Pulver Cooper & Blackley Pty Ltd

Proposed Residential Subdivision
Rayford Street and Daydawn Avenue, Warners Bay

Slope Stability Assessment

Report No. RGS01426.1-AE

30 May 2017

REGIONAL
GEOTECHNICAL SOLUTIONS

REGIONAL
GEOTECHNICAL SOLUTIONS

Manning-Great Lakes

Port Macquarie

Coffs Harbour

30 May 2017

Pulver Cooper Blackley Pty Ltd
98 Lawes Street
EAST MAITLAND NSW 2323

Attention: Mr Mark Daniels

Dear Mark

RE: Proposed Residential Subdivision at 40 Rayford St & 19 Daydawn Ave, Warners Bay

Geotechnical Assessment

Regional Geotechnical Solutions (RGS) has undertaken a slope stability assessment to assess the feasibility of undertaking residential subdivision development on the above adjoining sites, which are situated in an area with a history of slope instability.

The assessment was undertaken in accordance with the Australian Geomechanics Society 2007 *Practice Note Guidelines for Landslide Risk Management*. Based on the findings of the assessment, it has been concluded that residential development on the lower slopes would be feasible from a geotechnical perspective.

An area of recently active landslide was identified on the upper to mid slopes of the northern end of the site, with a lobe of resultant debris having travelled onto the lower, footslope area. Development should be avoided on the active part of the landslide on the upper slopes. This area is identified and delineated in the report.

A second area of historic landslide activity was identified on the lower slopes of the section of the property at 19 Daydawn Avenue. It is recommended that residential development be avoided in this part of the site, however, it is considered appropriate for incorporation into a road easement provided some remedial works are undertaken, primarily involving installation of measures to drain the subsurface profile.

Development of the remainder of the site is considered feasible from a landslide risk perspective. Some remedial works will be required to allow development in the area directly downslope of the active landslide at the northern end of the site, and some drainage measures should be undertaken if development is to encroach on the moderate to steep colluvial slopes near the centre of the site. For both areas, further geotechnical investigation is required to gather the information required to design the slope remediation and drainage works.

The report presents the findings of the assessment, delineates the geotechnical terrain of the area, identifies potential landslide hazards, and provides general recommendations regarding the geotechnical constraints and measures that would be required to allow residential subdivision development of the site.

If you have any questions regarding this development, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steven Morton

Principal

CONTENTS

Figures:

Appendices:

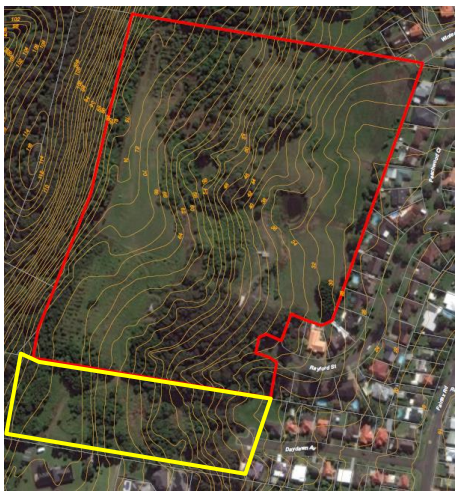
1 INTRODUCTION

At the request of Mr Mark Daniels of Pulver Cooper & Blackley (PCB) Pty Ltd, Regional Geotechnical Solutions Pty Ltd (RGS) has undertaken a geotechnical slope stability assessment on two adjoining properties located at

- No. 40 Rayford Street, Warners Bay; and
- No 19 Daydawn Ave, Warners Bay.

There is currently a proposal to establish residential development on the two lots. This report addresses both lots in conjunction and the combined lots are herein referred to as "the site".

The site is situated on the southeast facing slopes of Munibung Hill and is roughly rectangular, occupying an area of 355m by 442m. Surface elevations range from approximately RL25m AHD at the eastern boundary, to approximately 110m AHD at the western boundary.

	*Subject property comprising No 40 Rayford Stree outlined in red, and No 19 Daydawn Avenue outlined in yellow*

The site is bounded to the east by residential subdivision development, however, it falls within the East Munibung Hill Area Plan delineated under Section 4.20 of the Lake Macquarie City Council Development Control Plan 1 (DCP1). The plan designates the foothills of Munibung Hill as an area that will remain largely undeveloped with no further subdivision due to scenic quality, environmental and geotechnical constraints. The geotechnical constraints pertain to the site being located in a region of known previous slope instability.

Taking into account the planning constraints and slope stability concerns, the purpose of the work presented herein was to assess the site with regard to the geotechnical feasibility of developing all or some of the site for the purposes of a residential subdivision. The assessment has been undertaken in accordance with the AGS 2007 *Practice Note Guidelines for Landslide Risk Management* (Ref.1).

2 SITE INVESTIGATIONS

The assessment of the site involved the following:

- Review of a previous "*Site Stability – Design Report*" undertaken for the 19 Daydawn Avenue section of the site which contained the results of subsurface geotechnical investigations include borehole logs, sections, and piezometric information;
- Review of other available reports and published information regarding slope stability and landslide issues in the area;
- Walkover site assessment to observe surface conditions that may be relevant to slope stability – evidence of past landsliding, unusual ground formations, drainage conditions, the presence of disturbed or hummocky ground etc.
- Excavation, logging, and sampling of test pits within selected areas of the 40 Rayford Street part of the site. The logging involved assessment of profile conditions, evidence of disturbed ground, water inflows, presence of potential shear planes on which failure could occur. Due to the information available in the previous report for the 19 Daydawn Avenue, no further subsurface investigations were deemed necessary for this preliminary or feasibility stage of investigations.
- Identification, on the basis of the above information, of areas having the potential for residential development.

The test pit locations are shown on Figure 1. Test pit logs are included as Appendix A.

3 BACKGROUND AND GEOTECHNICAL SETTING

3.1 Regional Geology

The site is situated within an area underlain by the Moon Island Beach sub-group of the Newcastle Coal Measures. The elevated ridges and steep slopes nearing the crest of Munibung Hill to the west of the site are formed by the weathering resistant thick conglomerate and sandstone beds of the Teralba Conglomerate member. This is directly underlain by the Booragul Tuff and the Great Northern seam that sub-crop on the lower slopes, directly below the steeply sloping scarps that delineate the edge of the Teralba Conglomerate sub-crop. These units generally comprise tuffaceous claystones of low shear strength. Water which infiltrates through widely spaced joints in the overlying conglomerate concentrates at the interface of the conglomerate and these underlying claystone units. The water tends to flow laterally through these layers and daylights as seepage on the slopes below.

The lower slopes are typically underlain by the fine grained tuffaceous sandstones, siltstones and claystones of the Awaba Tuff. This directly overlies the Fassifern coal seam, which sub-crops at or about the level of Fairfax Road, to the east of the subject site.

A previous study by RGS at the northern end of Fairfax Road, approximately 450m north of the subject site, encountered Teralba Conglomerate overlying the Great Northern Seam, with the seam encountered at approximately RL55m AHD. The Bashi report, as well as other studies undertaken at Daydawn Avenue encountered the Great Northern Seam at approximately RL 40m AHD. This correlates well with the known overall regional dip of the strata towards the west and southwest, with dip angles varying between 2 and 5 degrees. Based on interpolation between these two locations, the Great Northern Seam would be expected to subcrop at approximately RL 40 to 45m at the northern end of the current site, and approximately 40m at the southern end.

3.2 History of Slope Instability in the Area

The site is situated in an area where large scale landslides are known to have occurred periodically through the 1920's, 1950's and into the 1970's. In the 1950's a large scale landslide above Chelston Street, to the west of Fairfax Road, resulted in a debris flow extending some 250m, with the debris crossing Fairfax Road and extending to the east.

Numerous studies and reports have been prepared in relation to the landsliding in the area. These previous works have indicated that the landslides typically occur due to the sliding of thickly bedded, joint-bound conglomerate and sandstone blocks over underlying, near horizontal tuffaceous claystone beds associated with the Great Northern coal seam, due to a combination of concentrated water flows and low shear strengths on the weathered claystone horizons.

Groundwater levels in the area have been shown to be a major contributor to triggering of the landslides with a study by Fell et al (Ref.3) indicating that landslides occurred on these slopes when groundwater levels rose to at, or near, the ground surface and that, based on available records at the time, this was likely to occur on an average return interval of approximately 25 to 30 years. The Fell paper included broad scale mapping of landslide-related zones within the study area. This mapping is overlain on the current subject site in Figures 3 and 4.

As shown on Figures 3 and 4, the previous mapping identified an inferred "old" landslide on the lower slopes of the property at 19 Daydawn Avenue.

In 1988 Lake Macquarie City Council undertook major works to install deep (up to 10m) subsoil drains within the landslide area to the west of Chelston Street, which is located to the north of the current site, but at a similar position within the slope profile and geological profile. The drains extended down to zones of water flow at the top of the claystone beds above the Great Northern Seam. The purpose of these deep drains was to discharge water from the potential slide planes and inhibit the buildup of groundwater levels and piezometric pressures in response to rainfall. It is understood there have been no significant landslides in the Chelston Street area since the installation of these drains.

4 SITE CONDITIONS

4.1 Surface Conditions

The site is located to the west and north of the western end of the existing Rayford Street and Daydawn Avenue, and extends through to the current termination of Winterlake Street at the northern boundary. An existing residence and some associated sheds and outbuildings occupy a small area off the end of Rayford Street. Otherwise the site is vacant. Much of the land was previously cleared for orcharding and grazing of livestock. Parts of the site, predominantly between Rayford Street and Winterlake Street, and areas upslope of those streets, are currently used for agistment of horses. No 19 Daydawn Avenue is vacant, has been cleared, and is now vegetated by mown grass.

Topographically, the western boundary of the site is delineated the toe of a steep escarpment that slopes from RL 110m AHD, to about 80mAHD at the boundary. Below this, the site can generally be divided into three areas:

An upper bench that occupies the western third of the site. This area has a gentle overall slope to the southeast, and ranges in elevation from RL 80m down to RL 70m at the northern boundary, and 60m at the southern boundary. This area is generally cleared, shows evidence (confirmed by old

aerial photographs) of having previously been occupies by orchards, and contains unusual drainage features including cross slope drainage features near the rear, or western boundary of the zone.

Steeply sloping Central zone – this zone occupies the central third (roughly) of the site and slopes steeply to the east and southeast at angles of between 20 and 30 degrees. Much of this zone is thickly vegetated by regrowth vegetation following past clearing for agricultural uses, other than on the Daydawn Avenue end of the site where it has been cleared and slashed.

Within this central zone, at the northern end of the site and off the end of Daydawn Avenue, there is some visible evidence of past landslide activity. At the northern end of the site near Winterlake Street there is evidence of possible recent re-activation. Such evidence includes irregular, hummocky ground, visible lobes of debris, scarps at the rear of the slide area, and erosion of soils disturbed and re-deposited by former landslides.

Eastern, lower slopes and footslopes – generally below approximately RL40mAHD, the lower slopes vary, but slope generally to the east. There are some areas of irregular ground that may be due to the deposition of landslide debris in the past. The lower slopes grade onto a gentle footslope area that appears to be poorly drained, but contained no significant seepage or water inflow into the test pits during the fieldwork.

The footslope area contains a small dam that was holding water at the time of the investigations, with no significant seepage observed.

The ground surface was trafficable at the time of the fieldwork.

4.2 Subsurface Conditions

The subsurface materials encountered in the test pits varied across the site, however, the findings correlate well with the known regional geology. Based on the profiles encountered in the test pits and the regional geological setting discussed in Section 3.1 above, a geotechnical model for the site is presented in Figures 5 and 6.

The following points are noted from Figures 5 and 6 and the subsurface conditions encountered by this and previous investigations:

- In most locations, the ground surface was underlain by a soil profile comprising colluvial clay soils. These varied in depth. On the lower slopes they were underlain by residual clays of high plasticity in some locations.
- In TP1 at the rear of the site the profile comprised deep gravelly colluvium with some organics. This was deemed to represent the 'tension zone' referred to by Fell (Ref. 3) which is part of the natural slope formation processes identified on Munibung Hill. This tension zone can be a zone of water ingress to the slope.
- The rock profile was weathered and rock types comprised conglomerate on the upper slopes, and interbedded extremely to highly weathered tuffaceous claystone, siltstone, and fine grained sandstone that was readily excavated by a small excavator on the lower slopes.
- Disturbed coal was observed in TP11 at the northern end of the site within the zone of recent landslide activity.
- No water inflows were encountered in the test pits.

Photographs illustrating significant site features are presented below.

Google Earth image with approximate outline of subject site shown in red. Cleared upper bench zone visible on western third of site. Heavily vegetated central slope zone in middle of site. Eastern third occupied by cleared zone of gentle lower slopes. Daydawn Avenue end of site (southern end) is cleared and vegetated by maintained grass with minor scattered trees.

Conglomerate outcrop adjacent to existing house in southeast corner of site.

Upper bench area in western third of site

Zone of recent landslide activity at north end of site viewed from footslope. Note hummocky, benched ground conditions

Lobe of landslide debris deposits on footslope at northern end of site.

Disturbed ground indicative of landslide activity near northern end of site

5 SLOPE STABILITY ASSESSMENT

5.1 Risk Assessment

The risk of slope instability at the subject site has been assessed using the principles and protocols of the Australian Geomechanics Society publication *Practice Note Guidelines for Landslide Risk Management, 2007*. This methodology represents the currently accepted state of practice for landslide risk assessment in Australia.

The slope risk assessment process involves identification of a potential slope failure event, or hazard, followed by an estimation of the likelihood of the event occurring, and the potential consequences should the event occur.

The terms used in the risk assessment process are defined below:

Hazard:	A condition with the potential for causing an undesirable consequence.
Likelihood:	The estimated probability that the hazardous event will occur.
Consequence:	Loss or damage resulting from a hazard event.
Risk:	A term combining the likelihood and consequence of an event in terms of adverse effects to property or the environment.

5.2 Hazard Identification

The following potential slope stability hazards were assessed in relation to the site and proposed development:

Hazard 1: Large scale translational slide of conglomerate blocks over saturated Booragul Tuff causing debris flow (>100m^3). Such a failure could cause complete destruction or large scale damage of several structures within a typical residential subdivision;

Hazard 2: Translational or rotational slide through colluvial and residual soil profile. Should such a failure occur it could potentially cause extensive structural damage and require large scale, costly repairs, and possibly temporary evacuation of a typical residential building until repairs are complete. Maintaining good slope drainage to prevent buildup of water pressures within the profile is recommended;

Hazard 3: Soil creep. Creep is an imperceptibly slow movement that takes place on sloping soil sites. It is an ongoing, natural slope process involving the progressive downslope movement of soils over the underlying rock profile. Creep will occur within the soil profile overlying weathered rock at this site, and will require management by undertaking good hillside construction practice as recommended in this report;

Hazard 4: Translational slide of soil and weathered rock profile on outer edge of profile resulting from ongoing stress relief due to erosion and valley formation processes on the outer slope. The existing slides in the northern part of the site and at 19 Daydawn Avenue are examples of this type of failure. Should such a failure occur it could potentially cause extensive structural damage and require large scale, costly repairs, and possibly temporary evacuation of buildings until repairs are complete. Maintaining good slope drainage to prevent buildup of water pressures is recommended, together with remedial works to reinstate the existing failures. Planning of subdivision layouts to avoid siting residential structures over these areas is recommended, to limit potential consequences;

Hazard 5: Small scale slide (<100m^3) due to failure of unsupported cuts and fills or poorly designed, constructed, or otherwise inadequate retaining walls. Such a failure could cause localised damage requiring moderate repairs to part of the structure.

Each of the identified hazards is illustrated on Figure 7.

5.3 Risk Evaluation for Existing Site Conditions

Table 1 summarises the factors affecting slope stability in relation to each of the hazards identified and assesses the risk of slope instability for each using the risk assessment matrix provided in Appendix C of the Australian Geomechanics Society (AGS) publication *Practice Note Guidelines for Landslide Risk Management, 2007*. A copy of the AGS risk matrix is presented as Appendix B.

Table 1: Slope Risk Assessment Based on AGS2007 method

Hazard	H1 – Large scale translational landslide and debris flow	H2 – Translational failure of colluvial soils over weathered rock profile	H3 - Soil Creep	H4 - Translational failure through weathered rock profile (existing failures)	H5 - Localised failure of poorly retained cuts
Slope height	50m	10 - 20m	50m	20 – 30m	Up to 3m
Cause or trigger	Slope deterioration and weathering, exceptionally prolonged and intense rainfall	Slope deterioration (10 - 100yr) followed by extreme weather (1in 1,000yr event)	Ongoing process of imperceptibly slow soil movement	Ongoing erosion, stress release, adverse wet weather event (1 in 20 - 30 yr event)	Cut steeper than angle of repose, unsupported,1 in 10yr rain event
Estimated probability	10^{-6} yr (inconceivable except under extreme exceptional circumstances)	10^{-5} yr	10^{-1} yr	10^{-2} yr	10^{-3} yr
Assessed Risk Without Mitigation					
Likelihood	Rare	Unlikely	Almost Certain	Likely	Possible
Consequence	Extensive damage to numerous structures within downslope area	Damage to one or possibly more structures requiring extensive repair	Ongoing, slow movement of foundation, displacement of services, possible minor distortion of pathways etc. Generally manageable within life of structure	Extensive damage to structure if within active zone (upper slope)[1]. Moderate to minor damage to structure(s) if within debris zone on footslope[1]	Localised minor damage to some of structure requiring minor repairs
	Catastrophic	Major	Insignificant	Major (Upper) Medium (Lower)	Minor
Risk	Moderate	Moderate	Low	Very High (Upper) High (Lower)	Moderate

	H1 – Large scale translational landslide and debris flow	H2 – Translational failure of colluvial soils over weathered rock profile	H3 - Soil Creep	H4 - Translational failure through weathered rock profile (existing failure)	H5 - Localised failure of poorly retained cuts
Proposed Mitigation, Management, Development Restrictions	Undertake drainage measures and subdivision works in accordance with good hillside practice.	Install subsoil drains. Found all structures in weathered rock where slopes exceed 10 degrees.	Found all structures in rock, where slopes exceed 10 degrees. Use good hillside construction/ drainage measures.	Avoid residential development on active slide area. Install drainage/ remedial measures to enable development within potential debris zone of northern slide area, or to allow use of former slide areas as road easements[3].	Avoid or retain cuts >1m on sloping areas of the site
Assessed Risk with Mitigation, Management, Development Restrictions					
Likelihood	Barely Credible	Rare	Almost Certain	Unlikely	Rare
Consequence	Catastrophic	Major	Insignificant	Minor [2, 3]	Minor
Risk	Low	Low	Low	Low	Very Low

Notes 1 Refer to Fig 5 for approximate delineation of upper and lower zone within existing northern slide area.

2 Post development damage on upper slope considered minor, as proposed management measures will avoid development in the upper slope zone

3 Includes proposed development on 19 Daydawn Ave, assuming former slide area to be remediated and then incorporated as road easement only.

5.4 Evaluation of Risk Level

The assessment indicates the risk of slope instability to be **High to Very High** in the areas affected by previous landslide activity at the northern end of the site and off the end of Daydawn Avenue. The **Very High** rating applies to the active landslide zone on the upper slopes of the northern failure. It is recommended that development be avoided in this area. Remedial measures are proposed that would reduce the likelihood of further re-activation of the landslide, but the remedial works proposed would not reduce the risk of instability to a level whereby development of the active slide area itself would be feasible.

The proposed remedial works will, however, reduce both the likelihood of failure and the potential downslope movement of debris from the landslide identified at the northern end of the site to the extent that, post remediation, the risk of developments on the footslope area below the slide being affected by the instability above could be reduced to **Low**.

On the Daydawn Avenue end of the site, the likelihood of reactivation of the existing landslide or further activation of landslides in the surrounding area can be reduced by installation of remedial measures predominantly in the form of subsurface drainage measures. This will require further, specific investigation and design work, however, on completion of the work and installation of the improved drainage measures, the risk of instability affecting the land surrounding the previous landslide would be considered **Low**. The risk of instability affecting the former landslide area itself would be **Moderate**. Development in that part of the site should be restricted to roads or public space.

As shown in Table 1, by adopting the recommendations of this report, the risks can be reduced to **Low** for a large proportion of the site. Based on the assessment presented in Table 1 and the proposed remedial measures, the risk of slope instability and potential development areas available at the site are presented on Figure 8.

6 GEOTECHNICAL CONSIDERATIONS FOR DESIGN AND CONSTRUCTION

6.1 Potential Development Area

Figure 8 delineates the identified landslide areas on which residential development should be avoided.

Development of the footslope area downslope of the active landslide in the northern part of the site, and the areas surrounding the former landslide off Daydawn Avenue is considered feasible provided some remedial works are undertaken.

If development in the colluvial slope area adjacent to the current active landslide is proposed (See Figure 8), preventative or remedial measures such as implementation of subsoil drains should be undertaken prior to construction.

The remainder of the subject site is considered appropriate for residential construction provided it is undertaken in accordance with good hillside construction practice as outlined in Appendix B herein, as well as with the specific recommendations of this report.

General recommendations to assist in the design and construction of a residential subdivision development on the site are provided in the following sections of this report. Stabilisation of the identified active and former landslides, and implementation of drainage measures for the colluvial midslope area, will require additional investigations to obtain the specific information required for design.

6.2 Type of structure

There are no specific constraints regarding the type of structure considered suitable for the slope, provided design and construction is undertaken in accordance with the recommendations of this report.

6.3 Foundations

As a general guide, for development on the sloping areas upslope of the Great Northern Seam subcrop line as shown on Figure 8, it is recommended that further site investigations be undertaken to determine suitable founding strata and appropriate foundation design parameters.

For the footslope areas downslope of the Great Northern Seam, structures may be supported on the natural profile provided they are designed and constructed in accordance with the guidance provided in AS2870-2011 *Residential Slabs and Footings.* This will require a site classification in accordance with AS2870-2011 for each of the proposed lots once final lot layouts are known.

6.4 Support of Excavations and Filling

Cuts or fills exceeding 1m in height should be avoided where practicable. Cuts and fills of up to 1m can be battered at 1V:2H or flatter. Deeper cuts and fills should be supported by engineer designed and properly constructed retaining walls.

All retaining walls should be provided with complete drainage at the back of the wall that drains to an ag drain, weep-hole or similar that allows free discharge of water from behind the wall.

Retaining walls must be designed to accommodate surcharge loading from all slopes, structures, or foreseeable traffic above the wall.

Further recommendations and design advice for retaining walls can be provided once the layout and configuration of the proposed development are known.

6.5 Access and driveway

The construction of driveways and site access must comply with the recommendations provided herein regarding limitations to, and support of, cuts and fills. Where cuts of more

than 1m are required for access construction, they must be supported by engineer-designed retaining walls. Driveways must be designed and configured so as to not impede the drainage of the slope.

6.6 Control of Stormwater

All stormwater should be collected from surface and roof runoff and should be discharged well beyond the building areas in a controlled manner that limits erosion. Once the final building location is selected, it is recommended that a berm be constructed around the upslope side to divert all upslope runoff around the building area.

6.7 Subsoil Drains

Should development be proposed in the colluvial midslopes near the centre of the site (delineated in yellow on Figure 8), it is important that measures be taken to prevent water travelling through the weathered rock profile from becoming trapped beneath the low permeability colluvial clay soils that cover the slope. To assist in preventing buildup of water pressures beneath the slope profile, it is recommended that a series of subsoil drains be installed within the proposed building area.

Prior to undertaking these works, additional geotechnical investigations should be undertaken to further define the slope conditions and allow the layout and configuration of the drains to be designed appropriately.

7 REMEDIAL MEASURES

7.1 Northern Landslide Area

Prior to development of the footslopes below the identified landslide zone on Figure 8, it is recommended that remedial measures be implemented within the identified active landslide zone above. Such measures are likely to involve:

- Installation of drainage measures such as subsoil drains or horizontal drains to promote drainage of the slope and prevent buildup of pore water pressures within the slope;
- Regrading of the failed outer slope to allow control of erosion and remove soils that appear prone to short term onset of instability;
- Installation of mesh, topsoil, and anchors to stabilise the disturbed soil mantle directly upslope of the development area.

7.2 Daydawn Avenue landslide area

Prior to development of the slopes off the western end of Daydawn Avenue, the identified landslide zone delineated on Figure 8 will require remediation prior to incorporation in the development area as a road easement. Remedial measures are likely to involve:

- Installation of drainage measures such as subsoil drains and horizontal drains to promote drainage of the slope and prevent buildup of pore water pressures within the slope;
- Regrading of the failed area to reduce locally steep slope angles.

7.3 Investigation and design of remedial measures

Further investigation and monitoring will be required in order to obtain the information required to design the appropriate measures. This will include drilling of boreholes at the northern end of the site to allow refinement of the slope model and obtain samples for laboratory testing so that appropriate design parameters can be adopted, and test pitting at the Daydawn Avenue end of the site to further define the depth and distribution of colluvial soils, presence of the coal seam, and identification of zones of water inflow within the profile.

Subsequent monitoring of inclinometers and piezometers would then be undertaken to identify water levels and possible movement horizons within the slope that would allow compilation of a more accurate subsurface model upon which to base the design of the remedial works.

8 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If site conditions encountered during construction vary significantly from those discussed in this report, Regional Geotechnical Solutions Pty Ltd should be contacted for further advice.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steven Morton

Principal

References:

1. Australian Geomechanics Society *Practice Note Guidelines for Landslide Risk Management,* Journal and News of the Australian Geomechanics Society, Vol 42, No 1, March 2007
2. Bashi & Associates Pty Ltd 19 *Daydawn Avenue, Warners Bay, Site Stability – Design Report*, 7 October 2016
3. Fell, R, Sullivan, TD, and Parker, C *The Speers Point Landslides* in Soil Slope Instability and Stabilisation, Walker & Fell eds, 1987

Figures

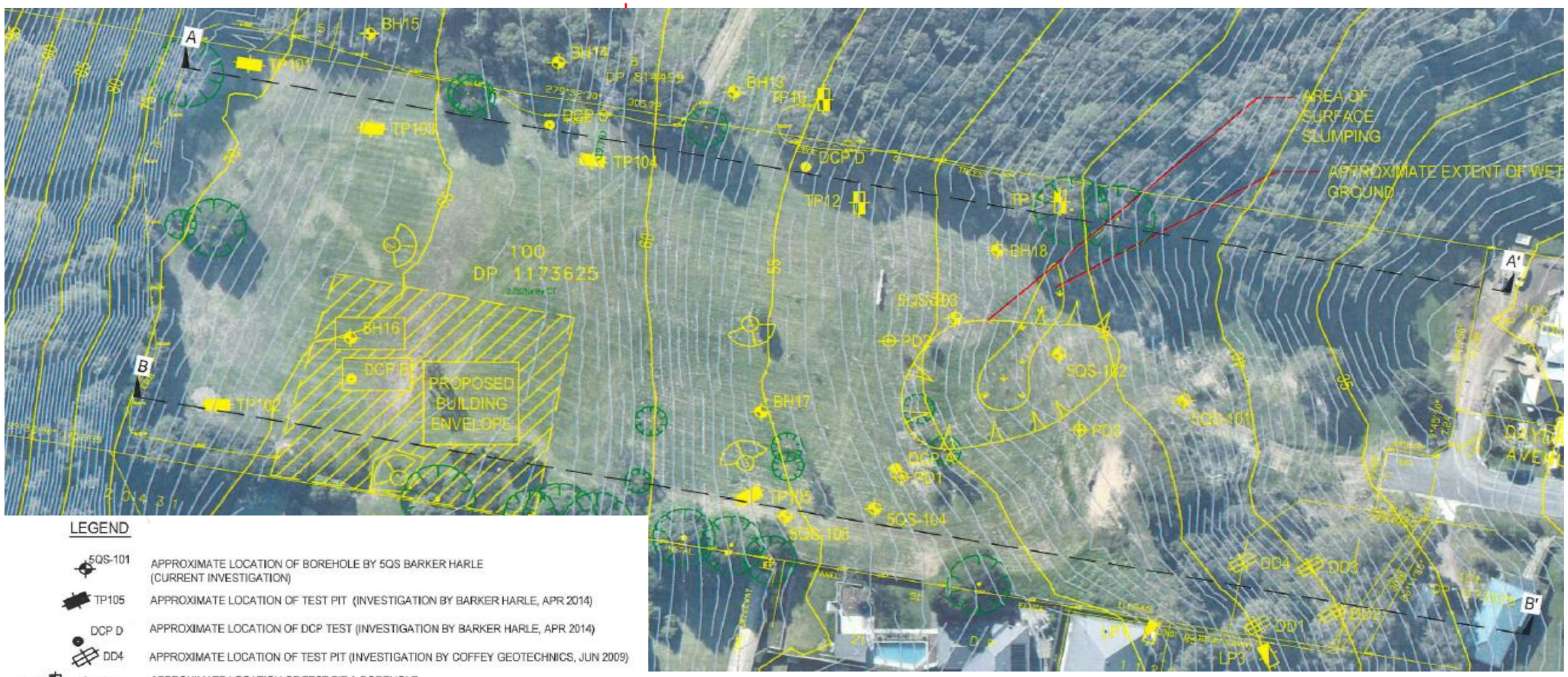
Legend

Test Pit Location

*As per supplied drawing by client titled " Existing Contours"

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper Blackley Pty Ltd	Job No.	RGS01426.1
Project:	Residential Subdivision Geotechnical Assessment 19 Daydawn Ave and 40 Rayford Street, Warners Bay	Drawn By: Date:	SRM 30-May-17
Title:	Test Pit Location Plan - Rayford Street	Drawing No.	**Figure 1**



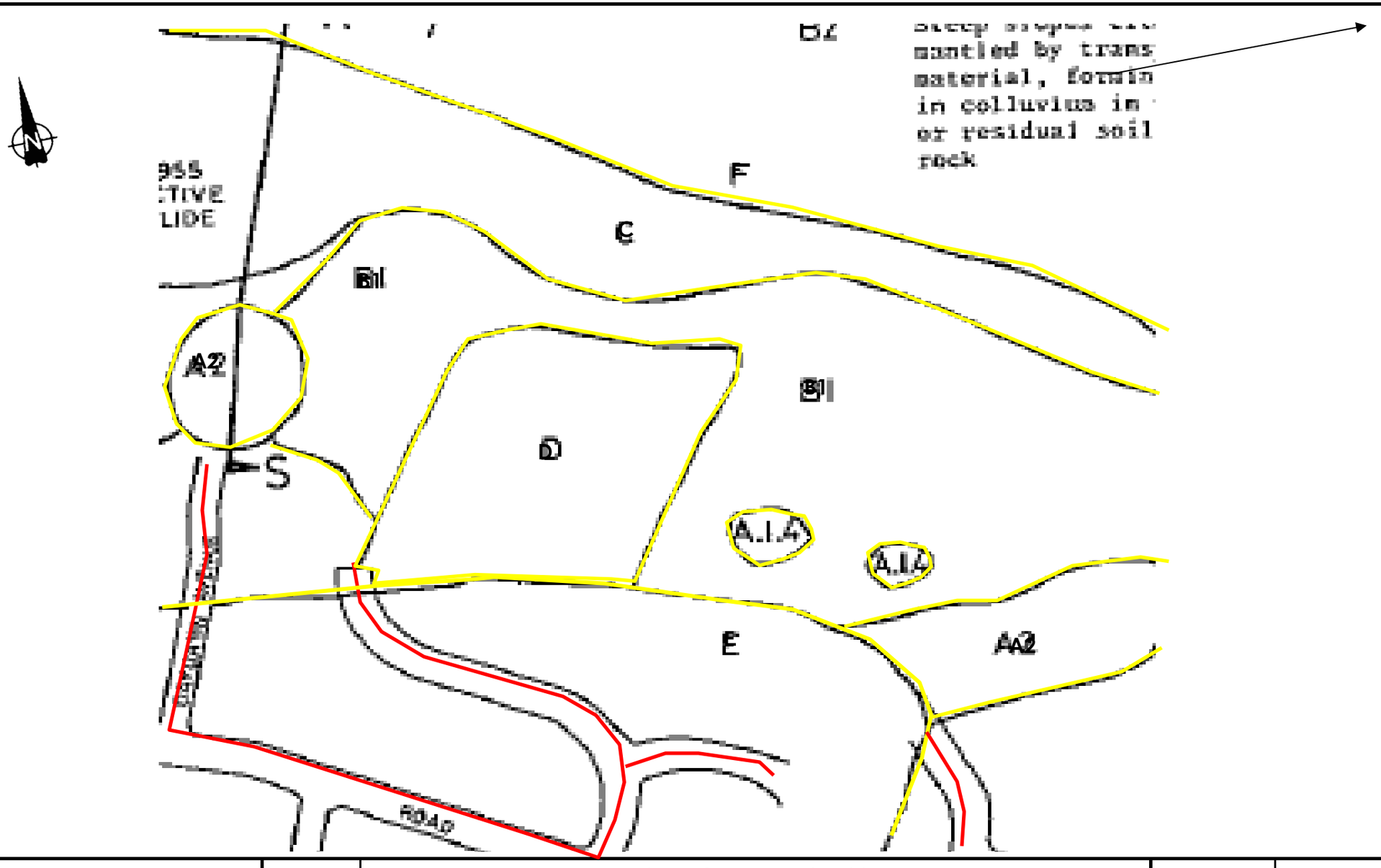
LEGEND

5QS-101	APPROXIMATE LOCATION OF BOREHOLE BY 5QS BARKER HARLE (CURRENT INVESTIGATION)
TP105	APPROXIMATE LOCATION OF TEST PIT (INVESTIGATION BY BARKER HARLE, APR 2014)
DCP D	APPROXIMATE LOCATION OF DCP TEST (INVESTIGATION BY BARKER HARLE, APR 2014)
DD4	APPROXIMATE LOCATION OF TEST PIT (INVESTIGATION BY COFFEY GEOTECHNICS, JUN 2009)
TP12 BH18	APPROXIMATE LOCATION OF TEST PIT & BOREHOLE (INVESTIGATION FOR 1992 PhD THESIS BY K S WILLIAMS-SWEENEY)
PT13 PD3	APPROXIMATE LOCATION OF TEST PIT & BOREHOLE WITH GROUNDWATER MONITORING WELL (INVESTIGATION BY COFFEY & PARTNERS PTY LTD, DEC 1984)
LP3	APPROXIMATE LOCATION OF TEST PIT (INVESTIGATION BY COFFEY & PARTNERS PTY LTD, FEB 1984)

*Locations of previous investigations on 19 Daydawn Avenue, reproduced from Drawing 2 of Bashi report (Ref 2)

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper Blackley Pty Ltd	Job No.	RGS01426.1
Project:	Residential Subdivision Geotechnical Assessment	Drawn By:	SRM
	19 Daydawn Ave and 40 Rayford Street, Warners Bay	Date:	30-May-17
Title:	Locations of Previous Investigations - Daydawn Avenue	Drawing No.	**Figure 2**



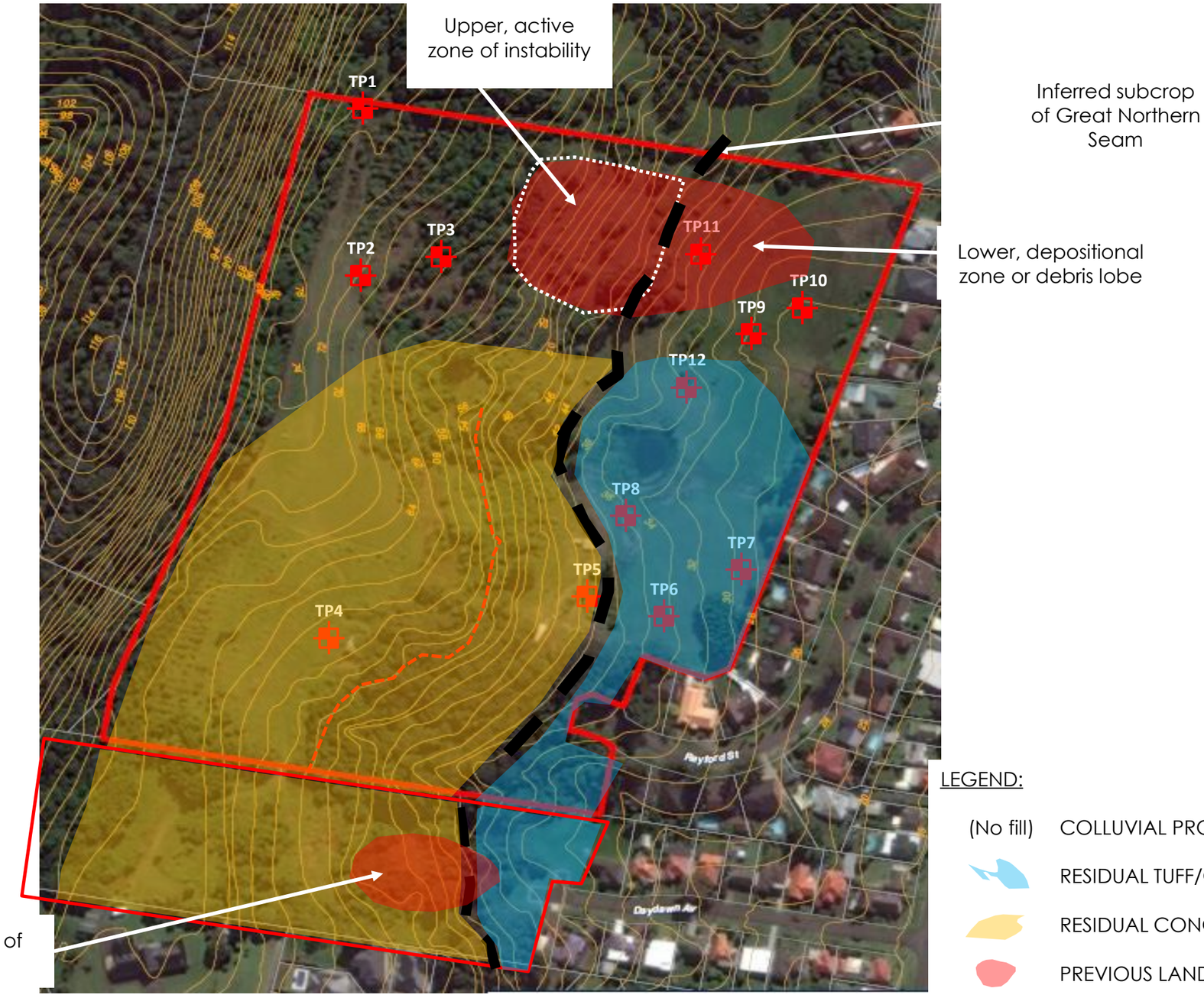
REGIONAL GEOTECHNICAL SOLUTIONS	**Client**	Pulver Cooper Blackley	Job No. RGS01426.1
	Project:	19 Daydawn Avenue & 40 Rayford Street Warners Bay	Drawn By: SRM Date: 30-May-17
	Title:	Landslide Zones (Fell)	Drawing No. **Figure 3**

GEOMORPHIC UNITS

A1	Known landslides	C	Upper bench area
A2	Inferred old landslides	D	Steep to moderate slopes of residual soil
A3	Known landslide debris	E	Footslopes
B1	Steep slopes mantled by transported material	F	Conglomerate ridge
B2	Steep slopes either mantled by transported material, forming toe in colluvium in unit C, or residual soil/weathered rock	R S	Section line

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper Blackley	Job No.	RGS01426.1
Project:	19 Daydawn Avenue & 40 Rayford Street Warners Bay	Drawn By:	SRM
		Date:	30-May-17
Title:	Landslide Zones (Fell) Relative to Subject Site	Drawing No.	**Figure 4**

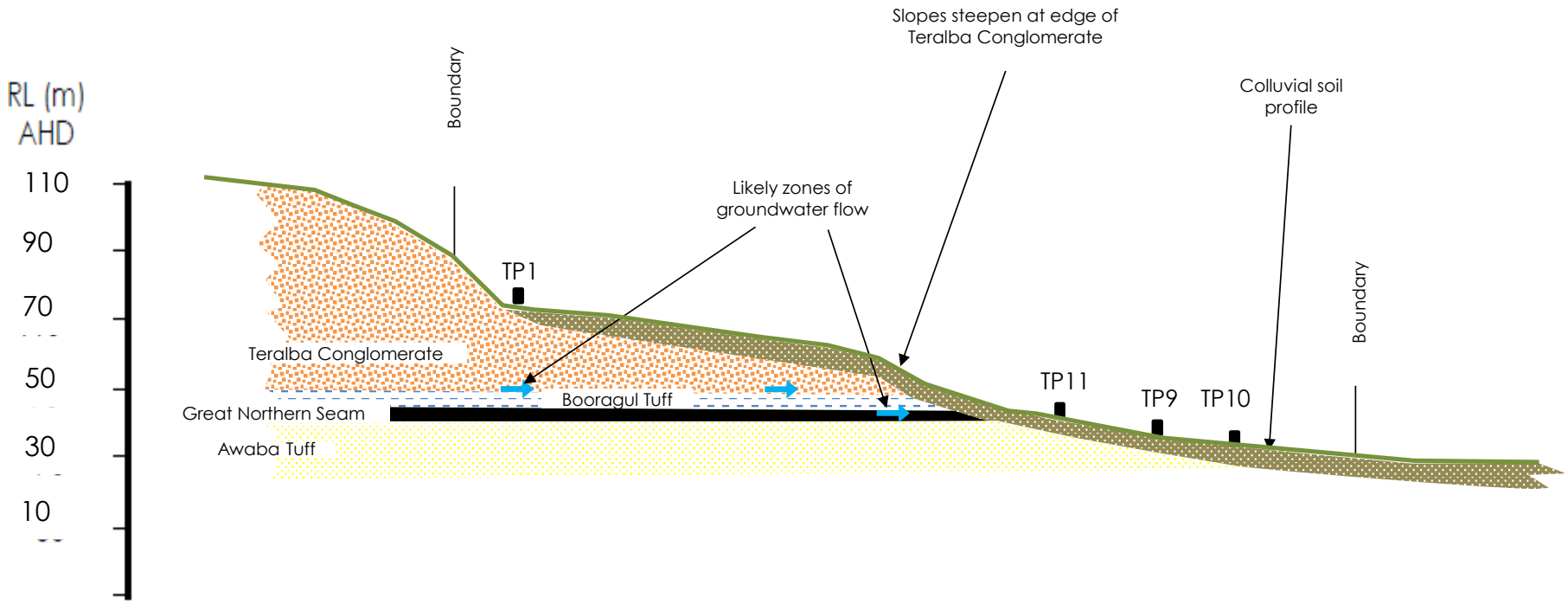


LEGEND:

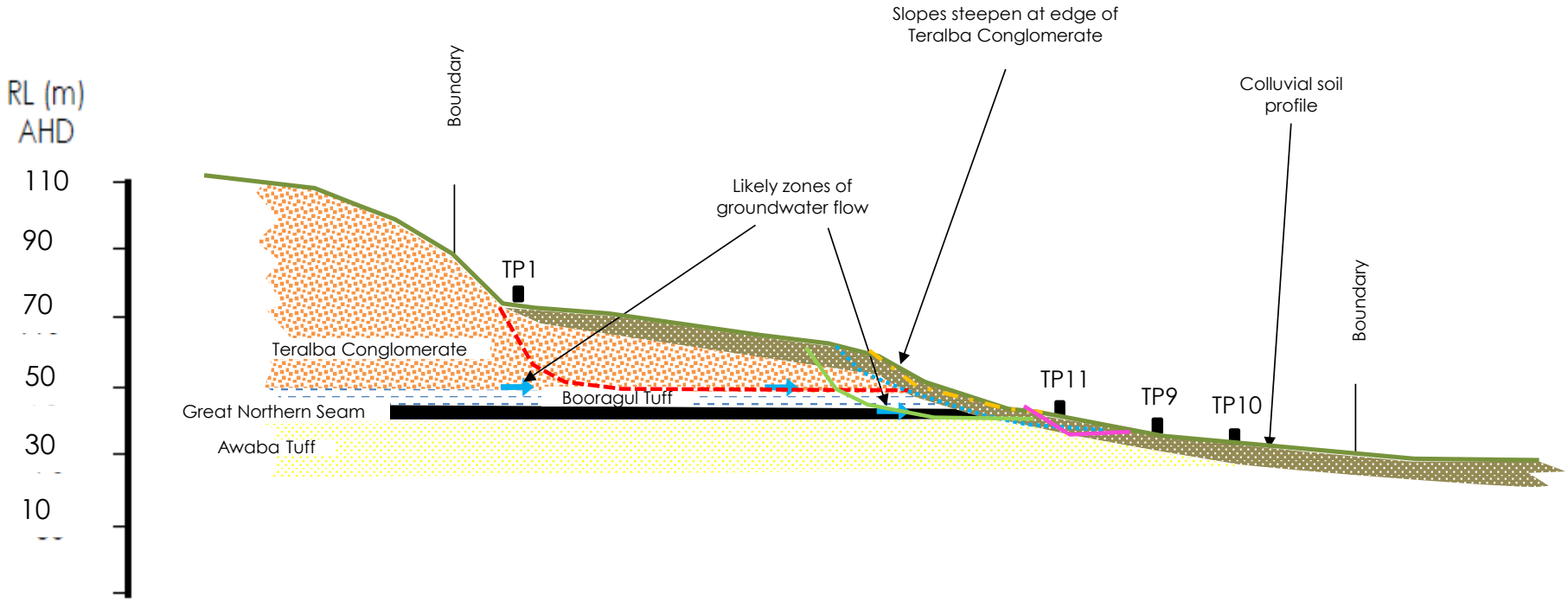
(No fill)	COLLUVIAL PROFILE
	RESIDUAL TUFF/CLAYSTONE
	RESIDUAL CONGLOMERATE ZONE
	PREVIOUS LANDSLIDE

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper Blackley Pty Ltd	Job No.	RGS01426.1
Project:	Residential Subdivision Geotechnical Assessment 19 Daydawn Avenue & 40 Rayford Street, Warners Bay	Drawn By:	SRM
		Date:	30-May-17
Title:	Geotechnical Zones	Drawing No.	**Figure 5**



REGIONAL GEOTECHNICAL SOLUTIONS	**Client**	Pulver Cooper & Blackley	Job No. RGS01426.1
	Project:	Residential Subdivision Geotechnical Assessment	Drawn By: SRM
		19 Daydawn Ave & 40 Rayford Street, Warners Bay	Date: 30-May-17
	Title:	CROSS SECTION	Drawing No **Figure 6**



LEGEND:

HAZARD H1 - Large scale translational slide of conglomerate blocks over saturated Booragul Tuff causing debris flow

HAZARD H2 - Translational or rotational slide through colluvial and residual soil profile

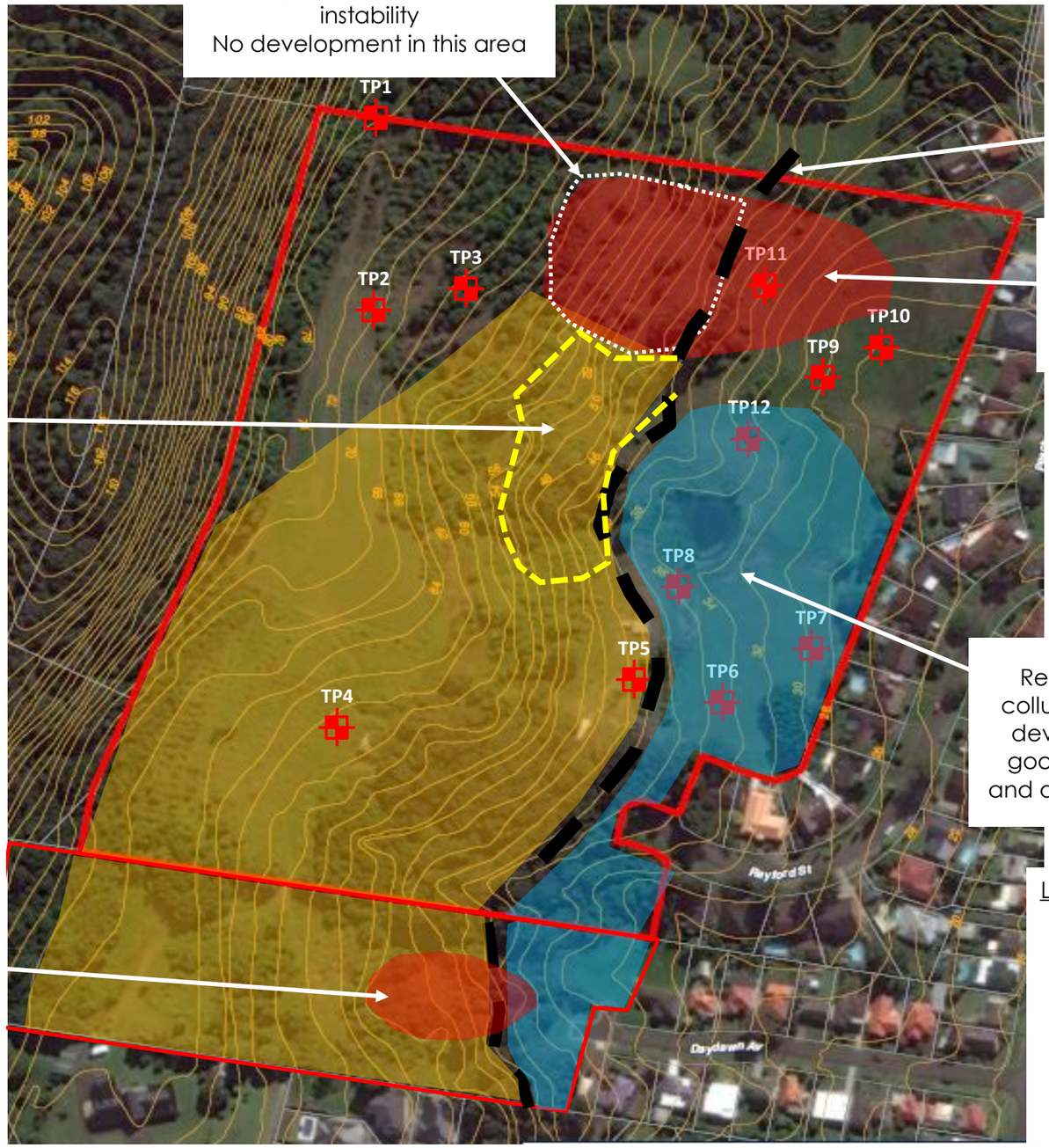
HAZARD H3 - Ongoing soil creep in colluvial soil profile

HAZARD H4 - Translational slide in weathered rock and soil profile - existing slides in northern part of site & southern end (off Daydawn Ave)

HAZARD H5- Rotational Failure in unsupported or inadequately retained cuts or fills

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper & Blackley	Job No.	RGS01426.1
Project:	Residential subdivision Geotechnical Assessment	Drawn By:	SRM
	19 Daydawn Avenue & 40 Rayford Street, Warners Bay	Date:	30-May-17
Title:	Identified Landslide Hazards	Drawing No	**Figure 7**



Upper, active zone of instability
No development in this area

Inferred subcrop of Great Northern Seam

Lower, depositional zone or debris lobe. Development feasible following remedial measures

Colluvial midslope area. Installation of subsoil drains recommended if development proposed in this area.

Remainder of residual slope and colluvial footslope areas feasible for development in accordance with good hillside construction practice and appropriate geotechnical design

Area of previous instability
No residential development in this area. Possible use as road easement if remedial measures are undertaken. Further investigation required to define extent of landslide and to assist in design of remedial measures.

LEGEND:

(No fill) COLLUVIAL PROFILE

RESIDUAL TUFF/CLAYSTONE

RESIDUAL CONGLOMERATE ZONE

PREVIOUS LANDSLIDE

REGIONAL GEOTECHNICAL SOLUTIONS

Client	Pulver Cooper Blackley Pty Ltd	Job No.	RGS01426.1
Project:	Residential Subdivision Geotechnical Assessment 19 Daydawn Avenue & 40 Rayford Street, Warners Bay	Drawn By:	SRM
		Date:	30-May-17
Title:	Geotechnical Zones	Drawing No.	**Figure 8**

Appendix A

Test Pit Logs

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP1**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered			0.5		GP	0.05m **TOPSOIL:** Sandy GRAVEL, fine to medium grained, grey, fine to coarse grained Sand, some Silt of low plasticity	D				TOPSOIL
						GP	**GRAVEL:** Fine to coarse grained, grey, brown, trace fine to coarse grained Sand, subrounded Gravel	M				COLLUVIUM
				1.0								Side wall collapsing
				1.5			1.50m					
							Hole Terminated at 1.50 m					
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

TEST PIT NO: TP2

CLIENT: Pulver Cooper Blackley Pty Ltd
PAGE: 1 of 1
PROJECT NAME: Proposed Subdivision Geotechnical Assessment
JOB NO: RGS01426.1
SITE LOCATION: 40 Rayford Street, Warners Bay
LOGGED BY: CN
TEST LOCATION: Refer to Figure 1
DATE: 7/11/16

EQUIPMENT TYPE: 8 T Excavator
EASTING:
SURFACE RL:
TEST PIT LENGTH: 3.0 m
WIDTH: 0.6 m
NORTHING:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	0.05m **TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, brown	D				TOPSOIL
						GP	**Sandy GRAVEL:** Fine to coarse grained, orange, pale brown, some Clay of low plasticity, fine to coarse Sand, subrounded Gravel	M				COLLUVIUM
				0.5								
				1.0								
				1.5			1.50m					
							Hole Terminated at 1.50 m					
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

TEST PIT NO: TP3

CLIENT: Pulver Cooper Blackley Pty Ltd
PAGE: 1 of 1
PROJECT NAME: Proposed Subdivision Geotechnical Assessment
JOB NO: RGS01426.1
SITE LOCATION: 40 Rayford Street, Warners Bay
LOGGED BY: CN
TEST LOCATION: Refer to Figure 1
DATE: 7/11/16

EQUIPMENT TYPE: 8 T Excavator
EASTING:
SURFACE RL:
TEST PIT LENGTH: 3.0 m
WIDTH: 0.6 m
NORTHING:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered			0.5		GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, dark brown, grey, Silt of low plasticity, some fine to coarse grained Sand 0.50m	M				TOPSOIL/COLLUVIUM
				1.0		GP	**Sandy GRAVEL:** Fine to medium grained, orange, brown, fine to coarse Sand, trace Clay of medium plasticity, subrounded Gravel 1.30m	M				COLLUVIUM
				1.5		Cl	**Gravelly CLAY:** Medium plasticity, orange, yellow, pale grey, trace red, fine to medium grained Gravel, subrounded, iron oxide stain, some fine to coarse Sand 1.65m	M ~ w_P	VSt			RESIDUAL HPP = 220kpa
				2.0			Hole Terminated at 1.65 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP4**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, dark brown, Silt of low plasticity, some fine to coarse grained sand	D				TOPSOIL/COLLUVIUM
							0.30m					
						SM	**Silty SAND:** Fine to medium grained, grey, pale grey, some fine to medium gravel, subrounded	M				COLLUVIUM
				0.5			0.50m					
						GC	**Clayey GRAVEL:** Fine to coarse grained, orange, pale grey, yellow, Clay of medium plasticity, some fine to coarse Sand					RESIDUAL
							0.80m					
							CLAYSTONE: Pale brown to orange, pale grey					CLAYSTONE - Tuffaceous Extremely to Highly Weathered
							0.90m					
							Hole Terminated at 0.90 m Due to refusal					
				1.0								
				1.5								
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP5**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, dark brown, Silt of low plasticity, some fine to coarse Sand	D				TOPSOIL
							0.10m					
						SP	**Gravelly SAND:** Fine to coarse grained, grey, brown, fine to medium grained gravel, subrounded, trace Clay of low plasticity	D				COLLUVIUM
				0.5								
							0.90m					
						GC	**Clayey GRAVEL:** Fine to medium grained, pale brown, pale grey, orange, yellow, some fine to coarse grained Sand	D - M				RESIDUAL
				1.0			1.00m					
							Hole Terminated at 1.00 m Due to refusal - Claystone of Highly to Moderately weathered encountered					
				1.5								
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP6**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	0.05m **TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, dark brown, Silt of low plasticity, some fine to coarse grained sand	D				TOPSOIL
						SP	**Gravelly SAND:** Fine to coarse grained, grey, fine to medium grained gravel, subrounded	D				COLLUVIUM
		0.40m					0.40m					
		U50		0.5		CH	**CLAY:** Medium to high plasticity, orange, yellow, pale grey, some fine to medium grained gravel, subrounded	M > w_P	VSt			RESIDUAL HPP = 220-250kpa
		0.70m					0.70m					
				1.0			**CLAYSTONE:** Pale grey, pale brown	M				CLAYSTONE - Tuffaceous Extremely Weathered
		1.20m										
		D										
		1.50m		1.5								
				2.0			2.20m					
							Hole Terminated at 2.20 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP7**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					ML	**TOPSOIL:** Sandy SILT, low plasticity, grey, dark brown, some fine grained Gravel	D				TOPSOIL
							0.10m					
						SP	**Gravelly SAND:** Fine to coarse grained, grey, fine to medium grained Gravel, subrounded, trace Clay of low to medium plasticity	M				COLLUVIUM
				0.5			0.50m					
		0.60m				CH	**CLAY:** High plasticity, grey, trace pale brown to orange	M ~ w_P	St - VSt			RESIDUAL HPP = 170-250kpa
		D										
		0.90m										
				1.0								
							1.40m					
							CLAYSTONE: Pale brown to orange, pale grey	M	VSt - H			CLAYSTONE - Tuffaceous Extremely Weathered
				1.5								
				2.0								
							2.20m					
							Hole Terminated at 2.20 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP8**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					ML	**TOPSOIL:** Sandy SILT, low plasticity, grey, dark brown, fine to coarse grained Sand, some fine to medium grained Gravel, subrounded	D				TOPSOIL
							0.10m					
						SP	**Gravelly SAND:** Grey, fine to medium grained Gravel, subrounded, some Clay of medium plasticity	M				COLLUVIUM
							0.45m					
		0.50m		0.5		CH	**CLAY:** High plasticity, pale grey, pale brown	M > w_P	St - VSt			RESIDUAL
		U50										HPP = 170-260kpa
		0.70m										
				1.0								
							1.05m					
							CLAYSTONE: Pale grey, grey, pale brown to orange	M	H			CLAYSTONE - Tuffaceous Extremely to Highly Weathered
							1.30m					
							Hole Terminated at 1.30 m Due to Highly to Moderately Weathered Claystone encountered					
				1.5								
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP9**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, Silt of low plasticity, some fine to coarse grained Sand	D				TOPSOIL
							0.10m					
						GP	**Sandy GRAVEL:** Fine to medium grained, grey, brown, fine to coarse grained Sand, trace Clay	D				COLLUVIUM
							0.40m					
				0.5		SC	**Clayey Gravelly SAND:** Fine to coarse grained, pale brown to orange, grey, Clay of medium plasticity, fine to medium grained Gravel, subrounded	M				
		0.70m										
		D										
		1.00m		1.0								
				1.5								
							1.90m					
				2.0		SC	**Clayey SAND:** Fine to coarse grained, grey, Clay of medium plasticity, some fine to coarse grained Gravel, subrounded	M				RESIDUAL
							2.30m					
							Hole Terminated at 2.30 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

TEST PIT NO: TP10

CLIENT: Pulver Cooper Blackley Pty Ltd
PAGE: 1 of 1
PROJECT NAME: Proposed Subdivision Geotechnical Assessment
JOB NO: RGS01426.1
SITE LOCATION: 40 Rayford Street, Warners Bay
LOGGED BY: CN
TEST LOCATION: Refer to Figure 1
DATE: 7/11/16

EQUIPMENT TYPE: 8 T Excavator
EASTING:
SURFACE RL:
TEST PIT LENGTH: 3.0 m
WIDTH: 0.6 m
NORTHING:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, Silt of low plasticity, some fine to coarse grained Sand	D				TOPSOIL
							0.10m					
						GP	**Sandy GRAVEL:** Fine to medium grained, grey, brown, fine to coarse grained Sand, trace Clay	D				COLLUVIUM
							0.30m					
						SC	**Clayey Gravelly SAND:** Fine to coarse grained, pale brown to orange, grey, Clay of medium plasticity, fine to medium grained Gravel	M				
		0.50m		0.5								
		D										
		0.80m										
				1.0								
				1.5								
							1.70m					
						SC	**Clayey SAND:** Fine to medium grained, grey, Clay of medium plasticity, some fine to medium grained Gravel, subrounded	M				RESIDUAL
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Pulver Cooper Blackley Pty Ltd	**TEST PIT NO:**	**TP11**
PROJECT NAME:	Proposed Subdivision Geotechnical Assessment	**PAGE:**	1 of 1
SITE LOCATION:	40 Rayford Street, Warners Bay	**JOB NO:**	RGS01426.1
TEST LOCATION:	Refer to Figure 1	**LOGGED BY:**	CN
		DATE:	7/11/16

EQUIPMENT TYPE: 8 T Excavator **EASTING:** **SURFACE RL:**

TEST PIT LENGTH: 3.0 m **WIDTH:** 0.6 m **NORTHING:** **DATUM:** AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	**TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, dark brown, Silt of low plasticity, some fine to coarse Grained Sand					TOPSOIL
						GP	0.10m **Sandy GRAVEL:** Fine to medium grained, grey, brown, fine to coarse Sand, trace Clay	D - M				COLLUVIUM
				0.5		SC	0.40m **Clayey SAND:** Fine to coarse grained, pale grey, pale brown to orange, yellow, Clay of medium plasticity, some fine to coarse grained Gravel, chunks of Boulders (600mmx200mmx100mm) encountered	M				
				1.0								
				1.5			1.80m					
							Hole Terminated at 1.80 m					
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

REGIONAL GEOTECHNICAL SOLUTIONS

TEST PIT NO: TP12

CLIENT: Pulver Cooper Blackley Pty Ltd
PAGE: 1 of 1
PROJECT NAME: Proposed Subdivision Geotechnical Assessment
JOB NO: RGS01426.1
SITE LOCATION: 40 Rayford Street, Warners Bay
LOGGED BY: CN
TEST LOCATION: Refer to Figure 1
DATE: 7/11/16

EQUIPMENT TYPE: 8 T Excavator
EASTING:
SURFACE RL:
TEST PIT LENGTH: 3.0 m
WIDTH: 0.6 m
NORTHING:
DATUM: AHD

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
600mm Tooth Bucket	Not Encountered					GM	0.05m **TOPSOIL:** Silty GRAVEL, fine to medium grained, grey, brown, Silt of low plasticity	D				TOPSOIL
						GP	**Sandy GRAVEL:** Fine to medium grained, grey, fine to coarse grained Sand	D				COLLUVIUM
							0.25m					
				0.5		SC	**Clayey SAND:** Fine to coarse grained, pale brown to orange, pale grey, Clay of medium plasticity, some fine to medium grained Gravel	M				
							0.60m					
						SC	**Clayey SAND:** Fine to coarse grained, grey, pale grey, Clay of medium plasticity, some fine to medium Gravel, subrounded					RESIDUAL
							0.90m					
				1.0			**CLAYSTONE:** Grey, pale brown					CLAYSTONE - Tuffaceous Highly to Moderately Weathered
							1.00m					
							Hole Terminated at 1.00 m Due to refusal					
				1.5								
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Appendix B

AGS2007 Risk Matrix & Hillside Guidelines

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

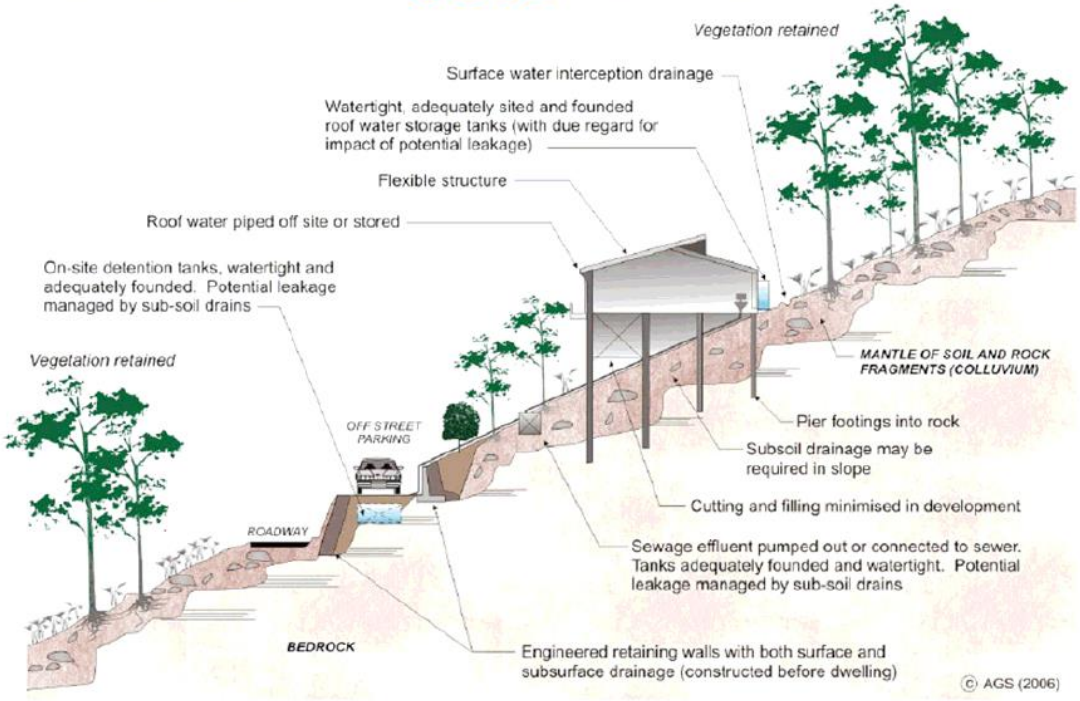
Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

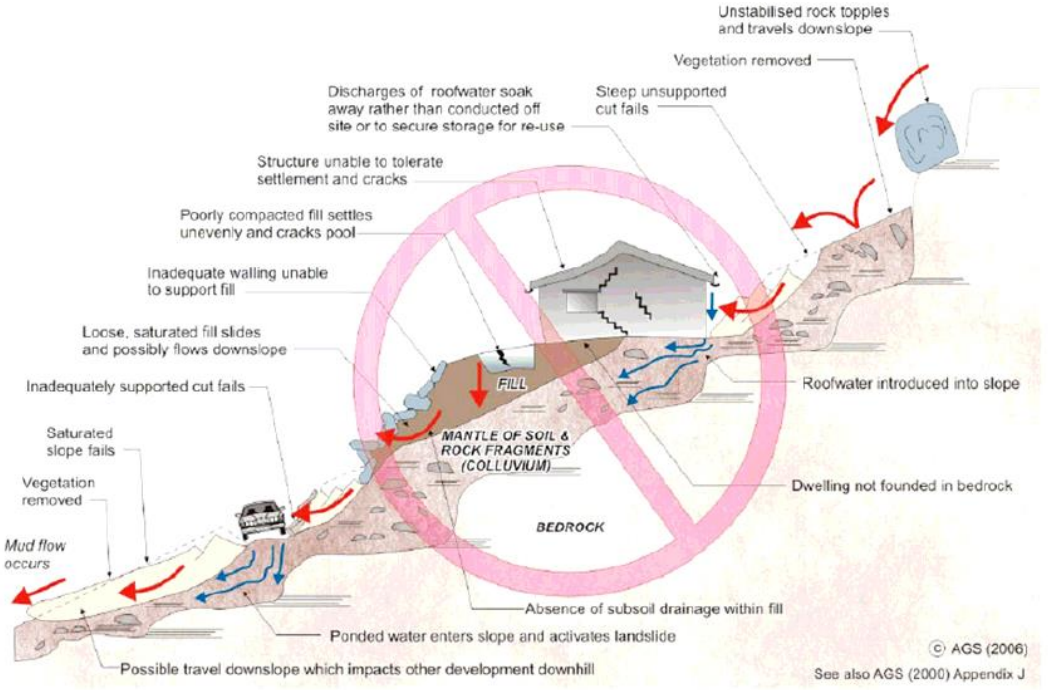
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



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.	