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CONSULTING ENGINEERS

Amity College - Proposed New Primary and Secondary School Campus

85 Byron Rd & 63 Ingleburn Rd, Leppington

Structural Report

19-07 / 9 July 2019 / Revision A

Contents

Document control

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Executive Summary

Amity College propose to establish a new primary and secondary school campus on part of Lots 1 and 2 in Deposited Plan 525996 at no. 85 Byron Road and no. 63 Ingleburn Road, Leppington.

The site is located approximately 39 kilometres south west of Sydney CBD and approximately 1.2 kilometres south of Leppington railway station.

The purpose of this report is to provide details on structural engineering aspects of the proposed school campus, inclusive of geotechnical conditions.

The ground conditions are summarised as follows:

- Topsoil and topsoil / fill from surface to depths of 0.2 to 0.4m
- Fill was encountered in some locations to a maximum depth of 0.6m
- Natural soil consisting of medium to high plasticity silty clay was generally encountered to depths of 0.9 to 3.0m below the surface
- Bedrock consisting of siltstone and shale / siltstone was encountered at depths of 0.9 to 3.0m below the surface. This material was assessed to be low to medium strength and extremely weathered to distinctly weathered.

The occurrence of high plasticity clay reactive soils that are prone to shrink-swell movement due to seasonal moisture change requires care to be taken in design of footing systems. The soils are classified as mildly aggressive to buried concrete structures and non-aggressive to buried steel structures.

The proposed buildings for the new school campus range from one to three storeys with one basement car parking level under some of the buildings. The super-structure will consist of concrete floors and some concrete roofs, a mixture of masonry, concrete and lightweight walls and steel framed and metal clad roofs.

It is envisaged that all the new buildings will be founded on the weathered siltstone and the ground floor slabs will be isolated from the areas of soil subject to shrink / swell movement. Basement floors will be concrete slab on grade and should not be impacted on by reactive clay subgrade as the majority (or all) of this material will have been removed during basement excavation.

Ground floors not over basements will be suspended flat concrete slabs supported on screw piles and isolated from the reactive clay subgrade around the perimeter of the buildings where moisture change potential is high. Ground floors over basements, all upper level floors and trafficable or green roofs will be suspended concrete slabs with beams / slab bands supported on concrete columns or walls.

Non-trafficable roofs will be supported on structural steel framing or a combination of structural steel and light-weight steel trusses. The lateral stability of the proposed buildings will be provided by a combination of reinforced concrete (or reinforced block) shear walls and vertical steel bracing.

All building structures and ancillary structures such as covered ways will be designed for loads determined from Australian Standards for a life of 50 years.

1.0 Introduction

1.1 Background

Amity College propose to establish a new primary and secondary school campus on part of Lots 1 and 2 in Deposited Plan 525996 at no. 85 Byron Road and no. 63 Ingleburn Road, Leppington.

1.2 The site

The site is located approximately 39 kilometres south west of Sydney CBD and approximately 1.2 kilometres south of Leppington railway station. Refer Figure 1.1 for location.

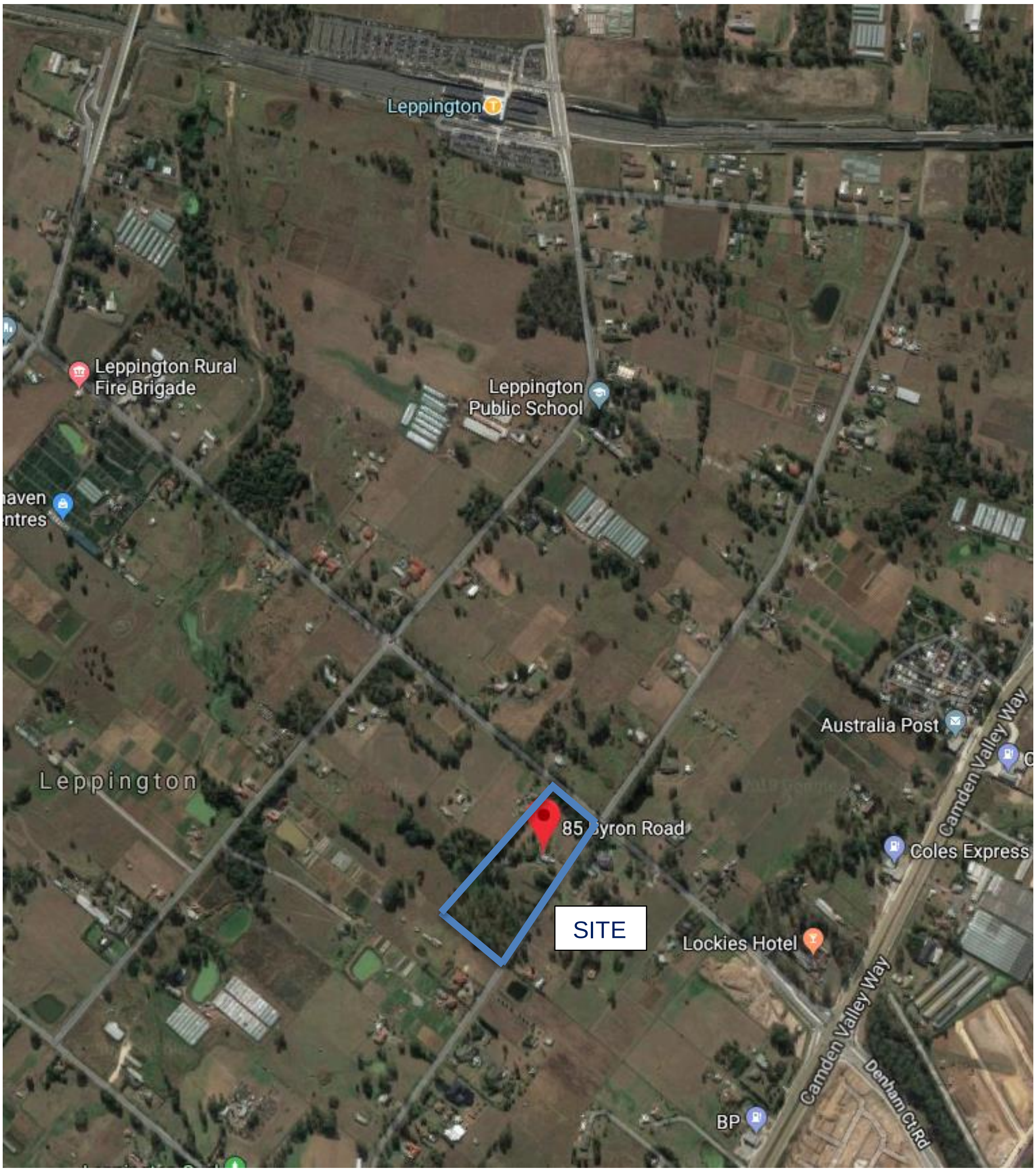


Figure 1.1 – Site Location

The site has an area of approximately 3.2 hectares and is roughly rectangular in shape. It has frontages to Byron Road to the south east and Ingleburn Road to the north east. The proposed school will occupy approximately 2.2 hectares of the south west portion of the total site. Refer Figures 1.2 and 2.1.

1.3 The proposal

The proposed new school involves construction of new local roadways, a primary school and a secondary school with a maximum capacity of 1,000 students. Refer Figure 1.2 below for layout.

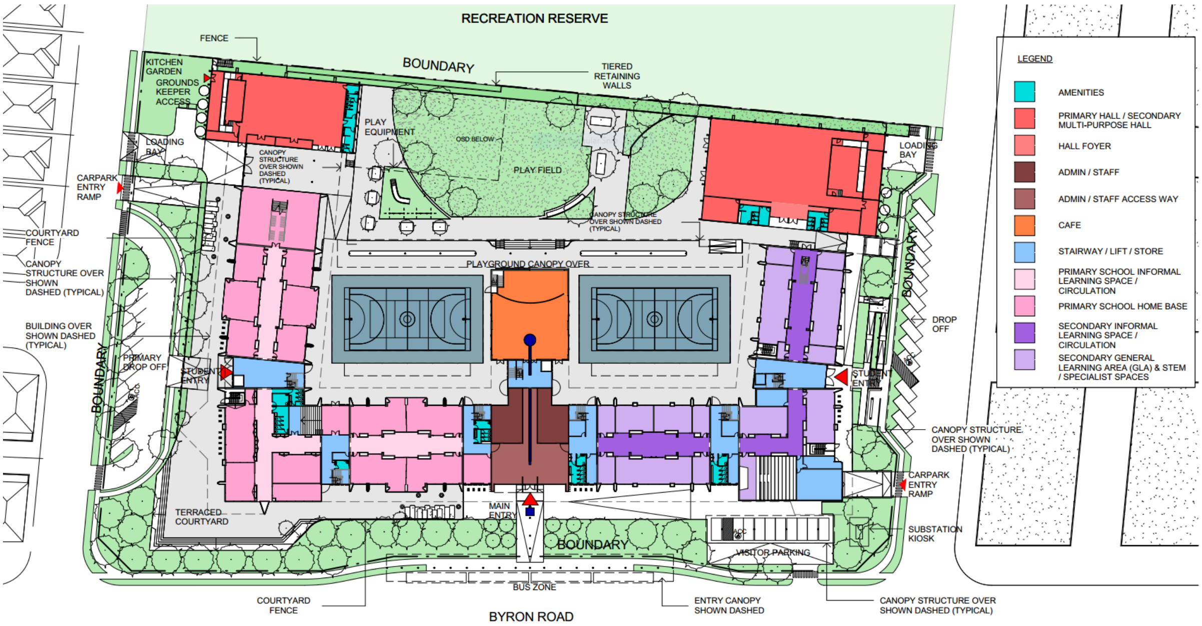


Figure 1.2 – Proposed Site Plan

From a structural perspective the school campus development includes:

- Primary school informal learning space, circulation, home bases and hall
- Secondary school informal learning space, circulation, general learning areas, specialist spaces and multi-purpose hall
- Administration and staff facilities
- Ground keeper facilities
- Café
- Miscellaneous covered walkways and canopies

1.4 Purpose of this report

The purpose of this report is to provide details on structural engineering aspects of the proposed school campus, inclusive of geotechnical conditions.

SEARs section ‘Plans and Documents’ states the EIS must include a ‘Geotechnical and Structural Report.’

2.0 Existing conditions

2.1 Land form and vegetation

The site for the proposed new school campus consists primarily of grassed and tree covered areas previously used for residential and farming purposes. Refer Figure 1.1 for aerial photograph.

Site levels in the area of the proposed new school campus range from RL 102 to RL 94 with maximum natural slopes of approximately 15%. The majority of the site drains to the north west. Refer Figure 2.1 for topographic survey with contours.

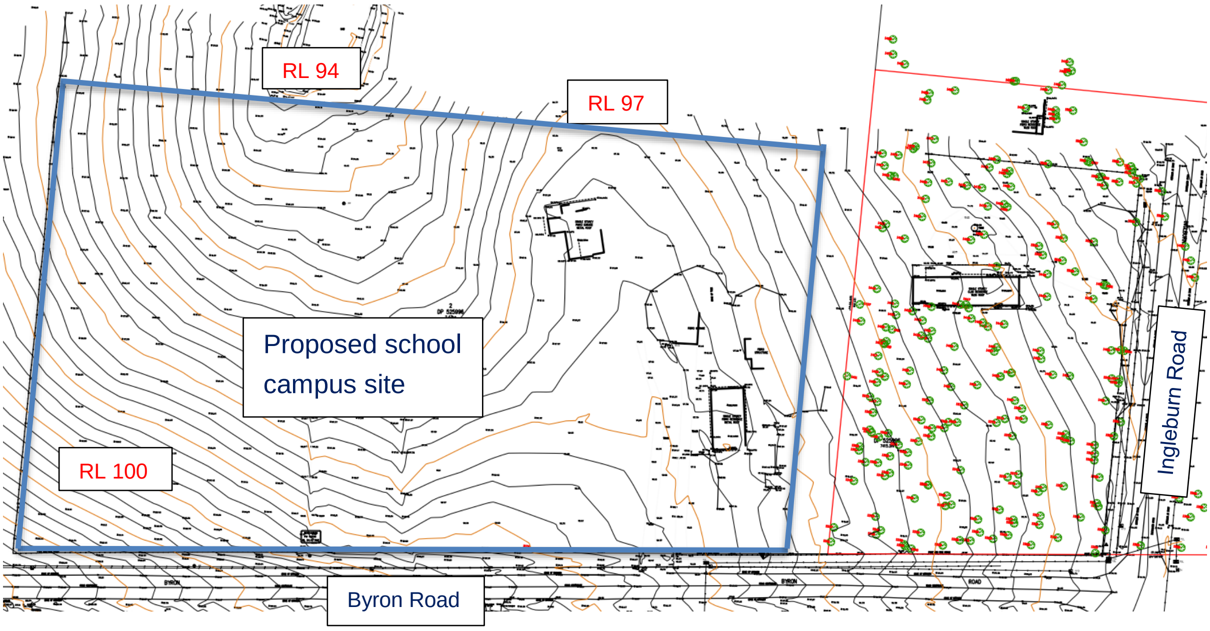


Figure 2.1 – Site Survey with contours

2.2 Geotechnical conditions

Geotechnical data is provided in the report dated October 2018 (ref: JC18322A-r2) prepared by GeoEnviro Consultancy Pty Ltd. Refer Appendix B for an extract from this report.

The ground conditions are summarised as follows;

- Topsoil and topsoil / fill from surface to depths of 0.2 to 0.4m
- Fill was encountered in some locations to a maximum depth of 0.6m
- Natural soil consisting of medium to high plasticity silty clay was generally encountered to depths of 0.9 to 3.0m below the surface
- Bedrock consisting of siltstone and shale / siltstone was encountered at depths of 0.9 to 3.0m below the surface. This material was assessed to be low to medium strength and extremely weathered to distinctly weathered.
- No groundwater was encountered during the investigation

The occurrence of high plasticity clay reactive soils that are prone to shrink-swell movement due to seasonal moisture change requires care to be taken in design of footing systems. The site is classified as Class H2 (highly reactive) in accordance with AS2870 'Residential Slabs and Footings' standard.

The soils are classified as mildly aggressive to buried concrete structures and non-aggressive to buried steel structures.

Shoring and retaining structures design parameters are provided in section 7.1.2 of the report as follows:

Material	Bulk Density (kN/m^3)	K_a	K_o	K_p	Effective Cohesion, C' (kPa)	Effective Friction Angle (deg)
Compacted Fill	17.5	0.35	0.65	-	2	20
Natural clay	20.0	0.30	0.5	2.0	5	20
Siltstone	22.0	0.2	0.3	2.5	10	25

Footing design parameters are provided in section 7.1.3 of the report as follows:

Minimum Founding Depths	Foundation Material	Allowable Bearing Capacities	Allowable Shaft Adhesions *1
1.0m below surface	Natural Very Stiff Clay	150kPa	-
2.5m below surface and 0.5m into natural clay	Natural Very Stiff Clay	250kPa	15kPa
3.0m below surface and 0.5m into Siltstone	Extremely Weathered Siltstone	600kPa	50kPa

Note: *1 Shaft adhesion is only applicable for deep pier footings and should ignore the upper 1.0m of the pier to allow for ground disturbance and weathering

Batter slope design parameters are provided in section 7.1.4 of the report as follows:

Material	Temporary	Permanent
Fill and topsoil (Landscape)	1V : 1.5H	1V : 3H
Natural Clay	1V: 1H	1V : 2H
Weathered Shale/Siltstone	1V : 0.5 to 1H	1V : 1H

Steeper batter slopes may be adopted for shale batters subject to inspection and further by geotechnical engineer during excavation works

3.0 Structural engineering

3.1 Overall concept

The proposed buildings for the new school campus range from one to three storeys with one basement car parking level under some of the buildings. The super-structure will consist of concrete floors and some concrete roofs, a mixture of masonry, concrete and lightweight walls and steel framed and metal clad roofs.

The buildings will be separated into blocks of up to 40m long with movement joints provided to assist with control of shrinkage, creep and thermal movements between the blocks.

3.2 Footings

It is envisaged that all the new buildings will be founded on the weathered siltstone and the ground floor slabs will be isolated from the areas of soil subject to shrink / swell movement.

Where basement excavation occurs it is likely concrete pad footings will be used. Elsewhere it is likely steel screw piles with concrete pile caps will be the most economic footing solution.

3.3 Floors

Basement floors will be concrete slab on grade and should not be impacted on by reactive clay subgrade as the majority (or all) of this material will have been removed during basement excavation.

Ground floors not over basements will be suspended flat concrete slabs supported on screw piles and isolated from the reactive clay subgrade around the perimeter of the buildings where moisture change potential is high.

Ground floors over basements, all upper level floors and trafficable or green roofs will be suspended concrete slabs with beams and / or slab bands supported on concrete columns or walls. These floors may be post-tensioned or reinforced concrete.

To minimise the cost of suspended floors and maintain structure within the depth allowed, it will be necessary to align columns up through the building and eliminate where possible the need for transfer beams. Refer marked up copies of the Architectural Plans presented in Appendix A for suggested column layouts.

3.4 Roofs

Non-trafficable roofs will be supported on structural steel framing or a combination of structural steel and light-weight steel trusses.

3.5 Lateral stability system

The lateral stability of the proposed buildings will be provided by a combination of reinforced concrete (or reinforced block) shear walls and vertical steel bracing for the roof structure.

The above lateral stability elements will be designed to resist both wind and earthquake loads.

3.6 Design Parameters

3.6.1 Design life

The minimum design life of the main structural elements will be 50 years.

3.6.2 Design loads

All building structures and ancillary structures such as covered ways will be designed for loads determined from Australian Standards using the following design parameters.

- Importance Level 3 (IL3) to AS 1170.0

- Dead loads to AS 1170.1, plus superimposed dead loads as follows:
  - Generally 1.3 kPa
  - Stairs and corridors 0.3 kPa
  - Toilets 2.5 kPa
  - Trafficable roofs 3.0 kPa
  - Halls 1.5 kPa
  - Terrace and Plaza 2.5 kPa
  - Plant rooms 2.5 kPa
  - Stages 0.1 kPa
  - Library 0.3 kPa

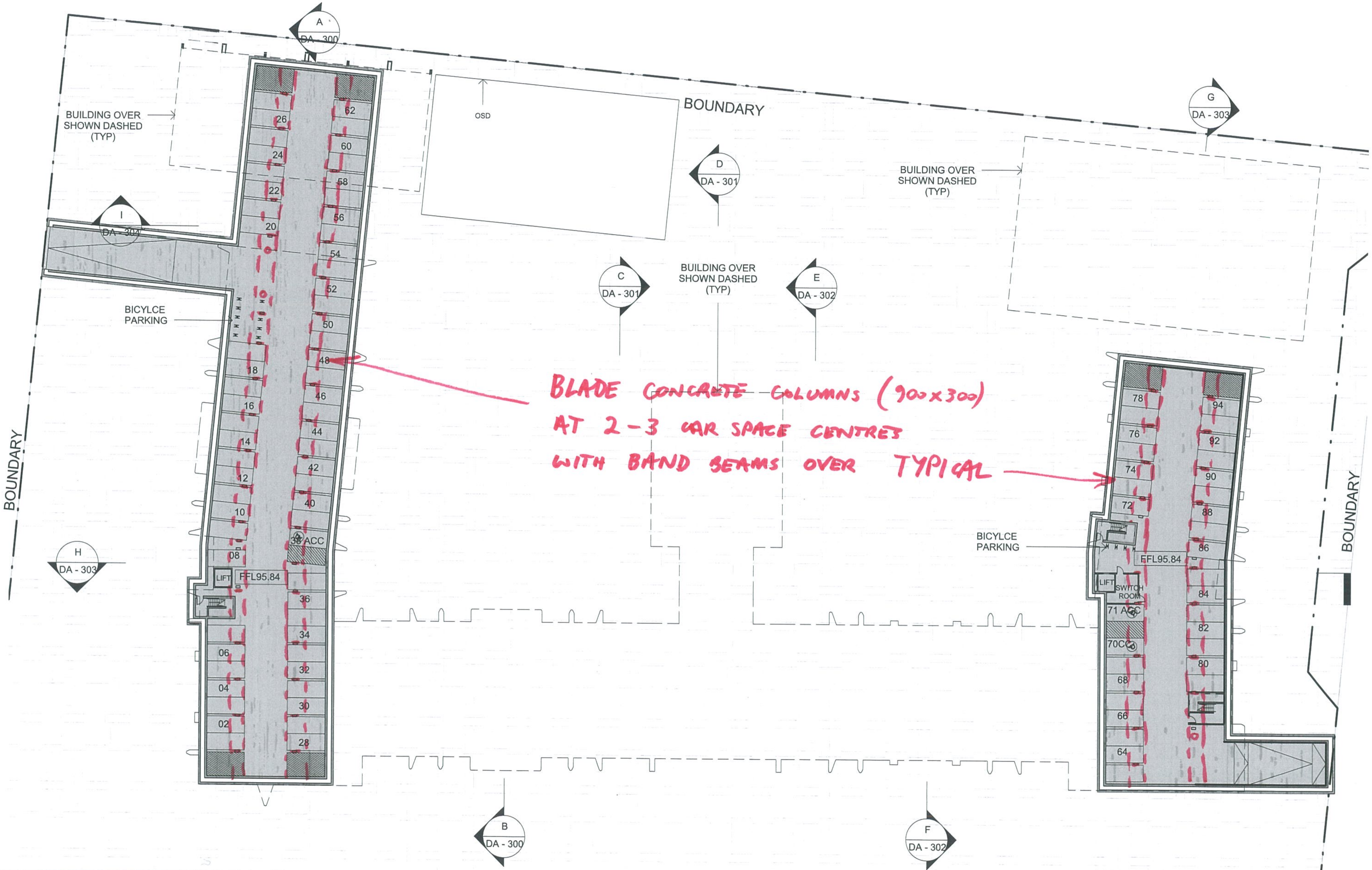
- Live loads to AS 1170.1
  - Generally 3 kPa
  - Stairs and corridors 4 kPa
  - Toilets 2 kPa
  - Trafficable roofs 4 kPa
  - Halls 5 kPa
  - Terrace and Plaza 5 kPa
  - Plant rooms 5 kPa
  - Stages 7.5 kPa
  - Library 7.5 kPa

- Wind loads to AS 1170.2
  - Region A2
  - Terrain Category 3

- Earthquake loads to AS 1170.4
  - Probability Factor; kp = 1.3
  - Hazard Factor Z = 0.08
  - Site sub-soil class Ce – Shallow soil

Appendix A

Drawings



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ON ORIGINAL SHEET

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N°.	DESCRIPTION	DATE
A	ISSUE FOR DEVELOPMENT APPLICATION	30.04.19
B	ISSUE FOR DEVELOPMENT APPLICATION	31.05.19

amity college

SCALE	DRAWN BY	CHECKED BY	DATE
1 : 500 @A3	BM/MC	PR	November 2018

PROJ. No.	DRAWING No.	REV.
A1803	DA - 105	B

GRAN ASSOCIATES AUSTRALIA ARCHITECTS PTY LTD
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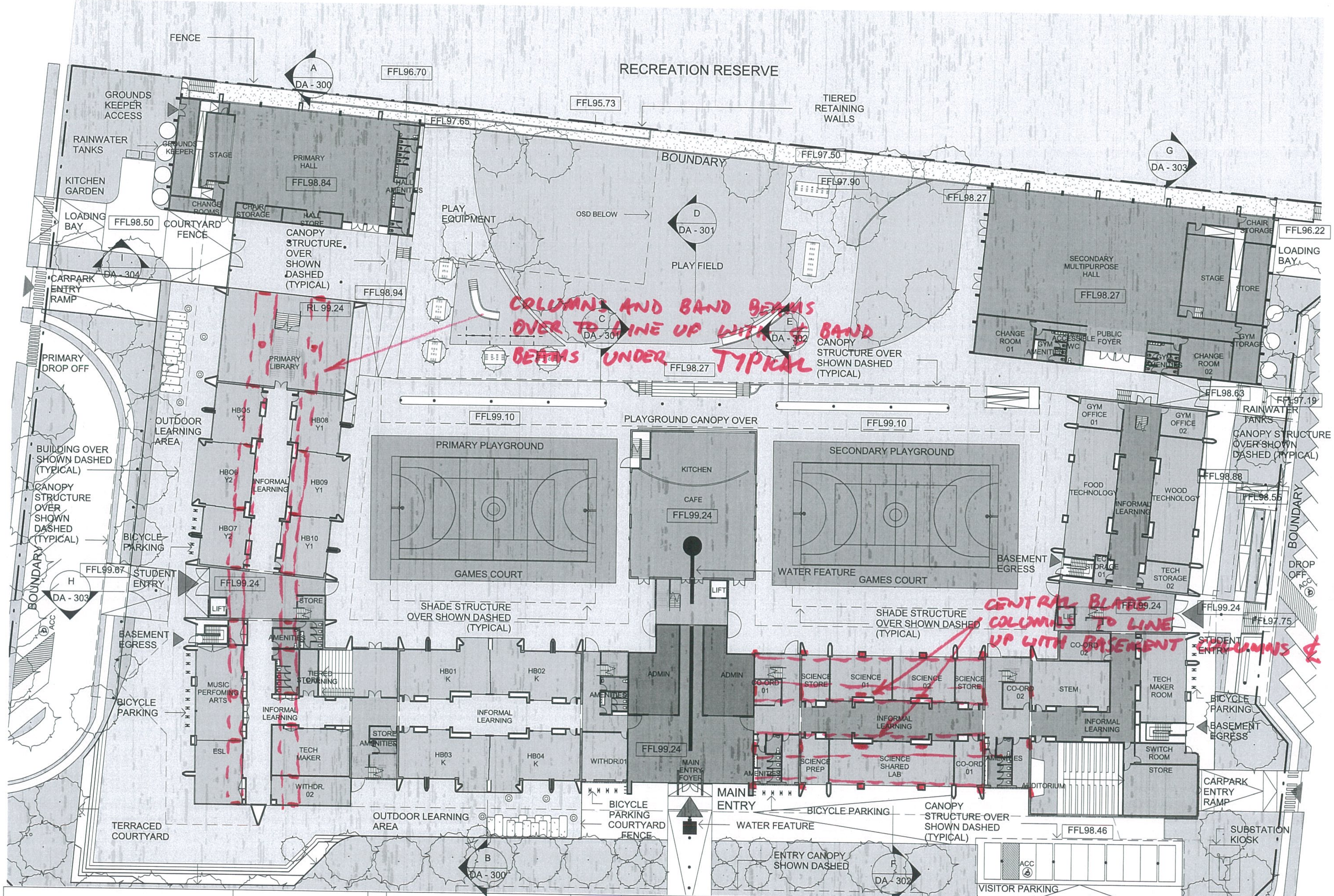
FAX: +61 2 9818 6285
PETER REED ARAIA, AIA NOM ARCH 5377
ANTHONY KEMENY FRAIA NSW REG No. 4599

PROJECT
AMITY COLLEGE LEPPINGTON
85 Byron Road, Leppington NSW

TITLE:
BASEMENT FLOOR PLAN



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B	ISSUE FOR DEVELOPMENT APPLICATION	31.05.19
C	ISSUE FOR DEVELOPMENT APPLICATION	27.06.19

amity college

SCALE	DRAWN BY	CHECKED BY	DATE
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PROJ. No.	DRAWING No.	REV.
A1803	DA - 100	C

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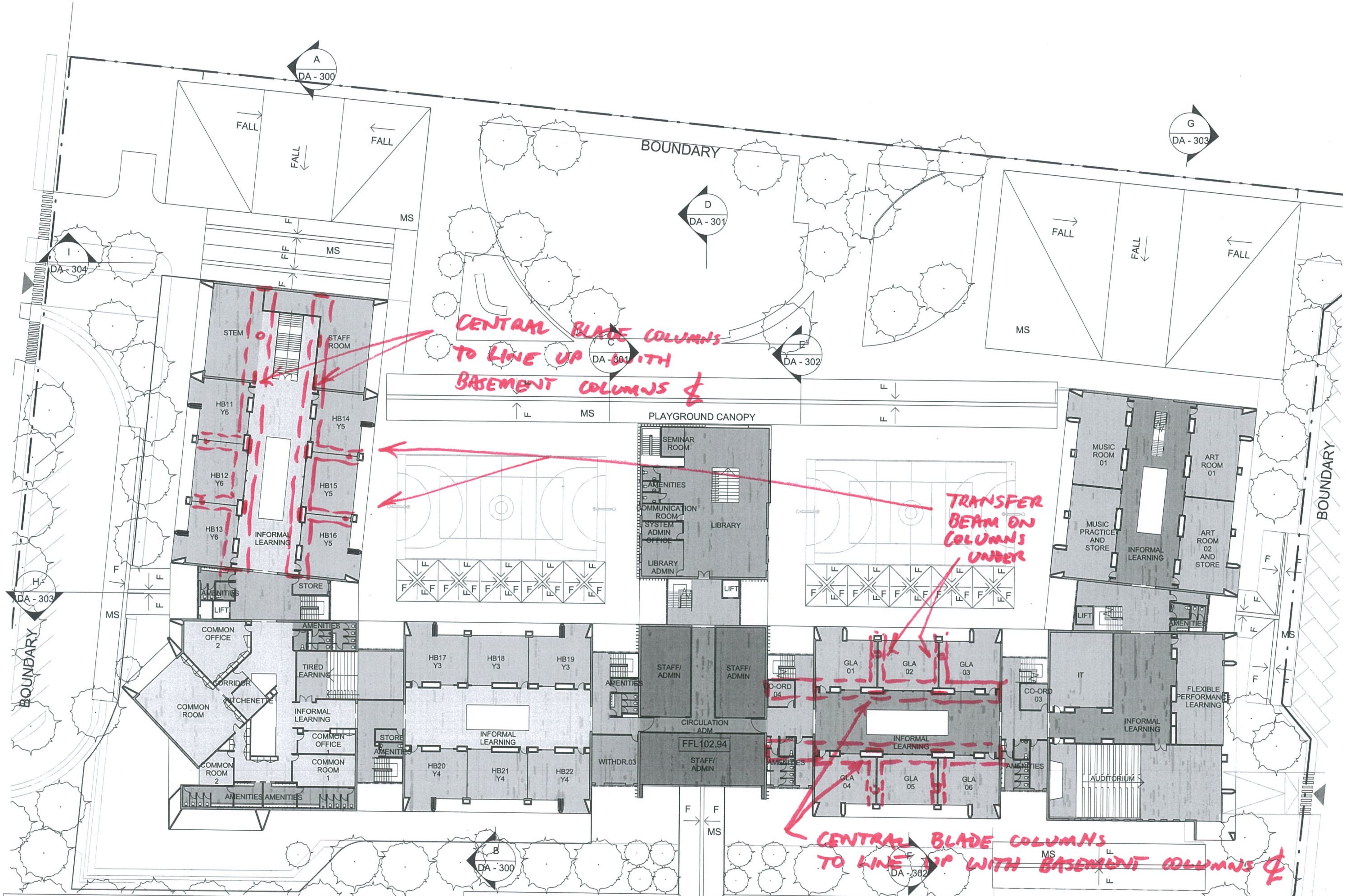
ANTHONY KEMENY FRAIA NSW REG No. 4599

PROJECT
AMITY COLLEGE LEPPINGTON
85 Byron Road, Leppington NSW

TITLE:
GROUND FLOOR PLAN



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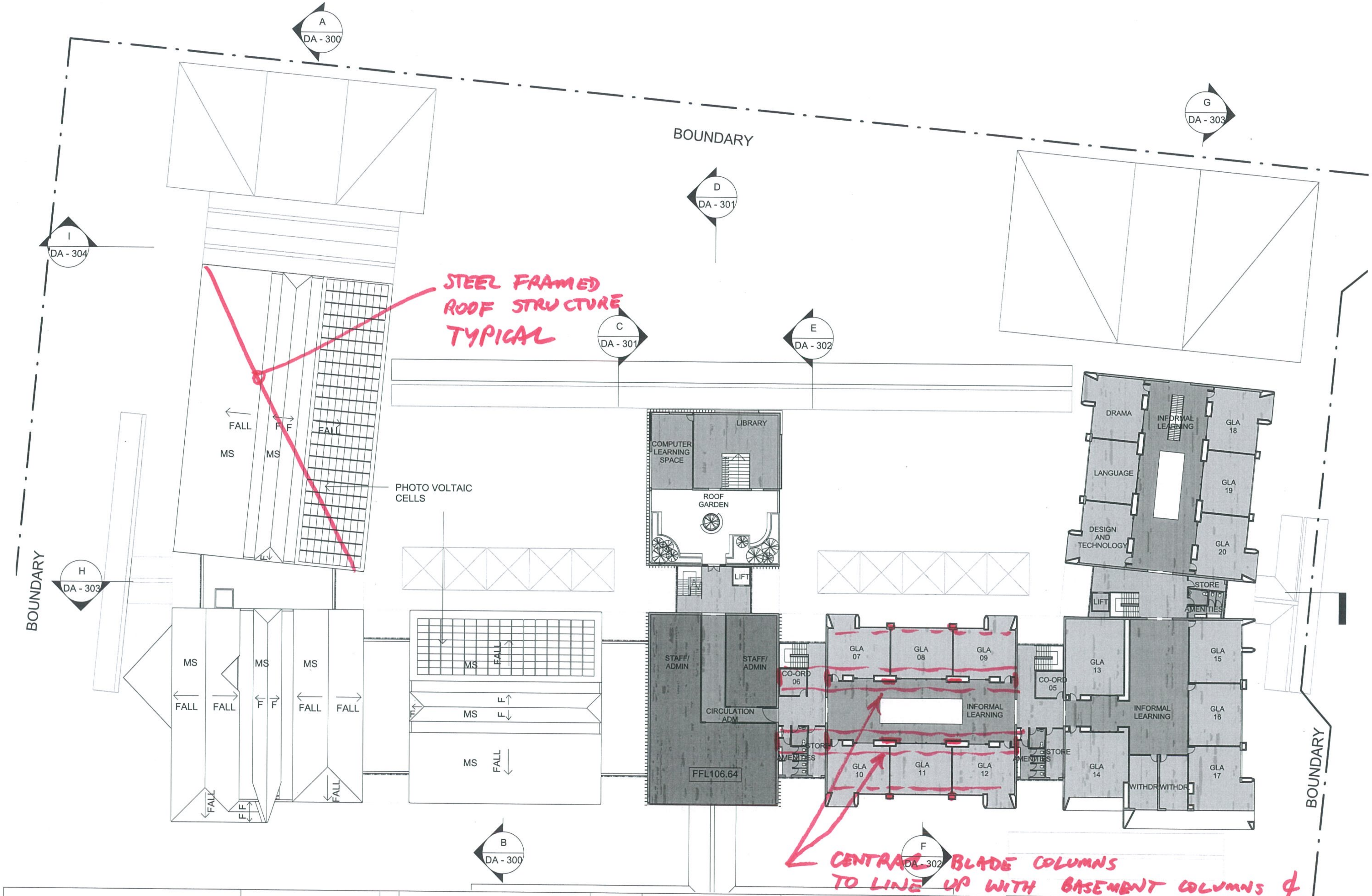
ANTHONY KEMENY FRAIA NSW REG No. 4599

PROJECT
AMITY COLLEGE LEPPINGTON
85 Byron Road, Leppington NSW

TITLE:
FIRST FLOOR PLAN



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amity college

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PROJ. No.	DRAWING No.	REV.
A1803	DA - 102	B

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PROJECT
AMITY COLLEGE LEPPINGTON
85 Byron Road, Leppington NSW

TITLE:
SECOND FLOOR PLAN

Appendix B

Extract from Geotechnical Report

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PO Box 1543, Macquarie Centre. North Ryde, NSW 2113
ABN: 62 084 294 762
Tel: (02) 9679 8733
Fax: (02) 9679 8744
Email: geoenviro@exemail.com.au

Report

Geotechnical and Salinity Investigation
Proposed New Amity College Campus
Lot 1 DP 525996 No 85 Byron Road and
Lot 2 DP 525996 No 63 Ingleburn Road
Leppington NSW

Prepared for
Amity College
C/- Gran Associates Pty Ltd
Level 1, 597 Darling Street
ROZELLE NSW 2039

Ref: JC18322A-r2(rev2)
May 2019

GeoEnviro Consultancy Pty Ltd
Unit 5, 39-41 Fourth Avenue, Blacktown, NSW 2148, Australia
PO Box 1543, Macquarie Centre. North Ryde, NSW 2113
ABN: 62 084 294 762
Tel: (02) 9679 8733
Fax: (02) 9679 8744
Email: geoenviro@exemail.com.au

8th May 2019

Our Ref: JC18322A-r2(rev2)

Amity College
C/- Gran Associates Pty Ltd
Level 1, 597 Darling Street
ROZELLE NSW 2039

Attention: Mr Peter Reed

Dear Sir

Re Geotechnical and Salinity Investigation
Proposed New Amity College Campus
Lot 1 DP 525996 No 85 Byron Road and
Lot 2 DP 525996 No 63 Ingleburn Road, Leppington

We are pleased to submit our Geotechnical and Salinity Investigation report for the proposed new Amity College Campus to be located at the above address.

This report should be read in conjunction with our Phase 1 and 2 Contamination Assessment report (ref JC18322A-r1(rev2) dated May 2019) and attached Explanatory Notes.

Should you have any queries, please contact the undersigned.

Yours faithfully
GeoEnviro Consultancy Pty Ltd

Solern Liew MIEA CPEng NER
Director

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TABLE OF CONTENTS

LIST OF DRAWINGS

LIST OF APPENDICES

1. INTRODUCTION

This report presents the results of a geotechnical and salinity assessment for the site identified as Lot 1 DP 525996 No 85 Byron Road and Lot 2 DP 525996 No 63 Ingleburn Road, Leppington, as shown on Drawing No 1.

The investigation was commissioned by Mr Peter Reed of Gran Associates acting on behalf of Amity College. The scope of this assessment was initially carried out in general accordance with our fee proposal referenced PC18424B dated 9th April 2018 and a more detailed scope was carried out based on our proposal referenced JC18322A-L2 dated 19th December 2018. This assessment was undertaken in conjunction with our Phase 1 and 2 Contamination Assessment report compiled in our report referenced JC18322A-r1(rev2) dated April 2019 (Reference 1) and this report should be read in conjunction with it.

We understand that the site occupies an area of about 3.3 hectares and the major southern and middle portions of the site is Zoned SP2 (Education Establishment) with the front portion of the site Zoned R3 (Residential). The proposed New Amity College Campus will occupy the portion of site Zoned SP2 and based on the masterplan drawings provided, the proposed school buildings will be 4 to 5 storeys high and will include a basement level requiring excavation up to 6m deep. Refer for Drawing No 2 for zoning plan and Drawing No 3 for proposed development plan.

The purpose of this investigation was to assess the subsurface ground conditions including fill and groundwater conditions and based on the information provided, to provide the following information;

- Subsurface conditions and provide recommendations on geotechnical issues considered relevant to the proposed development as follows;
  - Site preparations, fill construction and earthworks specification to AS3798 - Guidelines on Earthworks for Commercial and Residential Sites.
  - Shoring and retaining wall design parameters including lateral earth pressure coefficients, Ka, Ko and Kp
  - Slope batter design; temporary and permanent
  - Foundation design parameters including suitable footings, allowable bearing capacities and estimated settlement
  - Assessment on soil reactivity to AS2870
  - Recommendations on pavement subgrade preparation and pavement design
- Assessment on soil salinity and aggressiveness for durability design.

2. SCOPE OF WORK

2.1 Geotechnical Investigation

The scope of work for geotechnical investigation included;

- Drilling of boreholes using a truck mounted B80 drill rig and pendulum drill rig equipped with spiral augers.
- Standard Penetration testing (SPT) and hand penetrometer testing to assess the strength of the subsurface profiles.
- Visual soil classification and assessment of insitu material and bedrock level,
- Laboratory analysis to assess soil properties.

2.2 Salinity Assessment

The salinity assessment was performed in general conformance with our understanding of the guidelines prepared by the Department of Land and Water Conservation (Reference 4) and the Salinity Code of Practice prepared by Western Sydney Regional Organisation Council (Reference 5). The scope of work conducted consisted of:

- Drilling of boreholes using a truck mounted B80 drill rig and a pendulum drill rig equipped with spiral augers.
- Soil sampling of the topsoil and at every change in the soil texture at lower depths at selected Borehole locations.
- Laboratory analysis to aid assessment of physical and chemical properties

3. SITE INFORMATION

3.1 Site Location

The site is located at the south western corner of Ingleburn Road and Byron Road in Leppington and is approximately trapezoidal in shape measuring about 100m along Ingleburn Road and 290m along Bryon Road. The site widens to 125m at the rear. Refer to Drawing No 1 for site locality.

The site is within the jurisdiction of Camden Council, Parish of Cook and County of Cumberland.

Surrounding properties consist mainly of semi-rural residential allotments.

3.2 Site Topography and Ground Cover

The site is situated in a region typically characterised as gently undulating with relatively uniform ground surface generally falling to the north and north west towards Bonds Creek and Kemps Creek at angles typically ranging from 2 to 6 degrees.

Within the site, the northern portion of the site is approximately level with a slight dip to the north at angles of less than 2 degrees. Ground surface on the southern portion generally slopes towards a depression along western boundary at angles of between 3 and 4 degrees. Based on the survey drawing (Drawing No 1), the south eastern corner of the site is at Reduced Level (RL) 102.5m Australian Height Datum (AHD) and the north western corner of the site is at RL 93m AHD.

3.3 Ground Cover and Salinity Indicators

The site ground cover consists predominantly of thick grass with tree canopies on the southern portion. The site appeared well drained with no visible signs of permanent water-logged areas, groundwater or “springs” and this is confirmed by survey drawing and the uniformly hard and dry natural clay which exists across the entire site.

There were no obvious signs and indicators of salinity impacts such salt crystals on the surface, salt attacks and markings on existing building footings and vegetation distress.

3.4 Soil Landscape and Geological Setting

The 1:100,000 Soil Landscape of Penrith Series 9030 (Reference 2) prepared by the Soil Conservation Services of NSW indicates the site to be underlain by Residual soil belonging to the Blacktown landscape group. Typically, soil consists of highly plastic and moderately reactive subsoils with low permeability. Refer to Drawing No 4 for site locality with reference to the soil landscape map.

The 1:100,000 Geological Map of Penrith Series 9030 (Reference 3) indicates the underlying bedrock to consist of Bringelly shale of the Wianamatta Group consisting of shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff. Refer to Drawing No 5 for site locality with respect to the geological setting

3.5 Hydrology and Hydrogeology

Topography, surface cover and geology control the hydrogeology of the site. It is anticipated that the majority of rainfall runoff will flow to Scalibrini Creek which leads to Bonds Creek and then into Kemps Creek to the north west.

Groundwater is also expected to flow in a general direction towards the west to Scalibrini Creek. Due to the relatively impervious nature of the underlying subsurface soil and bedrock, rainfall runoff infiltrating through the subsurface soil and expected bedrock profiles is expected to be minimal.

Based on our local knowledge and previous investigation of the general surrounding area, we expect permanent groundwater table to be at a significant depth below the proposed basement excavation level (ie 6m depth). The results of this investigation confirmed the subsurface profile to be dry with no subsurface groundwater seepage, aquifers or "springs".

Our search of the NSW Department of Primary Industries groundwater database for the region indicates five groundwater bores within 1km from the site as summarised below;

Bore ID	Depth (m)	SWL (m)	Northing (mAMG)	Easting (mAMG)	Recorded Use	Water Bearing Zones (m)
GW110356	6.00	2.50	6238969.0	297896.0	Monitoring	2.50-6.00
GW110359	6.00	2.90	6238973.0	297920.0	Monitoring	2.90-6.00
GW110358	7.00	4.90	6238993.0	297917.0	Monitoring	4.90-7.00
GW112660	-	-	6239181.0	296770.0	Monitoring	-

The above monitoring boreholes were located within an existing service station site along Camden Valley Way, approximately 600m to the west and the groundwater encountered is likely to be trapped groundwater around and within the underground tank farm and this is typical of service station sites.

3.6 Soil Salinity Map

Based on soil salinity risk map (Reference 5) prepared by the Western Sydney Regional Organisation of Councils Ltd, the site is situated in area with moderate salinity potential. Refer to Drawing No 6 for soil salinity map.

3.7 Acid Sulphate Soil Map

The acid sulphate soil risk map prepared by the Department of Land and Water Conservation (Reference 12) indicates the site to be situated in an area with "No Known Occurrence" of acid sulphate soil. Refer to Drawing No 7 for an extract of the map prepared by the Department of Land and Water Conservation

3.8 Site Inspection and Description

A site visit was carried out on the 23rd to 30th April 2018 and 4th April 2019 by a soil scientist and a geotechnical engineer to observe existing site features. Reference should be made to Drawing No 2 for site features.

At the time of the site investigation, the site was mainly used for residential with the southern rear portion of the site consisting of medium dense trees. Refer to attached Drawing No 2 for site features. The following is a summary of site features noted;

Site Feature	Description
A	Driveway constructed of crushed rock.
B	Single-storey brick, weatherboard and tile dwelling with a metal garage to the rear.
C	Single-storey fibro/metal dwelling with a number of small metal, timber and fibro sheds to the west. Sheds used for storage of miscelaneous items. Some minor hydrocarbon staining visible on surface
D	Driveway constructed of crushed rock, sandstone and traces of building debris (eg bricks and asphalt lumps)
E	Metal, timber and fibro shed with building extensions.
F	Area of previous numerous small buildings and sheds. Previous market garden area (1950s)
G	Backfilled depression with rubbish fill consisting of concrete boulders, bricks, glass and asbestos fragments
H	Recent Market Garden beds
I	Previous market garden/agricultural area

4. INVESTIGATION METHODOLOGY

4.1 Field Investigation

Field investigation was carried out on the 23rd and 24th April 2018 and 4th April 2019 was carried out in accordance with AS1726-2017 (Reference 11). The investigation involved drilling of forty five boreholes (BH 1 to BH 45) across the site as shown on Drawing No 8. The boreholes were drilled using a truck mounted B80 drill rig and a pendulum drill rig equipped for site investigation. The truck mounted drill rig boreholes (BH 1 to 40) were drilled using spiral augers attached to a V-bit to refusal followed by Tungsten Carbide (TC) bit drilling into shale to depths of about 0.9m to 4.0m below existing ground surface. The pendulum drill rig boreholes (BH 41 to 45) were drilled using a TC bit to refusal in shale at depths varying from 1.3m to 2.8m below existing grounds surface.

In order to assess the strength of the subsurface soil, Standard Penetration Testing (SPT) was carried out in the boreholes. Hand penetrometer testing was carried out on the recovered SPT split-tube clayey samples to augment the SPT results. The strength of the bedrock in the augered boreholes was subjectively assessed by examining the bedrock fragments from the drilling and engineering judgement.

Environmental soil samples were collected in duplicate from surface and at lower depths. Disturbed samples were taken from the site to our laboratory for analysis.

The test locations were located by offset measurements relative to site boundaries and site features. Refer to Drawing No 8 for borehole location plan and Borehole Logs in Appendix A for subsurface profiles encountered in each borehole. The reduced levels shown on the borehole logs were obtained from interpolation of contour lines obtained from the surface plan (Drawing No 1).

4.2 Laboratory Analysis

Geotechnical

"Undisturbed" U_{50} soil samples and disturbed samples were taken from the site to our NATA accredited laboratory for the Shrink-Swell Index and Atterberg Limits tests to assess the soil reactivity of the insitu soil to moisture variation and soil characteristics.

Three bulk subgrade soil samples were taken from the site to our NATA accredited laboratory for the following California Bearing Ratio (CBR) test to assess pavement subgrade characteristics and to provide preliminary pavement design.

The laboratory test reports are detailed in Laboratory Test Report in Appendix B of this report.

Salinity and Soil Aggressiveness

To assess the likely impact of soil salinity to the proposed development, strategic soil sampling was carried out across the site targeting the following areas;

Salinity risk areas	Borehole sampling
Previous market garden area	BH 1, BH 5, BH 45
Current Market Gardens	BH 44
Built up Areas	BH 17
Buried Fill area and Depression area	BH 26, BH 28, BH 43
Proposed onsite stormwater detention area	BH 42
Treed area (Elevated area)	BH 31, BH 35, BH 41,

Samples were analysed for the following;

- pH
- Electrical Conductivity (Ec)
- Cation Exchange Capacity (CEC)
- Exchangeable Sodium Percentage (ESP)
- Chloride (Cl)
- Sulphate (S04)
- Resistivity
- Emerson Dispersion
- Particle Size Distribution

Emerson and Particle Size analysis was carried out in our NATA accredited laboratory. The salinity analysis was carried out by Envirolab Services. The laboratory test reports for the salinity assessment are attached in Appendix C of this report.

5. SUBSURFACE CONDITIONS

Reference should be made to the Borehole Reports in Appendix A for a summary of subsurface profiles encountered in each borehole locations. Drawing No 9 to 11 provides typical soil and rock profile across the site.

The following is a summary of subsurface conditions noted;

Topsoil and Topsoil/Fill

Topsoil and topsoil/fill were encountered in all boreholes except BH 17 and 18 and 28 generally consisting of Clayey Silt of low liquid limit. Thickness of the topsoil and topsoil/fill was found to range from 200mm to 400mm.

in BH 23 some asphalt lumps and crushed rock were encountered noting that BH 23 was excavated along the edge of the accessway (Site Feature D).

Fill

Fill was encountered on the surface of BH 17, 18 and 28 comprising of Clayey Silt/Silty Clay and Gravelly Silt.

Some asbestos and tile fragments were encountered within the fill in BH 28 and this fill appeared to have been placed in the previous depression area (ie Site Feature G).

The fill was found to have thickness ranging from 300mm to 600mm.

Natural Soil

Underlying the topsoil and fill in all boreholes, natural soil consisting generally of high plasticity Silty Clay was encountered. In general, the plasticity of the clay reduces to medium plasticity at lower depths with the inclusion of ironstone and siltstone bands, Gravelly Silty Clay and Interbedded Clay and Siltstone in some boreholes.

The natural clayey soil was generally assessed to be dry to moist (ie moisture content less than or equal to the plastic limit). Based on the SPT and hand penetrometer results, the upper 1.2m of the natural clay profile was assessed to be very stiff to hard and the strength increases to hard at lower depths..

Bedrock

Bedrock consisting of Siltstone and Shale/Siltstone was encountered in all boreholes except BH 3, 10, 14, 18 and 24 at depths ranging from 0.9m to 3.0m below existing ground surface. The Siltstone and Shale/Siltstone was subjectively assessed to be low to medium strength and extremely weathered to distinctly weathered.

Groundwater

All boreholes were found to be dry during and shortly after completion of the site investigation.

6. RESULTS OF THE INVESTIGATION

6.1 Salinity

6.1.1 Guidelines

Salinity refers to the presence of excess salt in the environment and is able to occur if salts which are naturally found in soil or groundwater mobilise, allowing capillary rise and evaporation to concentrate the salt at the upper subsurface soil profile. Such movements are caused by changes in the natural water cycle. In urban areas, the processes which cause salinity are intensified by the increased volumes of water added to the natural system from irrigation of gardens, lawn and parks and from leaking infrastructures (eg pipes, sewer, stormwater, etc) and pool.

Saline soil may have adverse impact on development such as;

- Damage to buildings caused by deterioration of bricks, mortar and concrete when salt drawn up into capillaries of bricks and mortar expands resulting in spalling.
- Deterioration of concrete kerbs and gutters as a result of chemical reaction between concrete and sulphates.
- High chloride content in the soil may result in corrosion of steel reinforcement and buried metal structures.
- Damage to underground pipes and infrastructures.
- Water logging of ground surface due to sealing effect of sodic and dispersive soil.
- Loss of vegetation cover and plants due to high salt content resulting in retardation of plants.

In recognition of the potential adverse impact of salinity to development, the Western Sydney Regional Organisation of Councils Ltd has drafted a Salinity Code of Practice (Reference 5) to address the issue of salinity. It is acknowledged in the Code that salinity problems can change substantially over time and it is difficult to predict exactly where salinity will occur and how it will respond to the changing environment conditions.

For assessment of soil salinity and aggressiveness, the Department of Land and Water Conservation has prepared a guideline entitled "Site Investigation for Urban Salinity" (Reference 5). The fundamental criterion for assessing soil salinity is based on Electrical Conductivity.

Class	**EC_e (ds/m)**
Non-Saline	<2
Slightly Saline	2-4
Moderately Saline	4-8
Very Saline	8-16
Highly Saline	>16

Soil dispersion relates to stability of the soil in the presence of water. The following is a measure of soil dispersion;

Emerson Class No	**Dispersibility**
1	Very High
2	High
3	High to moderate
4	Moderate
5 and 6	Slight
7 and 8	Negligible/Aggregated

Sodic soils are dispersible and are vulnerable to erosion and tunnelling. Sodicity is a measure of Exchangeable Sodium Percentage (ESP) and Cation Exchangeable Capacity (CEC). The following is a measure of soil sodicity;

ESP (%)	**Rating**
Less than 5	Non-Sodic
5 to 15	Sodic
Greater than 15	Highly Sodic

The measure of Cation Exchangeable Capacity is as follows;

CEC ($cmol^+/kg$)	**Rating**
Less than 6	Very Low
6 to 12	Low
12 to 25	Moderate
25 to 40	High
Greater than 40	Very High

In addition to the above, the presence of Sulphate and Chloride in the soil has the potential to cause high soil aggressivity to concrete and steel structures, in particular if the structures are in direct contact with the soil. The following is a measure of soil aggressivity to concrete based on the AS 2159-2009 "Piling – Design and Installation" (Reference 7).

Sulphate expressed as SO_3		**PH**	**Chloride in water (ppm)**	**Soil conditions A***	**Soil conditions B#**
In Soil (ppm)	**In Groundwater (ppm)**				
<5000	<1000	>5.5	<6000	Mild	Non-aggressive
5000-1000	1000-3000	4.5-5.5	6000-12000	Moderate	Mild
10000-20000	3000-10000	4-4.5	12000-30000	Severe	Moderate
>20000	>10000	<4	>30000	Very Severe	Severe

Approximate 100ppm of SO4=80ppm of SO^3
* Soil condition A = High permeability soils (eg sands and gravels) which is below groundwater
\# Soil conditions B = Low permeability soils (eg silts and clays) and all soils above groundwater

The following is a measure of soil aggressivity to steel piles based on the AS 2159-2009 "Piling – Design and Installation" (Reference 7).

pH	**Chlorides (Cl)**		**Resistivity Ohm.cm**	**Soil conditions A***	**Soil conditions B#**
	In Soil Ppm	**In water ppm**			
>5	<5000	<1000	>5000	Non-aggressive	Non-aggressive
4-5	5000-20000	1000-10000	2000-5000	Mild	Non-aggressive
3-4	20000-50000	10000-20000	1000-2000	Moderate	Mild
<3	>50000	>20000	<1000	Severe	Moderate

* Soil condition A = High permeability soils (eg sands and gravels) which is below groundwater
\# Soil conditions B = Low permeability soils (eg silts and clays) and all soils above groundwater

In addition to the above, the AS 3600-2018 "Concrete" (Referenced 8) outlines an exposure classification for concrete in sulfate soils as follows;

Exposure Conditions			**Exposure**	**Classification**
Sulphate expressed as SO_3		**PH**	**Soil conditions**	**Soil conditions**
In Soil (ppm)	**In Groundwater (ppm)**		**A***	**B#**
<5000	<1000	>5.5	A2	A1
5000-1000	1000-3000	4.5-5.5	B1	A2
10000-20000	3000-10000	4-4.5	B2	B1
>20000	>10000	<4	C2	B2

Approximate 100ppm of SO4=80ppm of SO^3
* Soil condition A = High permeability soils (eg sands and gravels) which is below groundwater
# Soil conditions B = Low permeability soils (eg silts and clays) and all soils above groundwater

6.1.2 Laboratory Test Results

The following is a summary of the laboratory test results;

Sample	Depth (m)	pH	EC	Factor	Ece	Cl	SO4	Resistivity	CEC	ESP
BH1	0.00-0.10	6.1	0.05	10	0.45					
	0.60-0.70	5.5	0.13	7.5	0.98	99	93	9200	7.9	14
	2.50-2.80	5.3	0.26	8	2.08	290	86	2300		
BH5	0.00-0.10	6.3	0.06	10	0.56					
	1.00-1.45	5.0	0.57	7	3.99	670	130	1700		
	2.50-2.90	5.0	0.69	8	5.52	710	180	2100		
BH17	0.00-0.10	6.8	0.18	10	1.80					
	0.50-0.60	7.3	0.10	7	0.70	20	10	7100		
	1.00-1.45	6.0	0.20	8	1.60	98	210	6600		
BH26	0.00-0.10	5.7	0.10	10	0.96					
	0.50-0.60	5.6	0.12	7	0.84	92	60	9700		
	1.00-1.45	5.0	0.48	8	3.84	480	230	4000	9.4	17
BH28	0.00-0.10	6.9	0.15	10	1.50					
	0.50-0.60	5.7	0.06	7.5	0.47	23	55	6900		
	1.00-1.45	5.1	0.55	8	4.40	560	170	6000		

Note: EC – Electrical Conductivity (dS/m)
EC_e-Electrical Conductivity (dS/m)
CEC – Cation Exchange Capacity (meq/100g or cmol+/kg)
ESP – Exchangeable Sodium Percentage (%)
Resistivity – ohm/cm
CL – Chloride (mg/kg)
SO4- Sulphate (mg/kg)

Sample	Depth (m)	pH	EC	Factor	Ece	Cl	SO4	Resistivity	CEC	ESP
BH31	0.00-0.10	6.0	0.05	10	0.48					
	0.50-0.60	6.1	0.06	7.5	0.43	20	48	7700	8.2	3
	1.00-1.45	5.1	0.57	8	4.56	600	240	4600		
BH35	0.50-0.60	5.2	0.38	7	2.66	290	230			
BH41	0.0-0.1	6.0	0.07	10	0.66					
	0.5-0.6	5.1	0.62	7	4.34	740	170		12	9
	1.4-1.5	5.3	0.50	8	4.00	550	140	2000		
BH42	0.0-0.1	6.0	0.06	10	0.56					
	0.4-0.5	6.4	0.06	7	0.41	10	59	17000		
	1.0-1.1	5.7	0.13	8	1.04	47	70			
BH43	0.0-0.1	6.6	0.10	10	0.97					
	0.5-0.6	6.0	0.13	7	0.91	33	89			
	1.2-1.3	5.1	0.40	8	3.20	330	210		14	13
BH44	0.0-0.1	6.9	0.11	10	1.10					
	0.4-0.5	6.7	0.10	7	0.67	20	10	10000		
	1.4-1.5	5.4	0.14	8	1.12	38	130		11	16
BH45	0.0-0.1	6.3	0.05	10	0.50					
	0.6-0.7	5.4	0.20	7	1.40	95	210			
	1.6-1.7	4.8	0.32	8	2.56	290	90	3100		

Note: EC – Electrical Conductivity (dS/m)
EC_e-Electrical Conductivity (dS/m)
CEC – Cation Exchange Capacity (meq/100g or cmol+/kg)
ESP – Exchangeable Sodium Percentage (%)
Resistivity – ohm/cm
CL – Chloride (mg/kg)
SO4- Sulphate (mg/kg)

Emerson Class

Test Pit	Emerson Class	Dispersiveness
BH 1 (0.6-0.7m)	2	High
BH 1 (2.5-2.8m)	1	Very High
BH 5 (1.0-1.45m)	1	Very High
BH 5 (2.5-2.7m)	1	Very High
BH 17 (0.5-0.6m)	1	Very High
BH 17 (1.0-1.45m)	2	High
BH 26 (0.5-0.6m)	5	Slight
BH 26 (1.0-1.45m)	2	High
BH 28 (0.5-0.6m)	2	High
BH 28 (1.0-1.45m)	1	Very High
BH 31 (0.5-0.6m)	4	Moderate
BH 31 (1.0-1.45m)	2	High
BH 35 (0.5-0.6m)	2	High

Particle Size

Test Pit	Clay/Silt (%)	Sand (%)	Gravel (%)
BH 1 (2.5-2.8m)	89	9	0
BH 26 (0.5-0.6m)	88	12	0
BH 31 (1.0-1.45m)	80	20	0

6.2 Geotechnical

For details of the laboratory test results, refer to the laboratory test reports in Appendix B of this report. The following is a summary of the laboratory test results;

Shrink/Swell Index

Sample	Depth (m)	Shrinkage (%)	Swell (%)	Shrink/Swell Index (%/pF)
BH 8	0.4-0.7	2.4	10.7	4.3
BH 25	0.4-0.7	0.6	3.1	1.2
BH 30	0.5-0.8	1.6	5.8	2.5

Based on the laboratory results, the natural soil was assessed to have a moderate to high reactivity to moisture variation.

Atterberg Limits

Sample	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
BH 5	0.4-0.6	61	27	34	18.0
BH 15	0.4-0.7	59	28	31	16.5
BH 33	0.4-0.7	58	28	30	15.0

The Atterberg limit test results confirm the insitu soil to have a high plasticity.

California Bearing Ratio

The following is a summary of the CBR test results;

Sample	Depth (m)	Optimum Moisture Content (%)	Field Moisture Content (%)	Swell (%)	CBR (%)
BH 11	0.3-0.6	20.5	15.0	2.5	2.5
BH 14	0.3-0.7	21.0	15.0	3.5	2.5
BH 40	0.4-0.7	22.0	17.0	2.6	3.0

The laboratory test results indicate the subgrade samples to have low CBR values of between 2.5% and 3.0%.

7. ASSESSMENT AND RECOMMENDATIONS

7.1 Geotechnical Issues

7.1.1 Site Preparation and General Earthworks

We anticipate that some site excavation and earthworks will be required to regrade the site to design levels. Our borehole investigation revealed the site to be generally underlain by natural ground comprising of topsoil overlying clayey soil overlying shale/siltstone bedrock at shallow depths. Some buried fill about 600mm deep was encountered in BH 28 located in the previous depression area (Site Feature G) and based on test pits excavated as part of the contamination assessment (Reference 1), the buried fill was found to be in excess of 2.3m and contains rubbish including concrete brick, plastic, metal and glass.

Typical bulk earthworks should include the following;

- Clearing of site vegetation and stripping of topsoil/organic layers to expose the natural clay. The topsoil may be reused as much as possible on site in landscaping and any surplus topsoil would need to be disposed off-site.
- Excavation of insitu fill and rubbish fill (Site Feature G) to expose natural residual soil. The insitu fill should be assessed by a suitably qualified NATA accredited laboratory to ensure suitability of the material for reuse as structural fill on site. Suitable structural fill should consist of compactable clays, shale and sandstone free of deleterious material (eg organic material and vegetation), silt and large oversized material with particle size greater than 75mm.
- The area exposed by the excavation should be proof rolled using a minimum 8 tonne vibrating roller to identify any soft or heaving areas. Any soft or heaving areas observed during proof rolling should be excavated and recompacted to a minimum 98% Standard Maximum Dry Density at ±2% Optimum Moisture.
- All structural fill beneath buildings and pavements should be controlled and compacted in layers not exceeding 250mm thickness compacted to the above specified compaction level. Any imported fill should be of good quality material such as ripped shale or sandstone with a maximum particle size of 75mm.
- Earthworks should be closely monitored by a geotechnical consultant and should include field density testing of fill at an appropriate frequency and level of supervision as detailed in AS3798 -2007 (Referenced 9). Fill placed and compacted in accordance with AS3798 (Reference 9) may be classified as “Controlled” fill.

Our general comments on suitable bearing material and reusability of onsite soil are as follows;

- The topsoil encountered on the surface in the boreholes are not considered suitable to support permanent structures such as pavements, slabs and buildings and therefore should be excavated and removed. The topsoil and topsoil/fill may be reused in future landscaping areas (eg earth mounds and footpaths).
- Any fill encounter during construction would be classified as "Uncontrolled" fill in accordance with the definition outlined in AS 3798 and is therefore not suitable to support permanent structures such as pavements, slabs and buildings with shallow footings.
- Fill containing foreign inclusion (eg rubbish and building waste from Site Feature G) or chemical contaminants are not considered suitable for reuse without treatment or remedial works.
- The underlying natural clayey soil and siltstone are generally considered suitable for reuse as structural fill provided the fill is well graded with maximum particle size of not greater than 75mm.

7.1.2 Bulk Excavation and Vibration Issues

We understand that the proposed school building will have a basement level and construction of basement will require excavation up to 3m deep in the majority of the site with deeper excavation up to 6m on the south eastern corner. Our borehole investigation revealed the site to be generally underlain by topsoil overlying very stiff to hard natural Silty Clay with shale/siltstone bedrock at depths ranging from 0.9m to 3.0m, therefore construction of basement will require rock excavation.

Rock excavation would need to consider use of dozer (eg D9 or D10) and hydraulic rock breakers. Cored borehole investigation to assess rock quality may be carried out to assess excavatibility of the bedrock.

Depending on the staging for the proposed development, rock excavation may require vibration monitoring to minimise risk of damage to surrounding structures and this should be undertaken by specialist vibration engineer/scientist.

7.1.3 Shoring and Retaining Structures

Site excavation will not require shoring if;

- The excavation is situated at least 1.5 times the depth of excavation away from building structures or services present at time of construction.
- The excavation is adequately battered to the recommended batter slopes outlined in Section 7.1.5

If shoring is required, a soldier pier wall system may be adopted and this system will involve drilling of bored or CFA piles at regular spaced intervals to form a line of soldier piles and shotcreting of the area between the soldier piles after each excavation stage. For soldier pile system, shotcrete infill should be reinforced and designed to span laterally between the soldiers. It should cover the full height of the exposed excavation face to minimise the risk of potential problems associated with degradation and weathering of the face.

For excavation situated within the zone of influence of buildings or structures, a rigid wall system such as a contiguous pile wall arrangement should be adopted in order to prevent potential undermining of existing footings causing damage. Construction of the contiguous pile wall would involve drilling a continuous line of bored or continuous flight auger (CFA) piles along the length of the excavation to form a concrete wall.

Soldier piles and contiguous piles should be taken down to the full height of the excavation and should be socketed a minimum of 0.5m below proposed excavation level (including footing excavations) and into shale/siltstone or to adequate depths of embedment into hard clay to provide toe restraint.

Shoring wall may be temporarily restrained by internal bracing or anchors. If rock anchors are adopted, the anchors should be inclined through the soil profile and into the bedrock. For preliminary design, an allowable bond stress between anchor grout zone and shale of 100kPa may be adopted. Anchors should be de-stressed once permanent lateral support is provided for the retaining wall.

Low shoring walls (ie less than 3m) may be designed as a cantilever system for the short term before building floor slabs are constructed to provide permanent restraints.

For retaining wall which will be propped by floor slabs or fixed at the top, thus limiting deflection, an "at-rest" lateral earth pressure coefficient (K_o) should be adopted. For other retaining walls designed as "cantilevered" or gravity walls, an "active" lateral earth pressure coefficient (K_a) may be adopted. For toe resistance, an active lateral pressure coefficient (K_p) may be adopted. We recommend the following design parameters be adopted in preliminary design;

Material	**Bulk Density (kN/m^3)**	**K_a**	**K_o**	**K_p**	**Effective Cohesion, C' (kPa)**	**Effective Friction Angle (deg)**
Compacted Fill	17.5	0.35	0.65	-	2	20
Natural clay	19.0 to 20.0	0.30	0.5	2.0	5	20
Shale/Siltstone	22.0	0.2	0.3	2.5	10	25

Permanent subsurface drains should be provided at the back of the retaining wall, or half hydrostatic ground water pressures should be taken into account in the design. Surcharge due to adjacent structures, construction loads and sloping backfill should be taken into account in the design

7.1.4 Footings

We understand that the proposed school buildings will be 4-5 storeys high with a basement level requiring excavation up to 6m deep.

Our borehole investigation revealed the site to be generally underlain by topsoil overlying very stiff to hard natural Silty Clay with shale/siltstone bedrock at depths ranging from 0.9m to 3.0m below existing ground surface.

Based on the results of the investigation, our recommendations on allowable bearing capacity and founding depths of footings are as follows;

Minimum Founding Depths	Foundation Material	Allowable Bearing Capacities	Allowable Shaft Adhesions *1
1.0m below surface	Natural Very Stiff Clay	150kPa	-
2.5m below surface and 0.5m into natural clay	Natural Very Stiff Clay	250kPa	15kPa
3.0m below surface and 0.5m into Shale/Siltstone	Weathered Shale/Siltstone	600kPa	50kPa

Note: *1 Shaft adhesion is only applicable for deep pier footings and should ignore the upper 1.0m of the pier to allow for ground disturbance and weathering

All footings should be taken through topsoil and fill and founded on natural clay or siltstone. For deep pier footings, bored piles, grout injected piles or Continuous Flight Auger (CFA) piles may be considered suitable. Bored piles may be considered suitable if the piles are above the groundwater and should this pile system be adopted, some trial piles should be carried out to further assess the groundwater conditions. Adoption of bored pile system should allow for additional costs associated with concreting by “Tremie” methods and use of temporary liners,

Care should be taken to ensure the footings are cleaned of loose or remoulded debris prior to concreting. Footing construction should be supervised and monitored by a suitably qualified geotechnical engineer in order to confirm the above design parameters.

The proposed footings should be designed to accommodate reactive soil proportioned to a Class ‘H1’ (Highly Reactive) site in accordance to AS2870 “Residential Slabs and Footings”.

7.1.5 Batter Slopes

For all unretained cut and fill, the following batter slopes may be adopted for preliminary design;

Material	Temporary	Permanent
Fill and topsoil (Landscape)	1V : 1.5H	1V : 3H
Natural Clay	1V: 1H	1V : 2H
Weathered Shale/Siltstone	1V : 0.5 to 1H	1V : 1H

Steeper batter slopes may be adopted for shale batters subject to inspection and further assessment by an experienced and qualified geotechnical engineer during excavation works

7.1.6 Pavement Design

Pavement subgrade preparation for access roads and car parks should include the following;

- Stripping of the topsoil and any "uncontrolled" fill to expose natural clay.
- Boxing of pavement subgrade to proposed design level.
- Proof rolling of the base of the excavation with a heavy vibrating roller (minimum 10 tonne).
- Any soft areas identified during rolling should be further excavated and replaced with ripped sandstone fill.
- The excavated clay material may be reused as filling beneath pavements subject to moisture reconditioning. Alternatively, imported good quality fill such as ripped sandstone having a maximum particle size of 75mm may be used.
- The fill material should be compacted in layers not exceeding 250mm loose thickness compacted to a minimum 98% Standard Maximum Dry Density (SMDD) at close to Optimum Moisture Content.
- The upper 300mm of the fill material forming the pavement subgrade should be compacted to a minimum 100% SMDD.

The subgrade preparation and pavement construction should be closely monitored by a geotechnical consultant and should include field density testing of the pavement material at an appropriate frequency and level of supervision as detailed in AS 3798 -2007.

Our laboratory test results indicate the pavement subgrade to have low CBR values ranging from 2.5% to 3.0%. For preliminary pavement design, we recommend a design CBR value of 3.0% be adopted. Confirmation of CBR value may be carried out after exposing to subgrade level.

Note that based on APRG, pavement subgrade with CBR less 3% will require stabilisation of the upper 150mm of the subgrade with lime. Trial lime mix should be carried out to achieve the desired CBR values.

Alternatively, the upper 150mm of the subgrade may be replaced with a select granular fill such as ripped sandstone having a maximum particle size of 75mm with a minimum CBR value of 15%.

In the absence of design traffic loading for the proposed roads, the following pavement design options may be adopted based on assumed design traffic loadings (ie Equivalent Standard Axle (ESA);

Material	**Assumed ESA**		
	5×10^4	**2×10^5**	**5×10^5**
Asphaltic Concrete (AC10)	40mm	40mm	40mm
2 Coat Flush Seal	-	-	-
DGB20 Base Course	150mm	150mm	150mm
Crushed Sandstone Subbase Course	250mm	310mm	340mm
Total	**440mm**	**500mm**	**530mm**

The final pavement thickness design should be carried out based on Austroads publication, “Pavement Design – A Guide to the Structural Design of Road Pavements”, and Austroads Pavement Research Group publication, Report No 21, “A Guide to the Design of New Pavements for Light Traffic”.

The pavement design assumes the subgrade and pavement materials to be compacted to the following Minimum Dry Density Ratios (AS1289 5.1.1, 5.2.1);

Pavement Material	**Compaction Level**	**Compactive Effort**
Base Course	98%	Modified
Sub-Base Course	98%	Modified

7.2 Salinity Issues

We understand that the proposed development may include cut and fill to regrade the site to design level for the proposed school building and roadways and excavation works for the proposed basements. The laboratory test results indicate the following;

- The topsoil was assessed to be Non Saline with EC values ranging from 0.45 to 1.8 dS/m.

- The natural soil in the upper 1m was generally assessed to be Non to Slightly Saline with EC values ranging from 0.41 to 2.66 dS/m, except in BH 41 where Moderately Saline soil (ie 4.34 dS/m) was encountered.

- The natural soil below 1m was generally assessed to be Slightly Saline to Moderately Saline with EC values ranging from 1.04 to 5.52 dS/m. Some Non Saline soil (ie 1.60 dS/m) was encountered below 1m in BH 17.

Based on the Emerson and the Exchangeable Sodium Percentage (ESP) test results, the insitu soil was found to be generally Highly to Very Highly Dispersive and Sodic to Very Sodic.

The subsurface soil was found to have low concentrations of Sulphate and a minimum pH value of 4.8 and therefore the soil is considered to be Mildly aggressive to buried concrete structures and therefore the site may be classified as "Class A2" in accordance to AS 3600-2018 "Concrete" (Reference 8).

The subsurface soil was found to have low concentrations of Chloride and with a minimum pH value of 4.8 and the lowest resistivity of 1700 ohms/cm, the site was assessed to be Mildly aggressive to buried steel structures based on AS 2159 (Reference 7).

For the proposed development, the following are our suggested management strategies;

- The non to slightly saline soil may be reuse on site or taken off-site for reuse on other sites. If moderately saline soil is to be excavated, it should where practical be placed at lower depths in the proposed fill areas and capped with a minimum 1.0m deep of non to slightly saline material on top.
- All excavation works into the moderately saline soil should be minimised by staging the construction into small areas to prevent salinity from developing.

- Appropriate batter slopes for excavations should be adopted to prevent erosion and scouring. Under good drainage conditions, the following batter slopes or less may be adopted;

Material	Recommended Minimum Batter Slopes
Compacted Fill	3 Horizontal : 1 Vertical
Very stiff residual clay	2 Horizontal : 1 Vertical
Weathered Shale	1 Horizontal : 1 Vertical

- Any site regrading should be planned to reduce cutting and filling and the earthworks undertaken in stages to alleviate erosion and localised instability problem. To minimise the effects of erosion, all batters, whether in cut or fill should be stabilised by planting (or the application of a sprayed-on mulch) with appropriate species of vegetation as soon as practical after construction.
- The site should be regularly inspected for rills, erosion and scouring of slopes as the insitu soil was generally assessed to be very dispersive. In areas with notable ground instability, the upper 300mm of the ground surface should be treated by stabilising lime or covering the area with good quality stable fill such as ripped sandstone.
- Trenching for underground services should be carried out in a manner such that there is minimal rotation and vertical displacement of the original soil profile.
- All proposed imported fill should be verified by sampling and testing to ensure the material is non to slightly saline. Importation of Moderately saline soil is not recommended. Highly saline soil is not considered acceptable.
- Adequate revegetation of the site should be carried out and this may involve treatment of topsoil material and planting appropriate plant species which are salt-tolerant.
- Adequate surface and subsurface drainages should be provided to prevent water logging, tunnelling, scouring and erosion caused by sodic soil.
- Reference should be made to the AS 2159 and AS3600 guidelines (Reference 7 and 8) for recommendations on durability protection of buried concrete and steel structures

8. LIMITATIONS

The interpretation and recommendations submitted in this report are based in part upon data obtained from a limited number of boreholes. There is no investigation which is thorough enough to determine all site conditions and anomalies, no matter how comprehensive the investigation program is as site data is derived from extrapolation of limited test locations. The nature and extent of variations between test locations may not become evident until construction.

Groundwater conditions are only briefly examined in this investigation. The groundwater conditions may vary seasonally or as a consequence of construction activities on or adjacent to the site.

In view of the above, the subsurface soil and rock conditions between the test locations may be found to be different or interpreted to be different from those expected. If such differences appear to exist, we recommend that this office be contacted without delay.

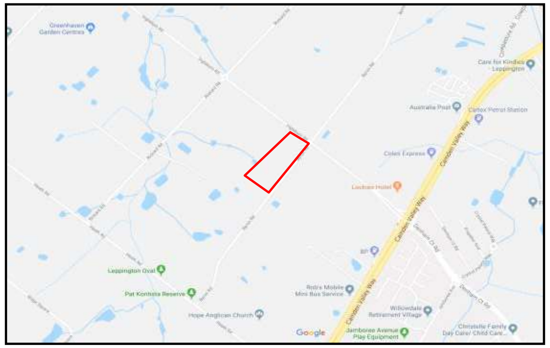
The statements presented in this document are intended to advise you of what should be your realistic expectations of this report and to present you with recommendations on how to minimise the risk associated with groundworks for this project. The document is not intended to reduce the level of responsibility accepted by GeoEnviro Consultancy Pty Ltd, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in to doing.

Your attention is drawn to the attached "Explanatory Notes" in Appendix D and this document should be read in conjunction with our report.

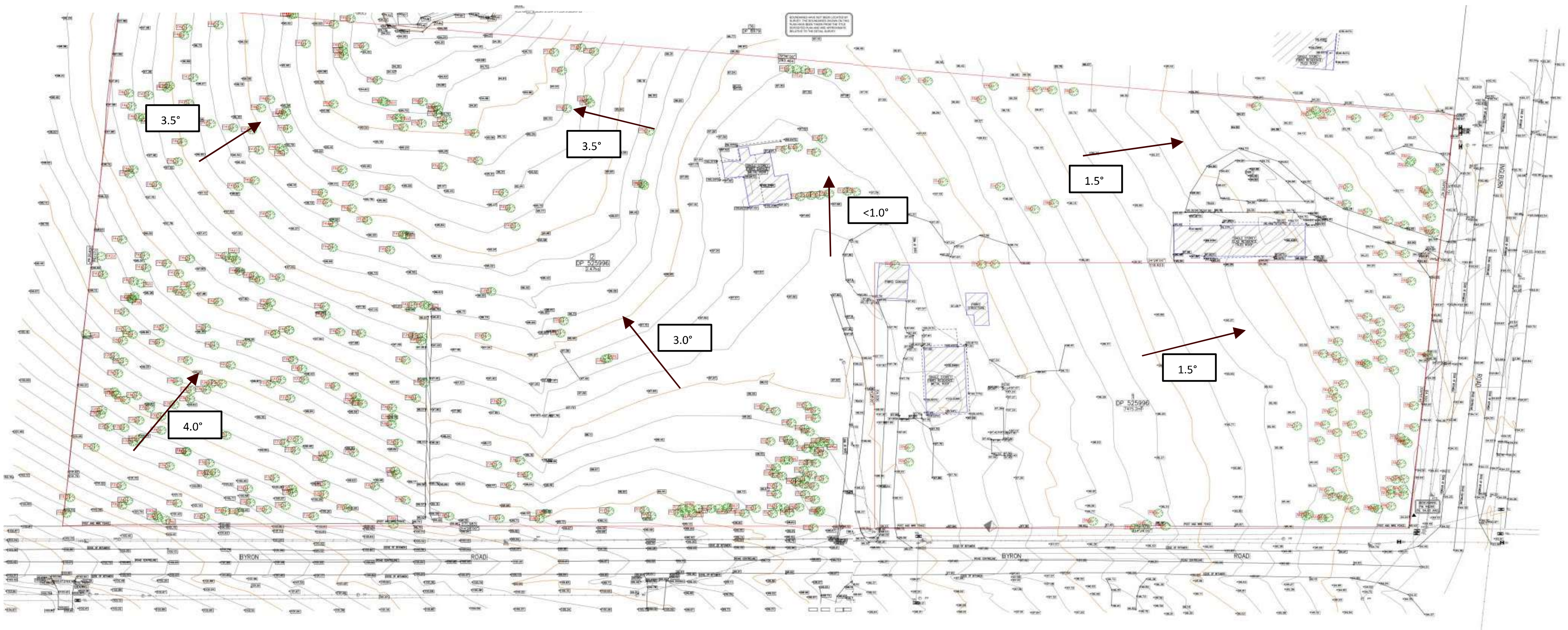
C:\\18JOB\322\A\JC18322A-r2(rev2)
17/4/2019 12:39 PM

REFERENCES

1. *Stage 1 and 2 Contamination Assessment – Proposed New Amity College Campus – Lot a DP 525996 No 85 Byron Road and Lot 2 DP 525996 No 63 Ingleburn Road Leppington – Geoenviro Consultancy Pty Ltd report referenced JC18322A-r1(rev2) dated May 2019*
2. *1:100,000 Soil Landscape Map of Penrith – Soil Conservation Service of NSW; Sheet 9030 - 1989*
3. *1:100,000 Geological Map of Penrith– Geological Series Sheet 9030 (Edition 1) 1991*
4. *Department of Land and Water Conservation – "Site Investigation for Urban Salinity".2002*
5. *Salinity Code of Practice – Western Sydney Regional Organisation of Councils Ltd – 2003 (Amended January 2004)*
6. *What do all the numbers mean? A guide for the interpretation of soil test results. – Department of Conservation and Land Management, 1992*
7. *Australian Standard, AS 2159-2009 "Piling – Design and Installation"*
8. *Australian Standard, AS 3600 -2018 "Concrete"*
9. *Australian Standard, AS 3798 – 2007 "Bulk Earthworks for Commercial and Residential Site"*
10. *Australian Standard, AS 2870- 2011 "Residential Slabs and Footings"*
11. *Australian Standard AS1726:2017 . "Geotechnical Site Investigations".*
12. *Acid Sulfate Soil Manual – NSW Acid Sulfate Soil Management Advisory Committee August 1998*
13. *Australian Standard AS 4678-2002 . "Earth- retaining Structures".*



Site Locality



Legend

Subject Site

7.0° Slope Angle

GeoEnviro Consultancy Unit 5, 39-41 Fourth Avenue, Blacktown NSW 2148, Australia Tel: (02) 96798733 Fax: (02) 96798744	Drawn By: AT	Date: 1/4/19		Gran Associates Pty Ltd 85 Byron Road and 63 Ingleburn Road Leppington Site Locality and Survey Plan	
	Checked By: SL	Date: 1/4/19			
	Revision By:	Date:			
	Scale: Not to Scale		A3	Project No: JC18322A	Drawing No:1

Site Feature	Description
A	Driveway constructed of crushed rock.
B	Single-storey brick, weatherboard and tile dwelling with a metal garage to the rear.
C	Single-storey fibro/metal dwelling with a number of small metal, timber and fibro sheds to the west. Sheds used for storage of miscelaneous items. Some minor hydrocarbon staining visible on surface
D	Driveway constructed of crushed rock, sandstone and traces of building debris (eg bricks and asphalt lumps)
E	Metal, timber and fibro shed with building extensions.
F	Area of previous numerous small buildings and sheds. Previous market garden area (1950s)
G	Backfilled depression with rubbish fill consisting of concrete boulders, bricks, glass and asbestos fragments
H	Recent Market Garden beds
I	Previous market garden/agricultural area

Note: The extent site features are only indicative

Legend

A — Site Feature

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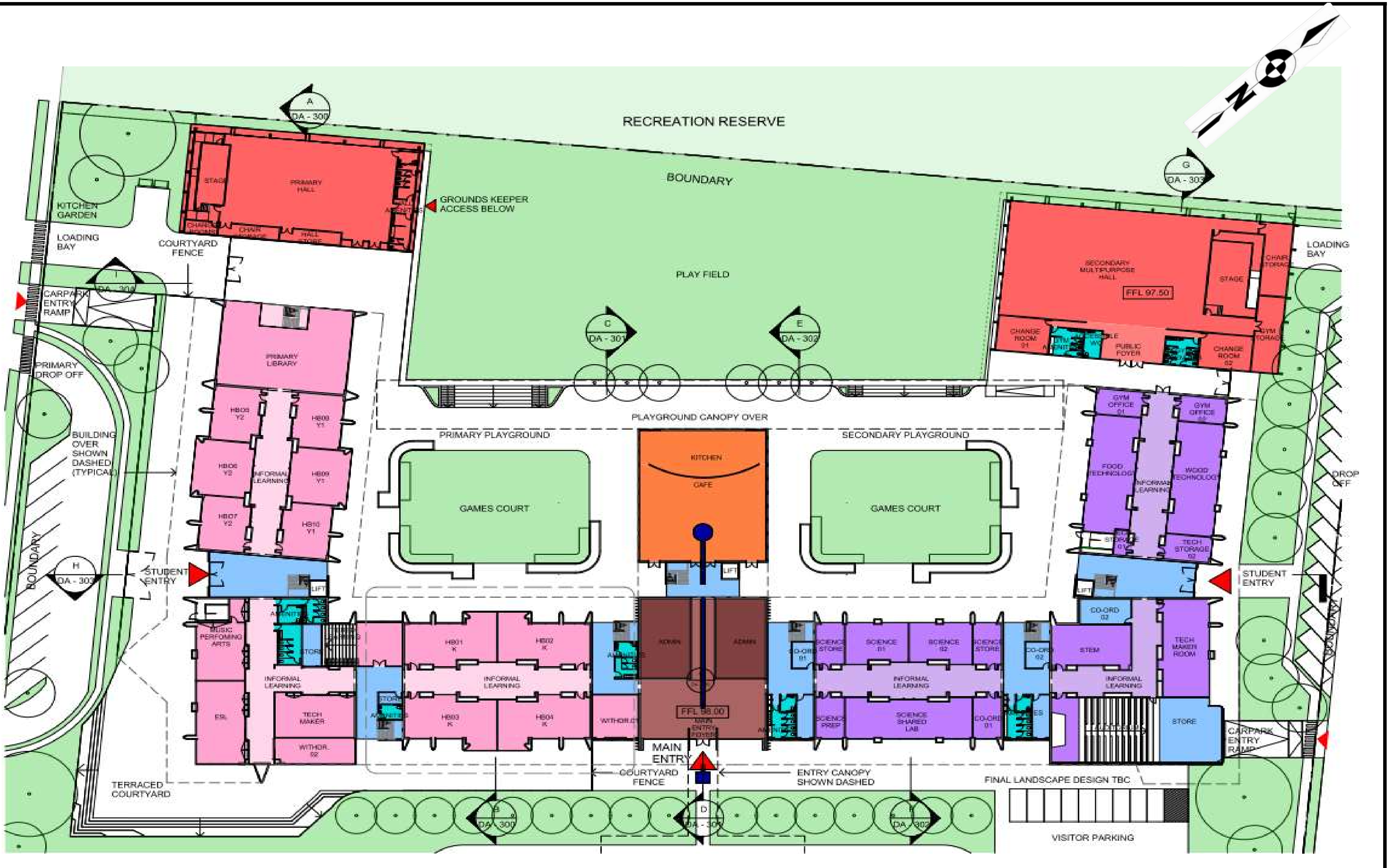
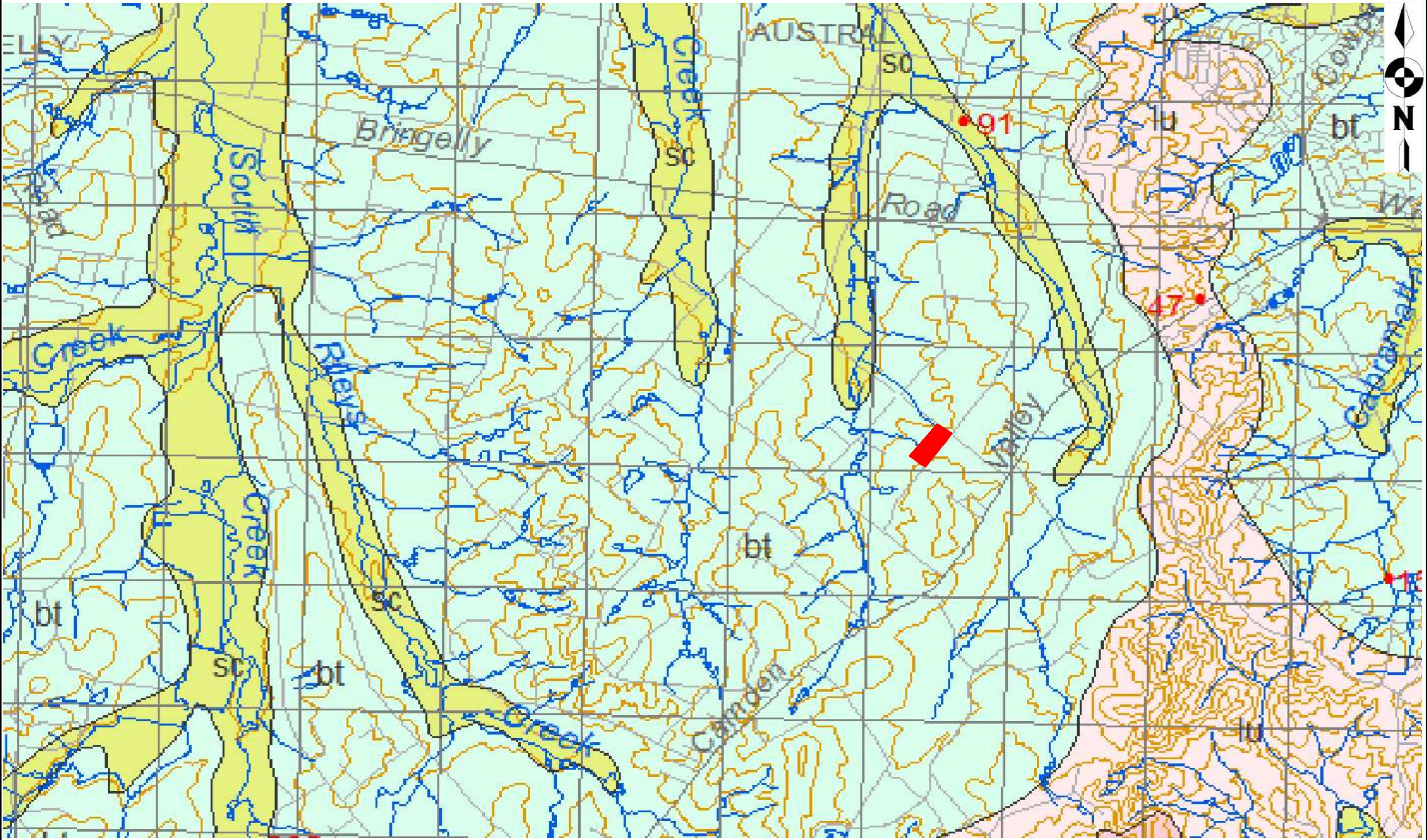
Checked By: SL	Date: 6/6/18	
Revision By:	Date:	
Scale: Not to Scale	A3	Project No: JC18322A — Drawing No: 2



GeoEnviro Consultancy Unit 5, 39-41 Fourth Avenue, Blacktown NSW 2148, Australia Tel: (02) 96798733 Fax: (02) 96798744	Drawn By: AT	Date: 1/4/19	Gran Associates Pty Ltd	
	Checked By: SL	Date: 1/4/19	85 Byron Road and 63 Ingleburn Road Leppington	
	Revision By:	Date:	Proposed Development Plan	
	Scale: Not to Scale	A3	Project No: JC18322A	Drawing No: 3



Legend

(red)	Subject Site
bt	Blacktown Landscape Group
sc	South Creek Landscape Group
lu	Luddenham Landscape Group

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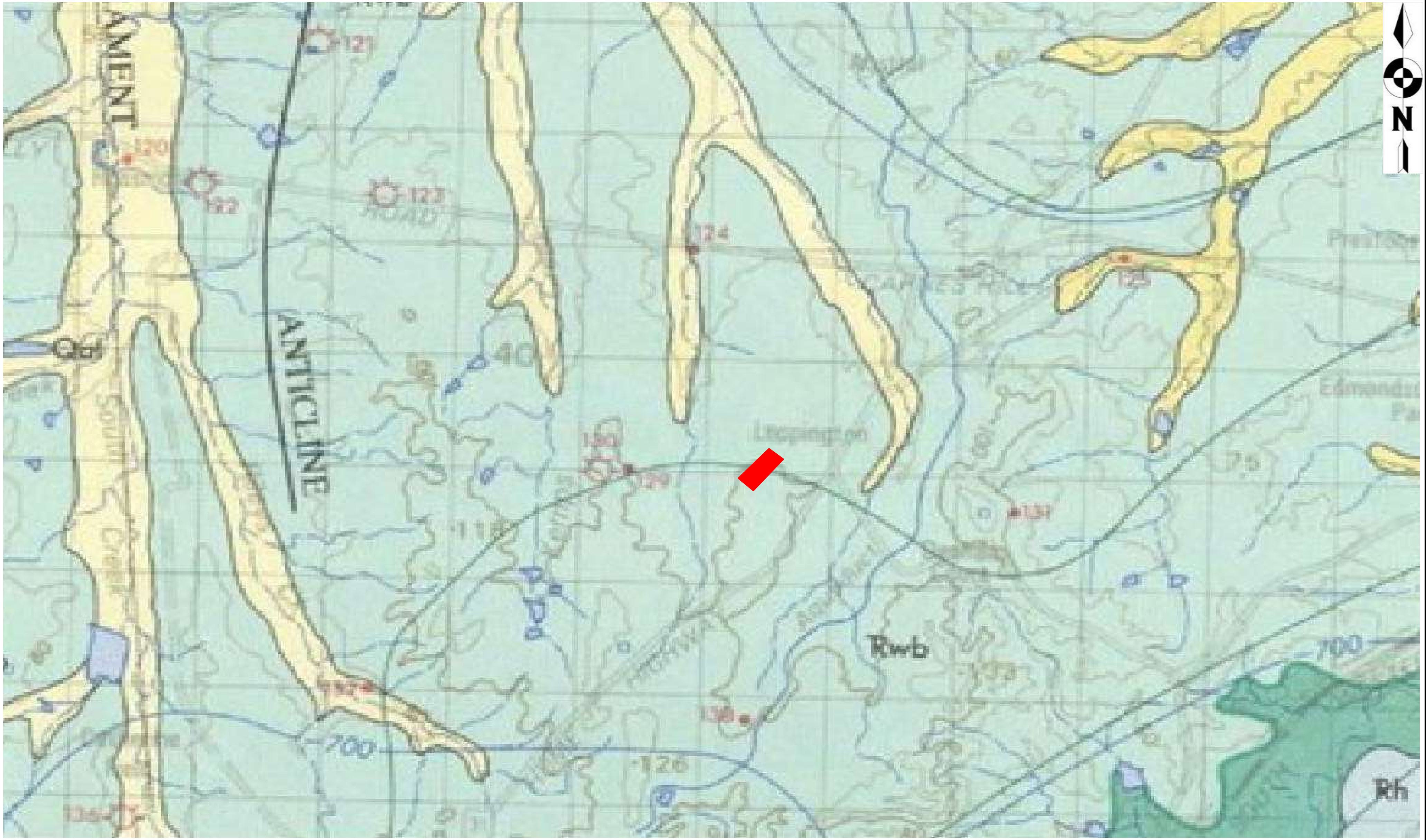
Gran Associates Pty Ltd
85 Byron Road and 63 Ingleburn Road Leppington
Soil Landscape Group Map

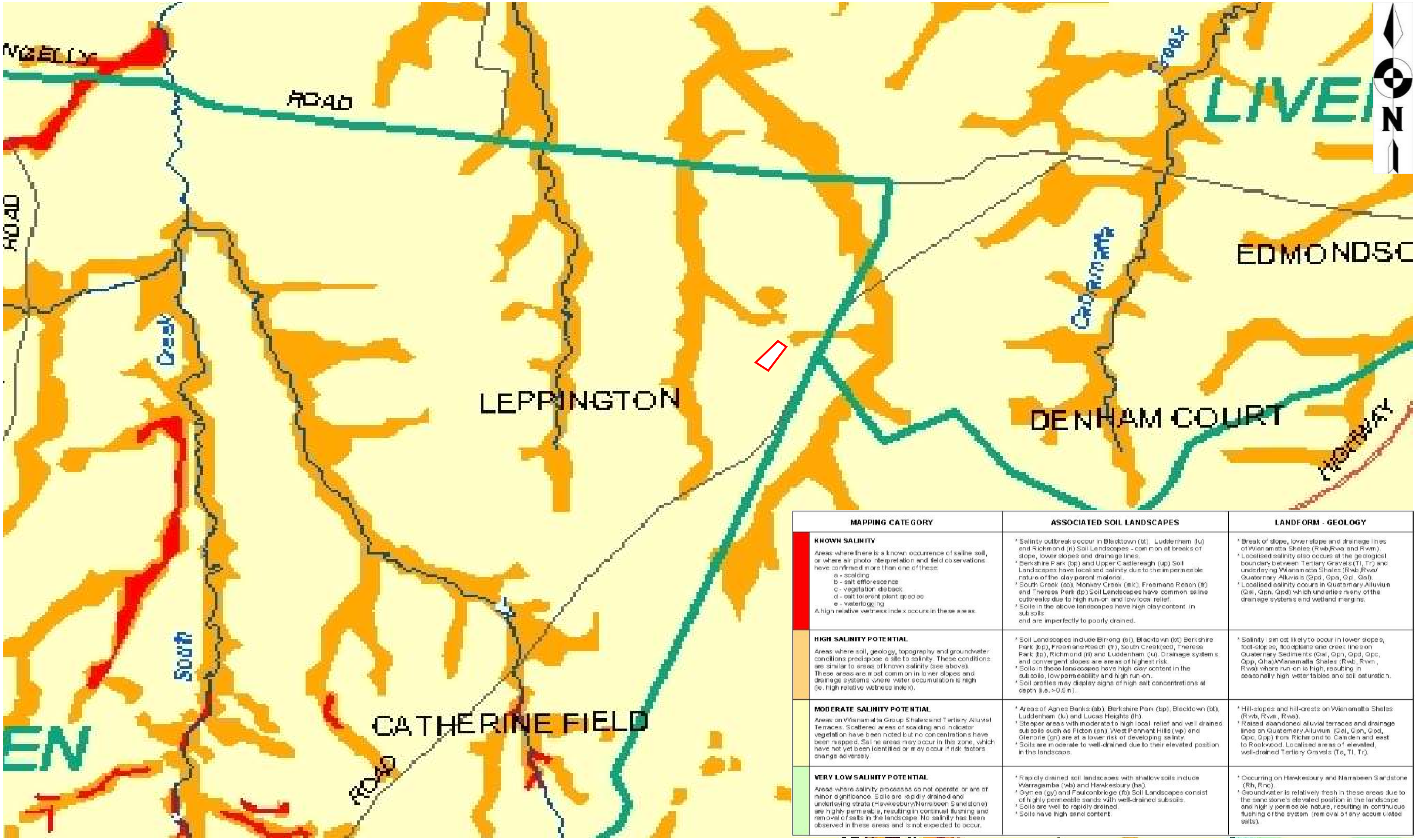
Project No: JC18322A | **Drawing No: 4**



Legend

- Subject Site
- Bringelly Shale (Rwb)
- Fluvial Deposit (Qal)

GeoEnviro Consultancy Unit 5, 39-41 Fourth Avenue, Blacktown NSW 2148, Australia Tel: (02) 96798733 Fax: (02) 96798744	Drawn By: AT	Date: 1/4/19	Gran Associates Pty Ltd 85 Byron Road and 63 Ingleburn Road Leppington Geological Unit Map	
	Checked By: SL	Date: 1/4/19		
	Revision By:	Date:		
	Scale: Not to Scale	A3	Project No: JC18322A	Drawing No: 5



	MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY
(red)	**KNOWN SALINITY** Areas where there is a known occurrence of saline soil, or where air photo interpretation and field observations have confirmed more than one of these: a - scalding b - salt efflorescence c - vegetation die back d - salt tolerant plant species e - waterlogging A high relative wetness index occurs in these areas.	* Salinity outbreaks occur in Blacktown (bt), Luddenham (lu) and Richmond (ri) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines. * Berkshire Park (bp) and Upper Castlereagh (up) Soil Landscapes have localised salinity due to the impermeable nature of the clay parent material. * South Creek (sc), Monkey Creek (mk), Freemans Reach (fr) and Theresa Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and low local relief. * Soils in the above landscapes have high clay content in subsoils and are imperfectly to poorly drained.	* Break of slope, lower slope and drainage lines of Wianamatta Shales (Rwb,Rwa and Rwm). * Localised salinity also occurs at the geological boundary between Tertiary Gravels (Tl, Tr) and underlaying Wianamatta Shales (Rwb,Rwa/ Quaternary Alluvials (Qpd, Qpa, Qpl, Qal). * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn. Qpd) which underlies many of the drainage systems and wetland margins.
(orange)	**HIGH SALINITY POTENTIAL** Areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to areas of known salinity (see above). These areas are most common in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index).	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek(sc0, Theresa Park (tp), Richmond (ri) and Luddenham (lu). Drainage systems and convergent slopes are areas of highest risk. * Soils in these landscapes have high clay content in the subsoils, low permeability and high run-on. * Soil profiles may display signs of high salt concentrations at depth (i.e. >0.5m).	* Salinity is most likely to occur in lower slopes, foot-slopes, floodplains and creek lines on Quaternary Sediments (Qal, Qpn, Qpd, Qpc, Qpp, Qha)/Wianamatta Shales (Rwb, Rwm, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation.
(yellow)	**MODERATE SALINITY POTENTIAL** Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt), Luddenham (lu) and Lucas Heights (lh). * Steeper areas with moderate to high local relief and well drained subsoils such as Picton (pn), West Pennant Hills (wp) and Glenorie (gn) are at a lower risk of developing salinty. * Soils are moderate to well-drained due to their elevated position in the landscape.	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwm, Rwa). * Raised abandoned alluvial terraces and drainage lines on Quaternary Alluvium (Qal, Qpn, Qpd, Qpc, Qpp) from Richmond to Camden and east to Rookwood. Localised areas of elevated, well-drained Tertiary Gravels (Ta, Tl, Tr).
(green)	**VERY LOW SALINITY POTENTIAL** Areas where salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlaying strata (Hawkesbury/Narrabeen Sandstone) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been observed in these areas and is not expected to occur.	* Rapidly drained soil landscapes with shallow soils include Warragamba (wb) and Hawkesbury (ha). * Gymea (gy) and Faulconbridge (fb) Soil Landscapes consist of highly permeable sands with well-drained subsoils. * Soils are well to rapidly drained. * Soils have high sand content.	* Occurring on Hawkesbury and Narrabeen Sandstone (Rh, Rno). * Groundwater is relatively fresh in these areas due to the sandstone's elevated position in the landscape and highly permeable nature, resulting in continuous flushing of the system (removal of any accumulated salts).

Legend

Subject Site

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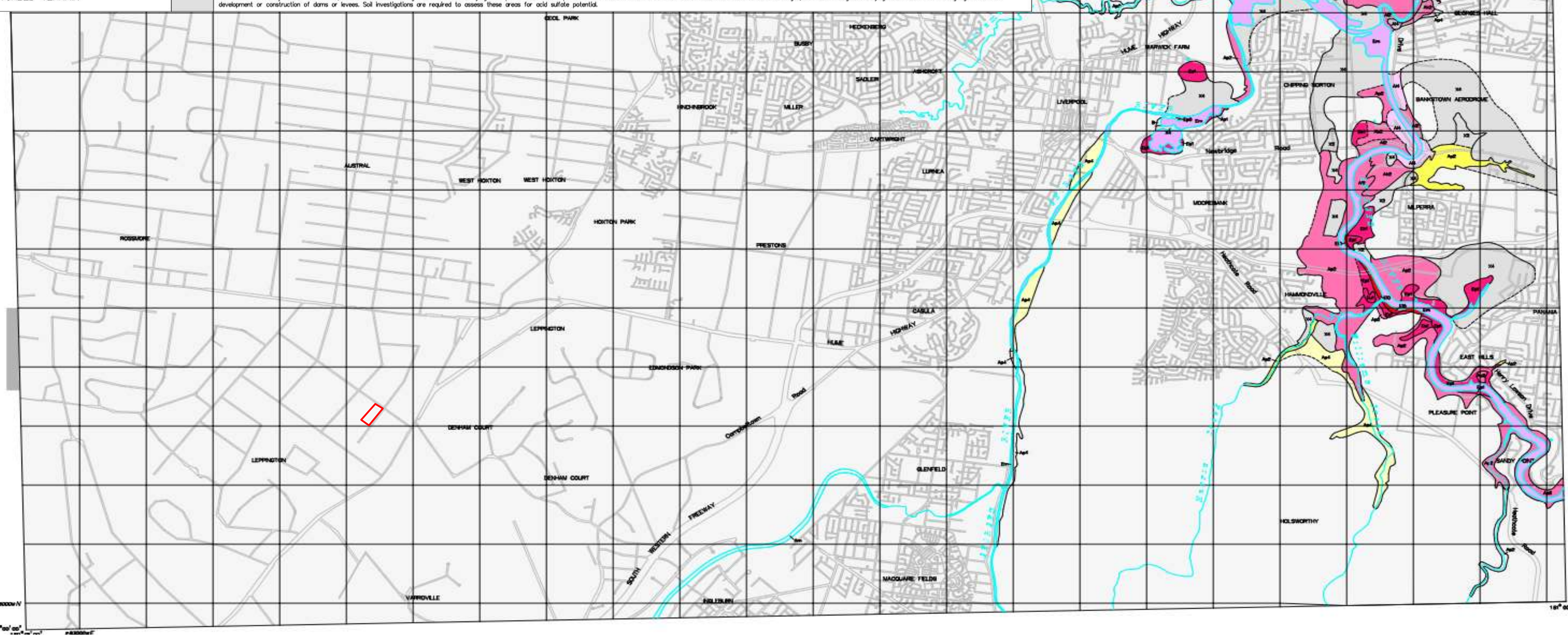
Revision By:	Date:		
Scale: Not to Scale		A3	

Gran Associates Pty Ltd
85 Byron Road and 63 Ingleburn Road Leppington
Soil Salinity Map

Project No: JC18322A **Drawing No: 6**

Map Class Description	Depth to Acid Sulfate Soil Materials		Environmental Risk	Typical Landform Types
HIGH PROBABILITY High probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	Severe environmental risk if bottom sediments are disturbed by activities such as dredging.	Bottom sediments of lakes, lagoons, tidal creeks, rivers and estuaries.
		At or near the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Estuarine swamps, intertidal flats and supratidal flats.
		Within 1 metre of the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Low alluvial plains, estuarine sandplains, estuarine swamps, backswamps and supratidal flats.
		Between 1 and 3 metres below the ground surface.	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavation for pipelines, dams or deep drains.	Alluvial plains, alluvial swamps, alluvial levees and sandplains.
		Greater than 3 metres below the ground surface.*	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavations, —e.g., large structure foundations or deep dams.	Elevated levees and sandplains, alluvial plains and alluvial swamps in estuarine reaches of catchments.
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	The majority of these landforms are not expected to contain acid sulfate soil materials. Therefore, land management is generally not affected by acid sulfate soils. However, highly localised occurrences may be found, especially near boundaries with environments with a high probability of occurrence. Disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance.	Elevated alluvial plains and levees dominated by fluvial sediments. Plains and dunes dominated by aeolian soils. Pleistocene plains. Lacustrine and alluvial bottom sediments.
		At or near the ground surface.		
		Within 1 metre of the ground surface.		
		Between 1 and 3 metres below the ground surface.		
		Greater than 3 metres below the ground surface.*		
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.	Land management activities not likely to be affected by acid sulfate soil materials.	Bedrock slopes, elevated Pleistocene and Holocene dunes, and elevated alluvial plains.
DISTURBED TERRAIN		Disturbed terrain may include filled areas, which often occur during reclamation of low lying swamps for urban development. Other disturbed terrain includes areas which have been mined or dredged, or have undergone heavy ground disturbance through general urban development or construction of dams or levees. Soil investigations are required to assess these areas for acid sulfate potential.		



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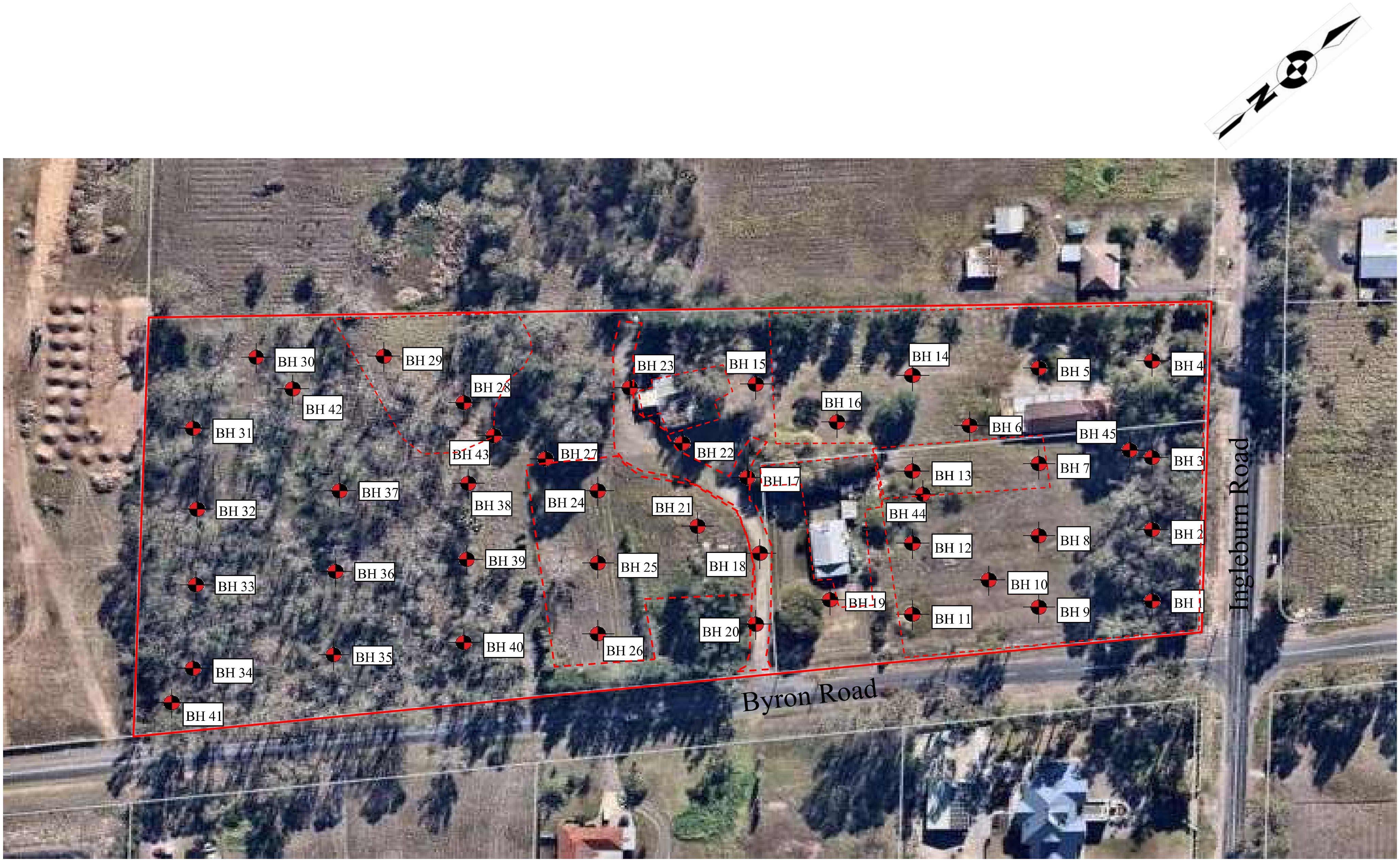
Gran Associates Pty Ltd

85 Byron Road and 63 Ingleburn Road Leppington

Acid Sulphate Soil Risk Map

Project No: JC18322A **Drawing No: 7**



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Borehole

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	Checked By: SL	Date: 15/4/19	
	Revision By:	Date:	
	Scale: Not to Scale	A3	Project No: JC18322A — Drawing No: 8

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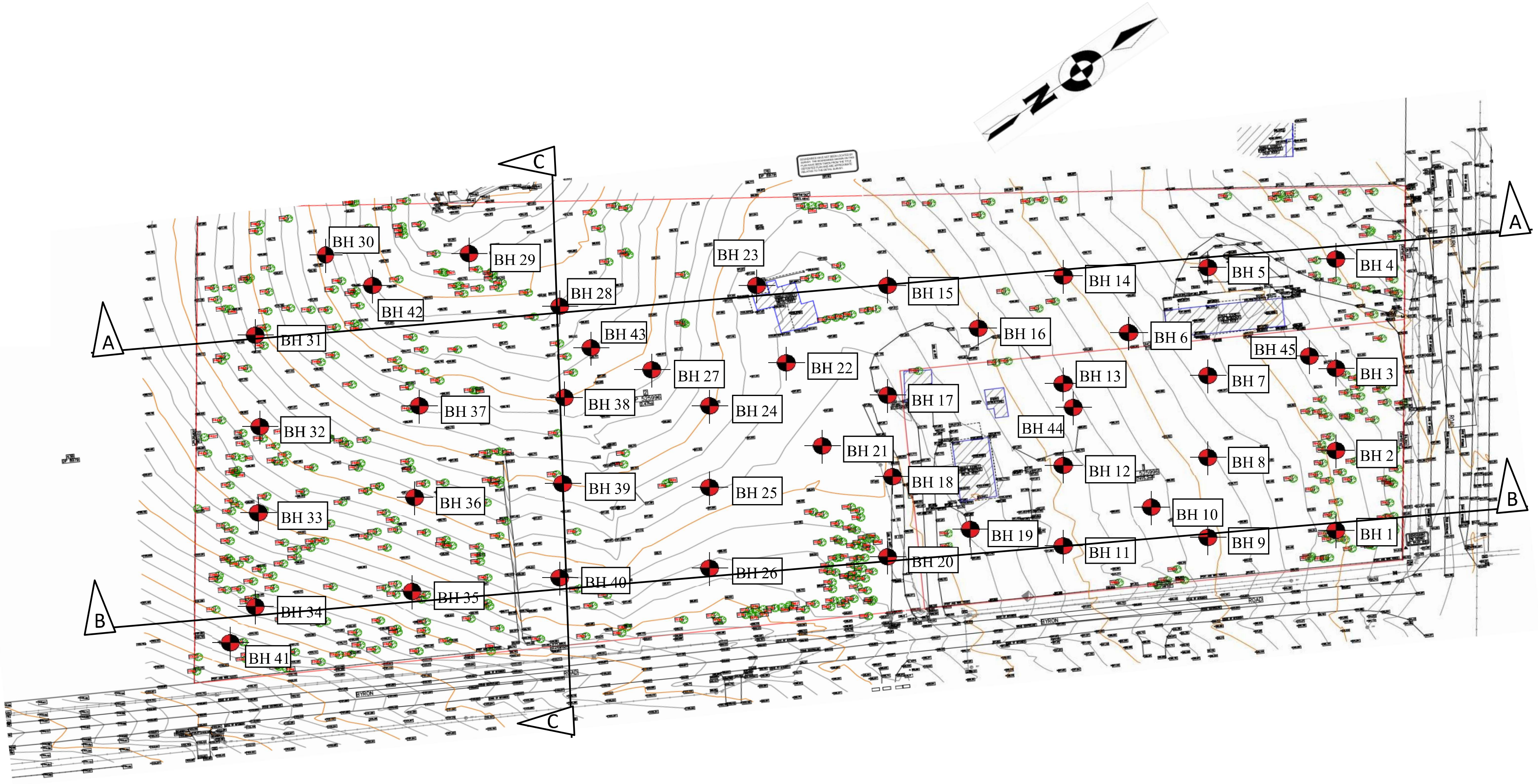
Form No. R012/Ver02/06/07



Note: Refer to Drawing Nos 10, 11 and 12 for soil/rock profiles of Sections A-A, B-B and C-C

Legend

Borehole

Section

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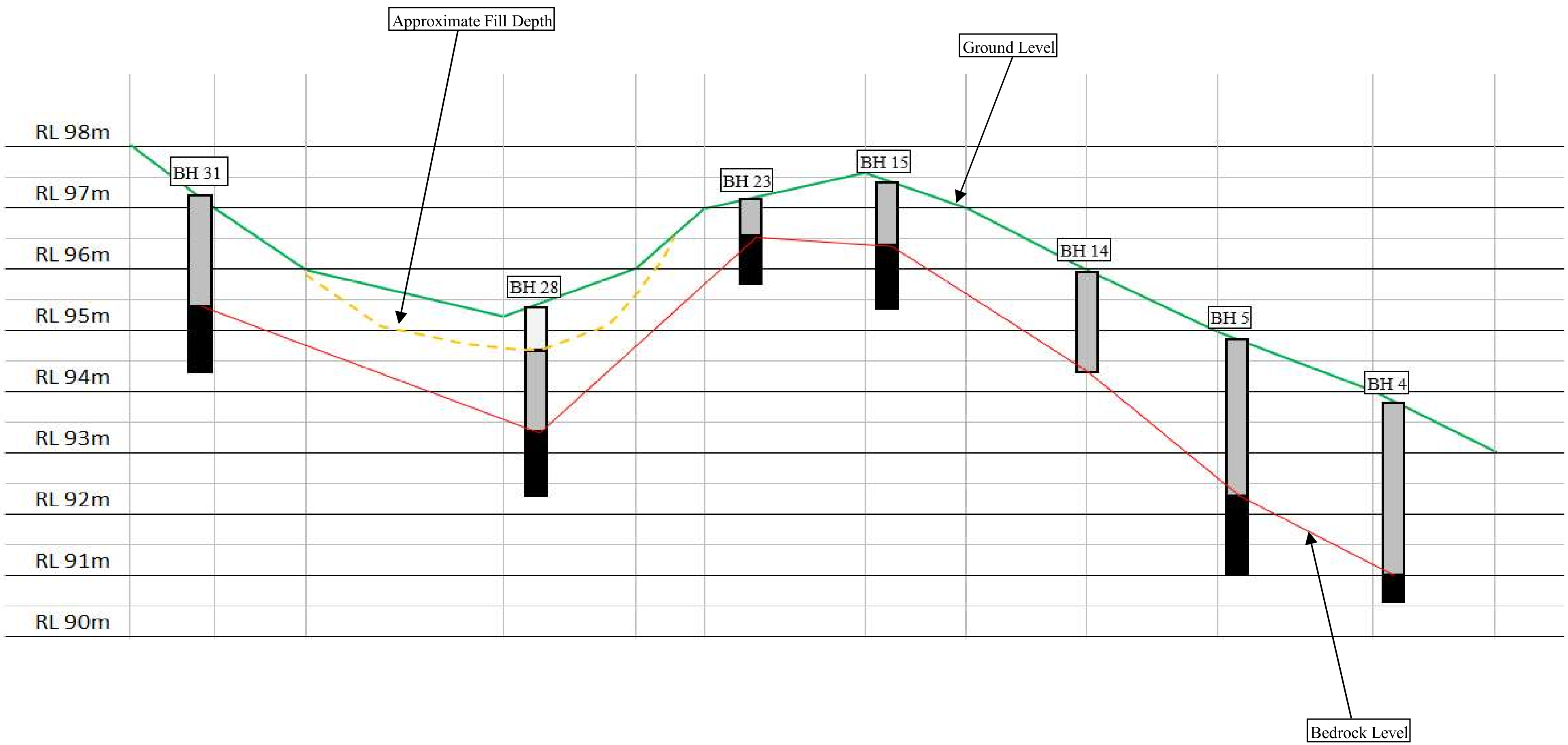
	Checked By: SL	Date: 5/3/19	
	Revision By:	Date:	
	Scale: Not to Scale	A3	Project No: JC18322A / Drawing No: 9



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☐	Fill
▒	Natural
■	Bedrock

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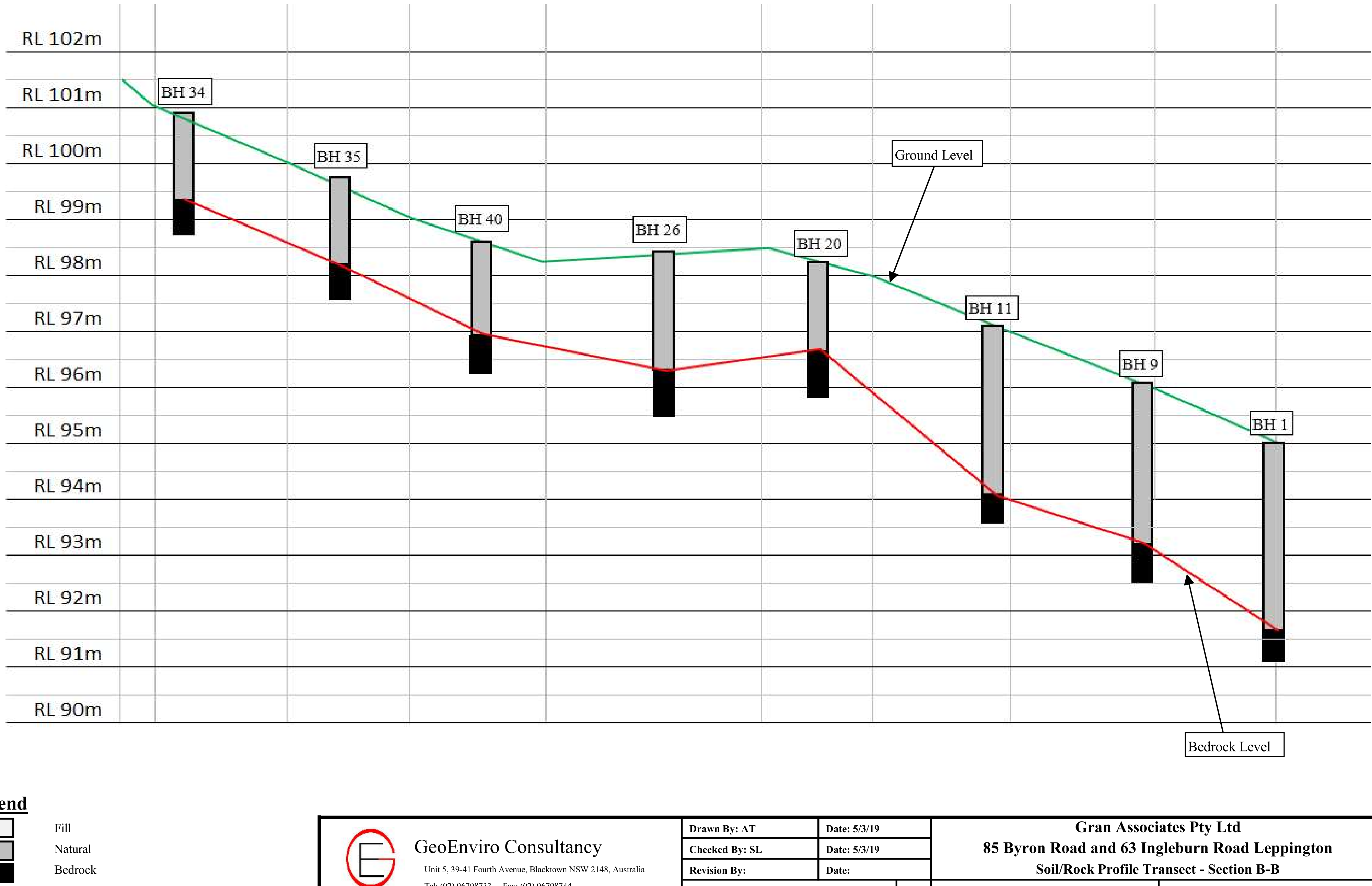
	Checked By: SL	Date: 5/3/19	
	Revision By:	Date:	
	Scale: Not to Scale	A3	**Project No: JC18322A** — **Drawing No: 10**



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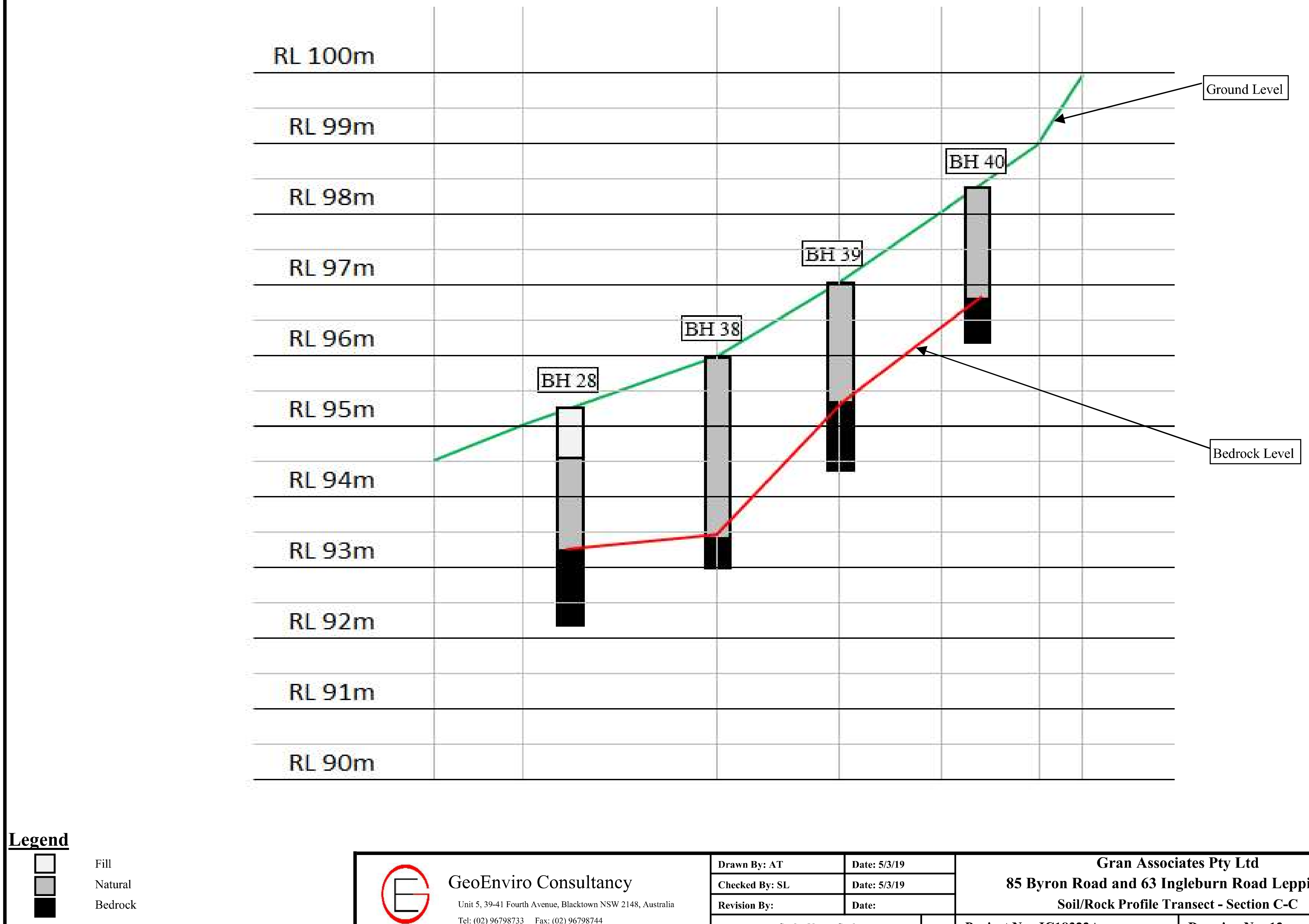
	Checked By: SL	Date: 5/3/19		
	Revision By:	Date:		
	Scale: Not to Scale	A3	Project No: JC18322A	Drawing No: 11



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Drawn By: AT	Date: 5/3/19	Gran Associates Pty Ltd 85 Byron Road and 63 Ingleburn Road Leppington Soil/Rock Profile Transect - Section C-C	
Checked By: SL	Date: 5/3/19		
Revision By:	Date:		
Scale: Not to Scale	A3	Project No: JC18322A	Drawing No: 12