassed with scattered clumps of lantana.

98. Cut batter around 4m high and 90m long exposing red-brown residual clay soils and weathered basalt cobbles and boulders. The basalt is thinly layered, flaggy and contains a high portion of extremely weathered basalt and clay with numerous, thin, curved seams pale grey altered rock.

99. Broad cut/borrow area.

100. Galvanised steel water tank.