APPENDIX D
LOCAL WATER MANAGEMENT PLAN

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Lot 1665 Wanneroo Road Sinagra

Local Water Management Strategy

Prepared for
Stockland
by Strategen

September 2019

strategen ENVIRONMENTAL

Lot 1665 Wanneroo Road Sinagra

Local Water Management Strategy

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September 2019

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Client: Stockland

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
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Draft Report	A	Client Review	JHunt / DNewsome	Electronic	14/4/2019
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Filename: STO18073.01 R002 Rev 2 - 25 September 2019

Executive Summary

The purpose of this Local Water Management Strategy (LWMS) is to define the strategy for water management at a local level for Lot 1665 Wanneroo Road Sinagra (the site) and to ensure that the site is capable of supporting the proposed land use.

The LWMS details the water management approach proposed for the development to support the Local Structure Plan (LSP). The LWMS has been developed in accordance with Better Urban Water Management (WAPC 2008). Water will be managed using a total water cycle management approach, which has been developed using philosophies and design approaches described in the Stormwater Management Manual for Western Australia (DoW 2007).

Since the 1960's the 40 ha site has been owned by Inghams Chickens until Stocklands bought the land from them. Stocklands plans to develop the site to accommodate approximately 700 homes and a primary school. The site is in the City of Wanneroo and is currently zoned urban deferred.

The site has sufficient public open space to manage the drainage requirements on site up to and including the 1% AEP event. A servicing report has identified that there will be sufficient water supply and wastewater servicing available and the site has sufficient groundwater license allocation to irrigate POS.

Based on the available geotechnical, hydrological and environmental information, this LWMS demonstrates that by following the recommendations detailed in the report the site is capable of being developed as proposed.

Table ES 1 below summarises how the water management principles and objectives for the site will be met.

Table ES 1: Compliance with water management principles and objectives

Category	Principles	Objectives	Methods for achievement
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target • mandate Water Efficiency Labelling and Standards rated water efficient products, water efficient irrigation, waterwise landscaping and rainwater storage tanks for individual green title lots.	• potable water use estimated at 66 kL/day through mandating water efficient fittings and appliances and reduced garden areas • irrigation volumes for POS and schools will be kept within the current licenced allocation volume • POS design will maximise retention of native bushland, include extensive rehabilitation and minimise the use of turf in POS where not required
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% AEP event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010). • adopt 'at source' stormwater management approach and consider reducing pit and pipe drainage system significantly. Treat polluted runoff by installing appropriate treatment systems where required. • Consider managing stormwater runoff by providing overland flowpaths and opportunities for infiltration of runoff on lots, road reserves and public open space where site conditions permit • Pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.	• Contain first 15mm of rainfall on lots and as high in the catchment as possible. • control of groundwater levels on the site is not proposed and thus impacts on groundwater regimes will be limited. • maintain pre-development flows off the site through detention and retention on site, while minimising land take for drainage to improve public amenity. • No identified predevelopment flow from the site due to high infiltration rates. Small post development flow from the site due to design constraint of road network.
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality • retain and/or detain and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.	• use of biofiltration areas • minimisation of turf areas and POS fertiliser use to reduce nutrient discharge to the environment • investigation and redevelopment of Brand Road landfill to manage and mitigate potential impacts to groundwater.

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1. Introduction

1.1 Project overview

Stockland Development Pty Ltd (Stockland) proposes to develop Lot 1665, Wanneroo Rd, Sinagra (the site; Figure 1), located in the City of Wanneroo, for residential purposes. The proposed Structure Plan is provided in Figure 2 and shows:

- residential land uses
- areas of Public Open Space (POS) and drainage
- a primary school
- internal road network.

The site is approximately 40 ha and is located in the East Wanneroo Cell 2 Structure Plan. The site is currently zoned Urban Deferred under the Metropolitan Region Scheme (MRS) and Urban Development under the Wanneroo Local Planning Scheme 2. The Urban Deferred status under the MRS is related to the Ingham Poultry operations on site, and the relocation of this facility is required to enable development of the proposal area.

1.2 Purpose and scope of this document

This document provides the Local Water Management Strategy (LWMS) for the site and has been developed to inform and support the lodgement of the Structure Plan for the Lot 1665 Wanneroo Rd Sinagra (the site) (Figure 2) prepared by Urbis.

The principal objective of this LWMS is to achieve better urban water management outcomes by guiding development within the precinct which incorporates and manages the total water cycle in a sustainable manner and meets objectives for water sensitive urban design. This includes consideration of:

- water conservation and efficiency (water use)
- water quantity management (groundwater levels and surface water flows)
- water quality management (groundwater and surface water quality).

This LWMS is presented in support of the LSP to fulfil the requirements of Planning Bulletin 92: Better Urban Water Management (WAPC 2008).

1.3 Statutory framework

This LWMS has been prepared in accordance with Better Urban Water Management guidelines (WAPC 2008) on advice from Department of Water and Environment Regulation (DWER). The document is consistent with regional and district scale urban water management planning, including the *State Water Plan* (DPC 2007) as well as *State Planning Policy 2.9 Water Resources* (WAPC 2006). The document aims to meet the principles and objectives of stormwater management in Western Australia, as detailed in the *Stormwater Management Manual for WA* (Department of Water 2007) and *Decision Making Process for Stormwater in Western Australia* (DWER 2017).

1.4 Relevant documents

DWER mapping indicates there is no District Water Management Strategy or Drainage and Water Management Plan covering the subject site.

2. Key principles and objectives

The LWMS uses the following documents to define its key principles and objectives for sustainable water management:

- *Liveable Neighbourhoods Edition 4* (WAPC 2009)
- *Water Resources Statement of Planning Policy 2.9* (WAPC 2004)
- *Stormwater Management Manual for WA* (Department of Water 2007)
- *Decision Making Process for Stormwater in Western Australia* (Decision Process, DWER 2017)
- *Better Urban Water Management* (WAPC 2008)
- *Wanneroo Development Design Specification WD5: Stormwater Drainage Design* (City of Wanneroo 2015).

Figure 1: Location plan

N

Scale 1:10,000 at A4

0 100 200 m

Coordinate System:
GDA 1994 MGA Zone 50

Date: 16/04/2019

Legend

- Lot 1665 Wanneroo Road, Sinagra
- Roads

Q:\Consult\2018\STO\STO18073\01_GIS_documents\ArcMap_documents\STO18073_G001_RevA.mxd

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Data source: Nearmap: Aerial image, flown 02/2019. Client: Stockland. Site data, 04/2019. Created by: c.thatcher

Figure 2: Structure plan

Data source: Nearmap Imagery flown 2/2019
Structure plan - URBIS & MNG 2019

Coordinate System: GDA 94 zone 50
Date: 19/06/2019
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Legend

- Lot 1665 Wanneroo Road, Sinagra

Zones
- Residential R25-R50
- Residential R25-R80

Reserves
- Park and recreation
- Public use: primary school

Other
- Neighbourhood connector road
- Local access road

The sections below outline the application of key policies in relating to this LWMS. The key points of these policies are discussed below. A summary of the key design principles and objectives from these documents is provided in Table 1.

Table 1: Water management principles and objectives

Category	Principles	Objectives
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% Annual Exceedance Probability (AEP) within the development area to pre-development flows • Retain and restore existing elements of the natural drainage system.
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• Implement current known best management practice as detailed in the DoW Stormwater Management Manual for Western Australia (2007) and the Decision Process for Stormwater Management in Western Australia. (DoW 2009), with an emphasis on a treatment train approach including nutrient input source control, use of bioretention systems, rehabilitation of waterways as living streams, and maintaining 1% AEP post development discharge volumes and peak flow rates at pre-development levels • maintain surface water and groundwater quality • ensure that the 1 year, 1 hour event (15 mm) receives treatment prior to discharge to a receiving environment.
Disease and nuisance insect management	• To reduce health risks from mosquitoes, retention and detention treatments should be designed so that between November and May, detained immobile stormwater is fully infiltrated in a time period not exceeding 96 hours.	• Permanent water bodies not proposed for the Study Area.

2.1 Water Resources Statement of Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water, including promotion of water conservation measures, reuse and recycling of water and best practice in stormwater management (WAPC 2004). These objectives are consistent with Liveable Neighbourhoods (WAPC and DPI 2007).

2.2 Stormwater Management Manual and Decision Process

The DoW position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: *Understanding the Context of the Stormwater Management Manual for Western Australia* (DoW 2004-2007), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- Water Quality: to maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions
- Water Quantity: to maintain the total water cycle balance within development areas relative to the pre-development conditions
- Water Conservation: to maximise the reuse of stormwater
- Ecosystem Health: to retain natural drainage systems and protect ecosystem health
- Economic Viability: to implement stormwater systems that are economically viable in the long term
- Public Health: to minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: to protect the built environment from flooding and water-logging
- Social Values: to ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater
- Development: to ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles Australia (DoW 2004-2007).

DWER revised the *Decision Process for Stormwater Management in WA* in 2017 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above. The Decision Process is a component of Chapter 4 of the Stormwater Management Manual for WA and focuses on achieving desired stormwater outcomes by:

- designing urban stormwater management systems that reduce risk to people and property from flooding to within acceptable levels
- designing urban stormwater management systems that mimic natural hydrological processes for that catchment
- retaining natural water bodies as the receiving environments for runoff of suitable quality from minor and major rainfall events
- retaining and planting vegetation (preferably local native species) wherever possible to reduce stormwater runoff volumes and peak flow rates, reduce urban temperatures, improve water quality, increase urban biodiversity, and improve aesthetics and urban amenity
- implementing stormwater management systems and site management, maintenance and other practices to prevent, reduce and treat pollutants
- designing urban stormwater management systems that achieve good urban amenity and provide multiple functions (DWER 2017).

2.3 Better Urban Water Management

The guideline Better Urban Water Management (WAPC 2008) focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management. This LWMS complies with the Better Urban Water Management process.

3. Pre-development environment

3.1 Previous studies

The following reports have informed the preparation of this document:

- Detailed Site Investigation, Strategen, October 2017
- Preliminary Hydrological Assessment, RPS, October 2017
- Geotechnical Study, Galt Geotechnics, October 2017
- Environmental Assessment Report, Strategen, March 2019
- Engineering Servicing Report, Cossill & Webley Consulting Engineers, Feb 2019.

3.2 Location and topography

Topography ranges between 28 m AHD in the west to 78 m AHD in the east (Figure 3).

3.3 Climate

The nearest Bureau of Meteorology station to the site is located at Perth Metro, approximately 20.3 km south of the site. The climate at Perth Metro is Mediterranean with an average rainfall of 732.8 mm/yr (BoM 2018) with approximately 80% of rain falling between May and October.

3.4 Existing land use

The site has supported poultry operations, inclusive of a feed lot since 1960.

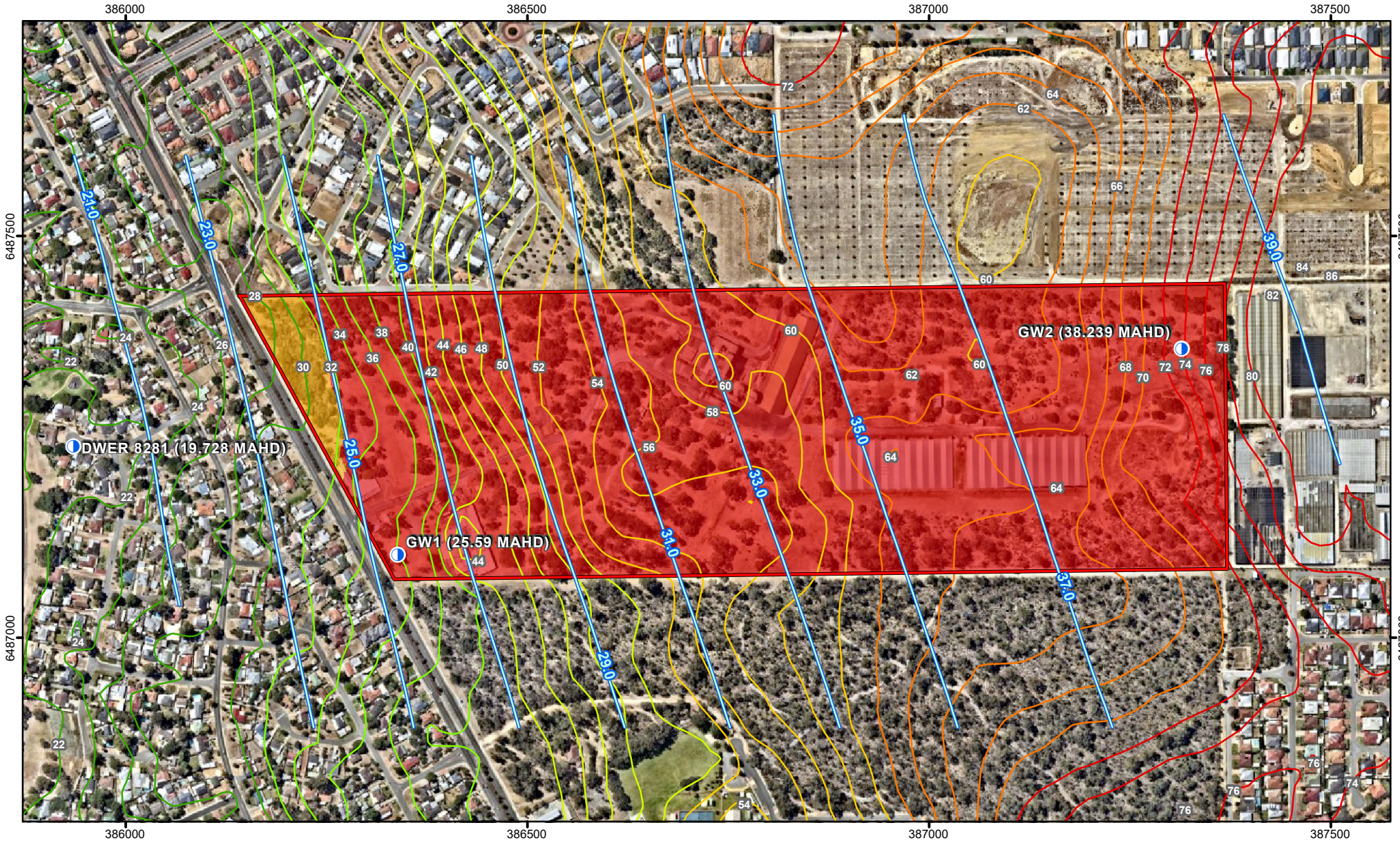

Figure 3: Groundwater and topography

Data source: Nearmap flown 2/2019
Coordinate System: GDA 94 zone 50
Date: 18/04/2019

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Legend

- Lot 1665 Wanneroo Road, Sinagra
- Groundwater Monitor Bore (Groundwater Level mAHD)
- Maximum Groundwater Level Contour (mAHD)

Depth to Groundwater (m)
- 4.0 - 8.0
- 8.0 - 40.0

Topographic contours (mAHD)
- 20 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80

3.5 Surface geology

Surface geology mapping is shown in Figure 5. The 1:50,000 Muchea Environmental Geology Map (GSWA 1985) indicates the geology of the site is typically as follows:

- S7 SAND – sand derived from Tamala Limestone pale yellowish brown, medium to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.

Based on Strategen experience on the Swan Coastal Plain, sands within post-development Study Area (S7) have a moderate Phosphorus Retention Index (PRI).

Geotechnical investigations undertaken by Galt (2017) (Appendix 8) indicate the soils of the site are consistent with the description above. This report also identified several localised areas of limestone and limestone pinnacle. These tended to occur in the western and southern sections of the site. The tests where limestone was observed or inferred to be present are detailed in Appendix 8.

3.5.1 Hydraulic conductivity

Hydraulic conductivity testing was undertaken by Galt (September 2017, IT01 to IT08) at general locations on the site (Table 2). Further details of the testing are presented in Appendix 8 (Galt, 2017). Locations of these tests are presented on Figure 5. Based on these results, a conservative value of 10 m/d was used for the infiltration rates in the calculations.

Table 2: Hydraulic conductivity results

Location	Soil	Measured hydraulic conductivity (m/day)
HA01/IT01	Sand	>15
HA02/IT02	Sand	>15
HA03/IT03	Sand	>15
HA04/IT04	Sand	>15
HA05/IT05	Sand	>15
HA06/IT06	Sand	10.3
HA07/IT07	Sand	>15
HA08/IT08	Sand	>15

The presence of subsurface limestone and some limestone outcropping may affect hydraulic conductivity (Figure 5). Where limestone is encountered and is expected to impact on hydraulic conductivity and drainage function, the area will be excavated to a depth of 1 m BGL and replaced with free draining in situ cut to fill material.

3.5.2 Acid sulphate soils

The site is not mapped as containing acid sulphate soils (DWER 2018).

3.5.3 Contaminated sites

Because of the use of the site for poultry farming, the site has been assessed in a Detailed Site Investigation (DSI) (Strategen, 2017) to determine the nature and extent of potential soil contamination on the site. Minor localised soil contamination was identified. These areas will be subject to remediation during the decommissioning and construction phases in a manner consistent with the *Contaminated Sites Act 2003.*

The DSI indicated that no further investigation and remediation of groundwater is required.

3.6 Surface water hydrology

The site is elevated and has a natural gradient across its entirety. There are no surface water bodies on the site and no geomorphic wetlands mapped within the site. Despite its relatively steep gradient, the site does not contain any significant watercourses owing to the highly permeable soils which mean the existing hydrological regime consists of infiltration of rainfall to the superficial aquifer.

The site does not have any drainage connection or outlet. An existing drainage sump is located adjacent to the north-west corner of the site and services the development immediately north of the site. The sump is designed as being 3.5 meters deep, is fenced and managed by the City of Wanneroo. The East Wanneroo Cell 2 - Adopted Structure Plan No.4 (Appendix 5) shows this drainage sump as extending onto the site. The City of Wanneroo as-con engineering drawings also show this sump, the existing catchment area, and details the requirements for the expansion of the sump onto the site to manage runoff from the site (Appendix 6).

3.7 Groundwater hydrology

3.7.1 Maximum groundwater level

Groundwater level and quality monitoring was undertaken as part of the DSI for the site on 8 September 2017 at GW1 and GW2 (Table 3, Figure 3). Maximum groundwater level (MGL) varies from 23 to 39 mAHD over the site. The depth to MGL is greater than 8 m over most of the site. The minimum depth to MGL is 4.4 m at the low point in the north-eastern corner of the site. The maximum depth to groundwater is 39.7 m in the north-east. The methodology utilised for determining the MGL and the period of monitoring was considered by DWER to be adequate to support the LWMS (Slodecki C [DWER] email dated September 11) (Appendix 2).

The water levels in GW1 and GW2 were compared to the levels in the local superficial aquifer DWER Bore 8281, approximately 300 m west of the site Figure 3) to determine a Maximum Groundwater Level. DWER Bore 8281 (WIN ID 61610661) has been monitored at least six times per year since 1970, a period of 48 years (Figure 4).

The separation of surface to groundwater of greater than 4 m is considered adequate clearance for finished floor levels and infiltration of stormwater at this location.

The monitoring confirms the generally westerly flow of groundwater towards Lake Joondalup, approximately 450 m to the west of the site.

Table 3: Groundwater bore location and elevation data

Monitoring bore	Easting (mE)	Northing (mN)	Depth to groundwater (mbTOC)	Top of casing (mAHD)	Ground level (mAHD)
GW1	386338.909	6487103.156	11.134	36.584	36.15
GW2	387300	6487353	36.269	74.295	73.934m

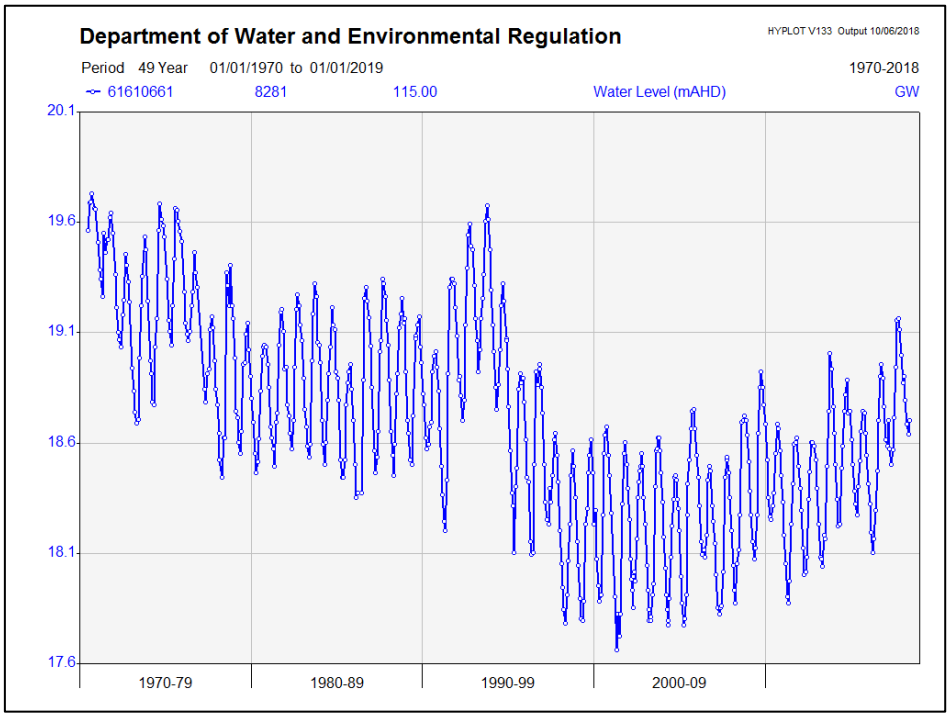

Figure 4: Long term groundwater levels

3.7.2 Groundwater quality

Concentrations of total nitrogen, NO_x and total phosphorus exceeded ANZECC and ARMCANZ (2000) guidelines for slightly disturbed freshwater ecosystems at the tested locations (Figure 3). The groundwater analytical data indicates that groundwater entering the site is broadly similar with groundwater quality migrating offsite (Strategen 2017, Table 4,Table 5). This finding indicates that historical poultry farm operations have not adversely impacted the quality of groundwater, and it can be argued that concentrations of nutrients in groundwater exceeding the adopted fresh water guidelines are reflective of regional groundwater quality, or attributable to upgradient land uses (i.e. large-scale nursery operations immediately upgradient of the site) (Strategen 2017).

Groundwater quality is considered generally suitable for irrigation purposes. Use of groundwater for irrigation of POS allows for vegetation uptake of nutrients in the irrigated groundwater, thus improving water quality.

Figure 5: Geology and soils

Data source: Nearmap Imagery flown 2/2019.
Coordinate System: GDA 94 zone 50
Date: 18/04/2019

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Legend

- Lot 1665 Wanneroo Road, Sinagra
- Approximate extent of outcropping surface limestone
- Hand Auger Borehole/ Infiltration test

Surface geology (DMIRS)

- S7 - SAND - pale and olive yellow, medium to coarse-grained, sub-angular quartz and a trace of feldspar, moderately sorted, of residual origin

Table 4: Nutrients and physico-chemcial parameters

		Physico-chemical Parameters				Nutrients						
		pH	Electrical Conductivity	Redox	Dissolved Oxygen	Total Nitrogen	NOx (as N)	Total Phosphorus	Fliterable Reactive Phosphorus	Nitrate-N	Ammonia (as N)	Sulphate (as SO_4)
ANZECC Freshwater guidelines		**6.5-8.5[1]**	**300-1,500 [2]**	NE	NE	**1**	**0.1**	**0.1**	NE	NE	**0.9**	NE
Non-potable use guidelines		NE	NE	NE	NE	NE	NE	NE	NE	**113**	NE	**1,000**
	Limits of Reporting (LOR)	-	-	-	-	**0.1**	**0.005**	**0.05**	**0.01**	**0.005**	**0.02**	**1**
Sample ID	**Date Sampled**	**-**	**µs/cm**	**mV**	**ppm**	**mg/L**						
GW1	8/09/2017	6.78	783	117	6.72	**8.2**	**3.4**	**6.9**	0.04	3.4	<0.02	82
GW2	8/09/2017	7.42	1399	76	3.51	**4.1**	**2.4**	**6.8**	<0.01	2.3	0.03	210

Table 5: Dissolved metals results

		Dissolved Metals									
		Aluminium	Arsenic	Cadmium	Chromium*	Copper	Iron	Lead	Mercury	Nickel	Zinc
ANZECC Freshwater guidelines		**0.055**	NE	**0.0002**	**0.001***	**0.0014**	NE	**0.0034**	**0.00006**	**0.011**	**0.008**
Non-potable use guidelines		**0.2**	**0.1**	**0.02**	**0.05**	**20**	**0.3**	**0.1**	**0.01**	**0.2**	NE
	Limits of Reporting (LOR)	**0.01**	**0.001**	**0.0001**	**0.001**	**0.001**	**0.01**	**0.001**	**0.0001**	**0.001**	**0.005**
Sample ID	**Date Sampled**	**mg/L**									
GW1	8/09/2017	0.02	<0.001	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.0001	<0.001	<0.005
GW2	8/09/2017	<0.01	0.002	0.0002	<0.001	**0.002**	<0.01	0.001	<0.0001	0.003	**0.014**

Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, monitoring and compliance reporting.

3.8 Water resources

3.8.1 Groundwater licence

The site has one existing superficial aquifer groundwater abstraction licence for 74,250 kL/yr (GWL 46759) registered to Inghams Enterprises Pty Ltd. This licence will be transferred to Stockland upon commencement of urban development for use in irrigation and dust suppression. The bore will be relocated from its current position to a POS area yet to be determined.

The site is not located in a Public Drinking Water Source Area.

3.9 Wetlands and vegetation

A search of the Department of Biodiversity, Conservation and Attractions Environmentally Sensitive Areas mapping tool (DBCA 2005) found no ESAs or wetlands within the site.

The site contains:

- areas of the federally listed Threatened Ecological Community (TEC) 'Banksia woodlands of the Swan Coastal Plain' (Endangered – Environmental Protection and Biodiversity Conservation Act 1999, EPBC Act)
- areas of Black Cockatoo foraging and potential breeding habitat, but no observable breeding hollows (360 Environmental 2017).

The development of the site has been referred to the Commonwealth Department of Environment and Energy (DEE) for assessment under the EPBC Act. Management of these areas is further discussed in the Environmental Assessment Report (EAR, Strategen 2019).

These matters do not directly affect water management on the site, other than developing a desire to minimise clearing of vegetation for construction of stormwater management structures.

3.10 Hydrological opportunities and constraints

The above described characteristics of the pre-development environment in the site provide a number of key constraints and opportunities for the application of water sensitive urban design with land use change:

- the sandy soils of the site have a high infiltration rate, resulting in infiltration on site being a preferred method of stormwater disposal
- the depth to groundwater is greater than 4 m
- sub surface limestone has been identified in some areas
- historical and current land uses within and adjacent to the site do not appear to have affected groundwater quality and there are currently no water quality controls. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, monitoring and compliance reporting
- groundwater is available for irrigation purposes.

These constraints and opportunities are used in to assist development of a suitable LWMS for the site.

4. Proposed development

The site is proposed to be developed for residential housing (Figure 2). The site will also contain a primary school (3.5ha) and four POS areas (4.7 ha). The site's main access will be from Wanneroo Road and will have minor access points to future developments to the north, east and south.

5. Water use and sustainability initiatives

5.1 Water conservation

It is expected that development of the site will lead to an increase in scheme water demand due to the number of people living on the site.

Water conservation measures will be implemented to reduce scheme water consumption within the development and will be consistent with Water Corporation's "Waterwise" land development criteria, and include:

- use of medium density residential zoning and smaller lots to reduce garden (ex-house) use of water
- promotion of use of waterwise practices including water efficient fixtures and fitting (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping)
- consumption target for water of 100 kL/person/year
- utilise fit for purpose water sources throughout the development
- use of native plants in POS areas and buffer areas
- maximising on site retention of stormwater.

Specific agreed measures and locations to achieve water conservation will be detailed in the UWMP.

5.2 Potable and non-potable water supplies

5.2.1 Household scale

The water source planning strategy for the site is for use of scheme water for domestic household use (both in and ex-house).

The use of rainwater tanks to supplement potable water use ex-house and in-house will be encouraged by the proponent. The use of rainwater tanks will be assessed as part of the UWMP process at subdivision stage when more detailed planning is commenced. The integration of rainwater tanks for non-potable water with the domestic water supply scheme would assist in reducing stormwater generation and minimise scheme water importation.

Superficial groundwater abstraction via installation of domestic groundwater bores could also be used for ex-house uses such as irrigation of garden and lawn areas.

5.2.2 Public open space

POS maintenance requirements will be managed by the proponent for a period of two years before hand-over to City of Wanneroo. Detail landscaping design and planting will be presented in the UWMP.

Water for the POS will be sourced from the existing site groundwater allocation (Section 3.8.1).

POS irrigation water use has been based on the following assumptions:

- permanent irrigation of turf with an irrigation rate of 6,750 kL/ha/yr
- establishment irrigation of planted areas (POS and landscaped verges) at a rate of 6,750 kL/ha/yr for two years.

The projected long-term irrigation demand is 34,227 kL/yr (Appendix 3).

POS design will be undertaken to ensure that sustainable outcomes which reduce water and fertiliser use, are implemented through the following principles:

- improvement of the existing soil with 50 mm of soil conditioner certified to Australian Standard (AS) 4454 mixed into the native soil or fill to a depth of 100 mm in turf and 250 mm in garden beds
- landscape plantings primarily based on native Waterwise plant species with a focus on native species
- planting design based on watering requirements to allow for hydrozoning
- garden beds to be mulched to 75 mm or in accordance with Bushfire Management Plan requirements
- turf areas to be focussed around facilities such as play spaces and picnic facilities, to ensure turf is located where it will be best utilised
- implementation of an appropriate management and maintenance program for POS that reduces irrigation rates and fertiliser use over the long term to promote future water savings.

For all areas, efficiencies will be sought during landscaping design at the subdivision stage to target a reduction in fertiliser and irrigation water use while maintaining a high standard of POS, including:

- retaining natural bushland where feasible
- reduce irrigated areas by minimising turf through prioritising turf in active areas
- utilise low water use vegetation and hard surfaces where feasible to reduce irrigation demand
- utilise efficient irrigation systems to reduce water use
- utilising establishment only irrigation for streetscapes and landscaping when feasible.

Based on the household and POS water strategies, a water balance for the site has not been provided in the LWMS, as it is typically required to support the identification of excess water generated by the development where use of this excess water as a non-potable water supply scheme is proposed. A water balance would not provide any further information on water use and potable/non-potable supply options. Furthermore, design and building of the proposed development to current industry standard should ensure water use is within current Water Corporation and DWER consumption targets.

5.2.3 Primary School

The proposed primary school on the site will require ground water for irrigation of the school gardens and break out areas. The Department of Education have stated that for a school of this size, they would require an irrigable area of approximately 2 ha (13,500 kL/a) (A Hastie 2019, personal communication, 17 April 2019).

The total irrigation demand for the Primary School and POS is 47,727 kL/yr, which is within the current licenced allocation for the site of 74,250 kL/yr.

5.3 Water Services

Cossill & Webley Consulting Engineers prepared an Engineering Servicing Report for the site which includes details of the water services available to the site (Cossill & Webley, 2019). That report states the following:

5.3.1 Wastewater

The Site is located within the Water Corporation's Neerabup sewer district. The Water Corporation has confirmed there is sufficient capacity in the existing system (subject to the extension of the Neerabup Main Sewer to the north of the site) to cater for the proposed future development yields. Standard Water Corporation sewerage headworks will apply.

The Water Corporation long term scheme planning allows for the Site to be serviced via two future 225mm diameter mains as depicted in Figure 11. The proposed 225mm diameter sewer that traverses the middle of the Site will need to be accommodated within the road reserve. The extension of the 450mm diameter Neerabup Main Sewer is required to the north of the site (beyond the extent of the Site perimeter) is required for catchment north of the site. This extension is near the City of Wanneroo Depot and according to the Water Corporation, this sewer main extension is currently underway (Cossill & Webley, 2019).

5.3.2 Water Reticulation

The Cossill & Webley report also states the following regarding water reticulation:

The Site falls within the Water Corporation Wanneroo Reservoir catchment (Figure 12) and can be serviced off the existing network from Wanneroo Road. Standard Water Corporation water headworks will apply to the development.

There is a 1000mm dia collector main located immediately south of the Site (within Lot 9000) as presented in Figure 13, which is protected by a 5 metre wide easement. This will need to be contained in the future in Lot 9000 within road reserve or future public open space. (Cossill & Webley, 2019).

6. Water management

6.1 Stormwater management strategy

The stormwater management strategy has been prepared to meet the objectives and principles of urban water management outlined in Table 1. Surface Water Plans for 1yr 1hr rainfall events (15mm), 18% AEP events and 1% AEP events are shown in Figure 6, Figure 7 and Figure 8 respectively.

The key elements of the stormwater management strategy are:

1. Manage (retain and/or detain and treat (if required)) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical. At source means that lot runoff is managed within lots and road runoff is managed within road reserves and the stormwater has not entered a piped or lined channel conveyance system (DWER 2017)
    - Retention of the first 15mm of rainfall on lots within soak wells or other detention and infiltration structures as much as practical
    - to treat the first 15 mm rainfall event from roads through bioretention areas or other techniques as close to source as feasible.
2. Any additional stormwater run-off created during rainfall events greater than 15 mm will be directed towards centralised basins in the POS via pipe drainage and overland flow paths. No stormwater will be discharged from the site.
3. There is to be a minimum of 500 mm clearance from the base of any bioretention or retention basins to the Maximum Groundwater Level (MGL) at that specific location.

The design of the stormwater drainage system manages all rainfall events on the site up to and including the 1% AEP, except for Catchment G (discussed later). The minor drainage system is designed to manage stormwater runoff during storm events up to and including the 18% AEP while the major drainage system is designed for rainfall events greater than the 18% AEP, up to and including the 1% AEP.

The minor drainage system manages storm water using a pipe and pit drainage system. For major events, the minor drainage system is utilised until its capacity is exceeded and then stormwater flows onto the road reserves and overland flow paths draining to infiltration basins or the sump.

No allowance has been made for runoff from surrounding sites. Development of these sites needs to incorporate management of stormwater on their sites to prevent runoff onto the site for events up to the 1% AEP.

Protection of property from flooding will be achieved by constructing residential, commercial and industrial building habitable floor levels 0.3m above the 1% AEP flood level.

The site will make use of the existing sump located between Santa Rosalia Vista and Wanneroo Road. This sump is currently designed to receive the stormwater from the developed area to the north of the site as shown in the City of Wanneroo as-con engineering drawings (Appendix 6), with an impervious area of 1.66 ha. The contributing area is shown in Figures 6, 7 and 8. The area is referred to in this document as the “external catchment”.

The connected impervious area of the external catchment (which is assumed to be road reserve only) was checked and was measured at 1.84 ha. This latter value was used in the stormwater modelling rather than the 1.66 ha as shown in Appendix 6.

Appendix 6 shows the design details of the external catchment and the sump. The details of the sump are shown in two stages, ‘initial’ and ‘ultimate’. The initial sump is located entirely on the external catchment (as is currently the how the sump is constructed) and the ultimate sump shown expanded, crossing the site boundary and therefore partly located on the site.

The details for both stages and the proposed final sump design as per this LWMS are shown in Table 6. The final design of the sump is smaller than that proposed as the ultimate design. This is due to a more refined modelling methodology which included a relatively high infiltration rate, reducing the size required.

Table 6: Existing sump details

	Initial Sump	Ultimate Sump	Final design
Total Impervious area	1.66 ha	5.28 ha	16.59 ha
10yr storage required	1096 m^3	3485 m^3	Not modelled
100yr storage required	2208 m^3	7022 m^3	4483 m^3
10yr design storage (RL 27.5)	1172 m^3	3515 m^3	Not modelled
100yr design storage	2545 m^3	7143 m^3	4483 m^3
Area at TWL (RL 29.00)	1025 m^2	2640 m^2	1678 m^2
Area at base (RL25.50)	429 m^2	1715 m^2	930 m^2

This sump will be expanded by the proponent to accommodate inflow from the site in addition to the inflow from the developed area north of the site. The use of this land is in accordance with the East Wanneroo Cell 2 – Adopted Structure Plan No 4 (Appendix 5).

The stormwater strategy for each catchment is:

- **Catchment A** – runoff will be collected in POS A for event sizes up to the 1% AEP
- **Catchment B, C and E** – runoff for small events will be contained in the bioretention area in POS C north. Runoff from larger events will overtop this area and flow via POS C north to the sump
- **Catchment D** – runoff for small events will be contained in the bioretention area in POS B. Runoff from larger events will overtop this area and flow via POS C north to the sump
- **Catchment F** – runoff for small and minor events will drain through the existing pipe and pit network in Spiccia Way and Vinci Entrance to the sump. Runoff for major events will flow overland to the sump along the north boundary of the site
- **Catchment G** – runoff will flow north to the proposed drainage basin on the neighbouring site
- **External Catchment** – runoff will flow into the sump as is currently the case.

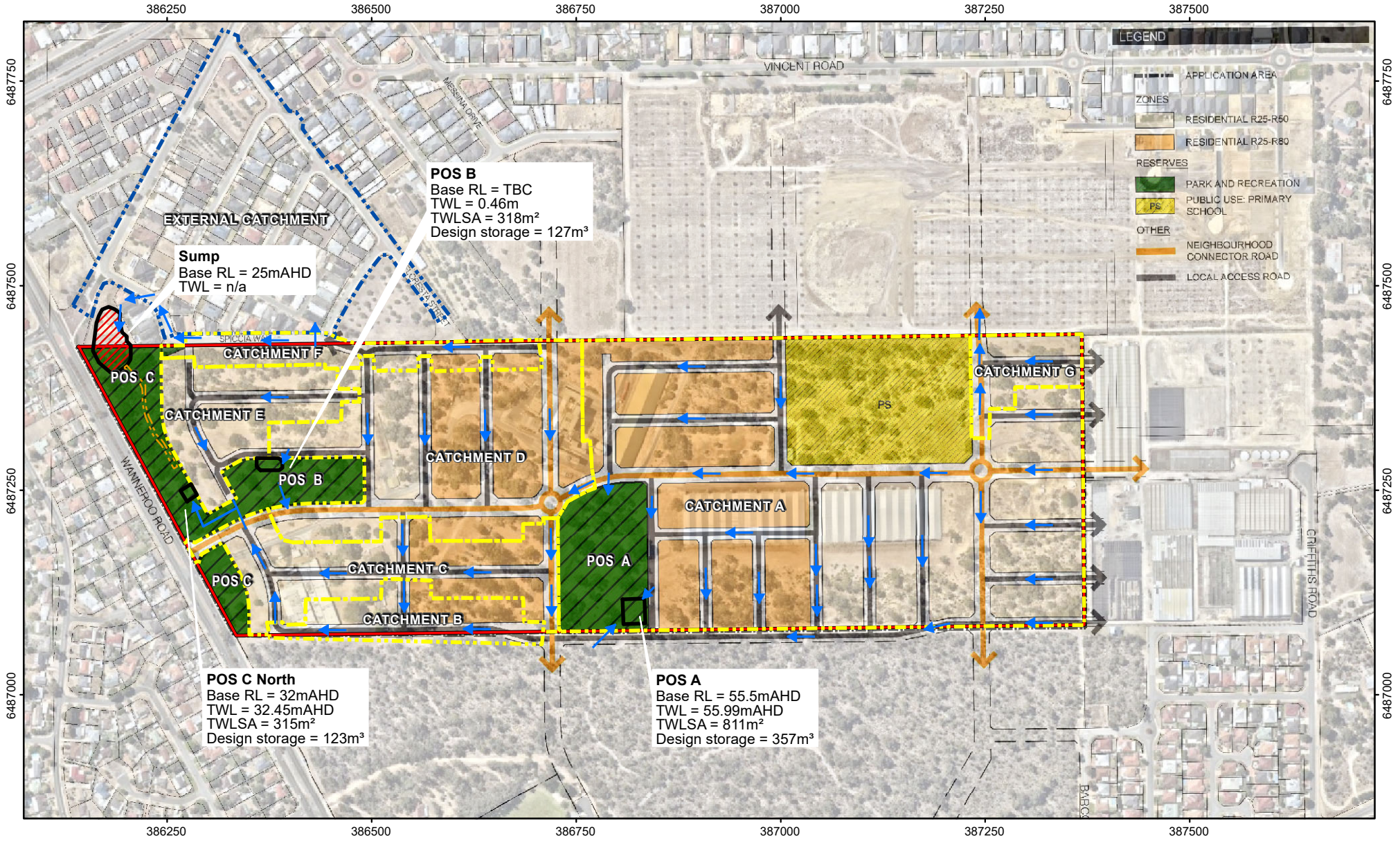

Figure 6: Surface water plan 1yr 1hr

Data source: Nearmap Imagery flown 2/2019
Structure plan - URBIS & MNG 2019

Coordinate System: GDA 94 zone 50

Date: 19/06/2019

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Legend

- Lot 1665 Wanneroo Road, Sinagra
- Public open spaces
- Catchments
- External catchment
- Bioretention
- Sump
- Indicative swale location
- Flow path

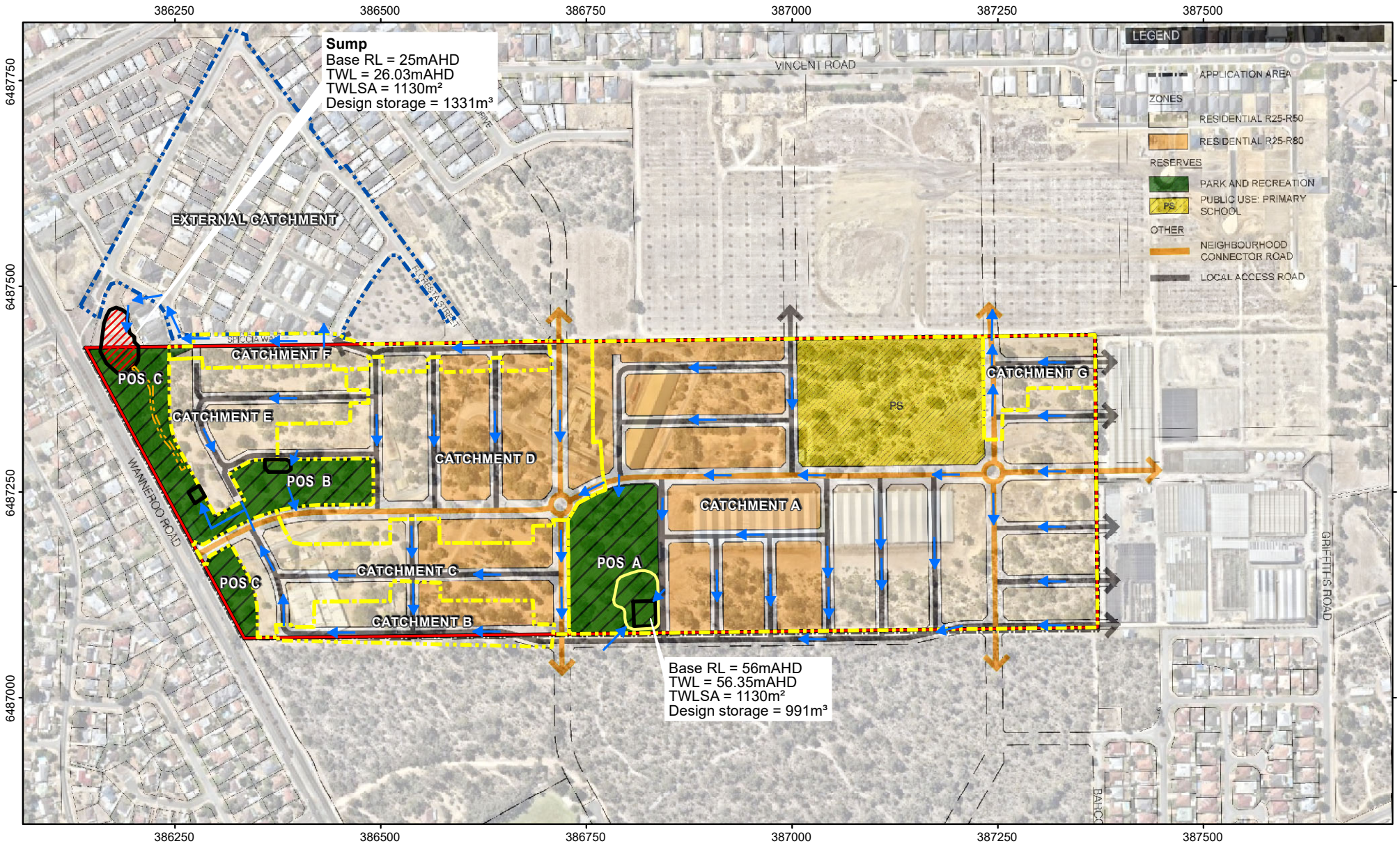

Figure 7: Surface water plan 18% AEP

Data source: Nearmap Imagery flown 2/2019
Structure plan - URBIS & MNG 2019

Coordinate System: GDA 94 zone 50

Date: 19/06/2019

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Legend

- Lot 1665 Wanneroo Road, Sinagra
- Public open spaces
- Catchments
- External catchment
- 18% AEP surface area (indicative)
- Bioretention
- Indicative swale location
- Sump
- Flow path

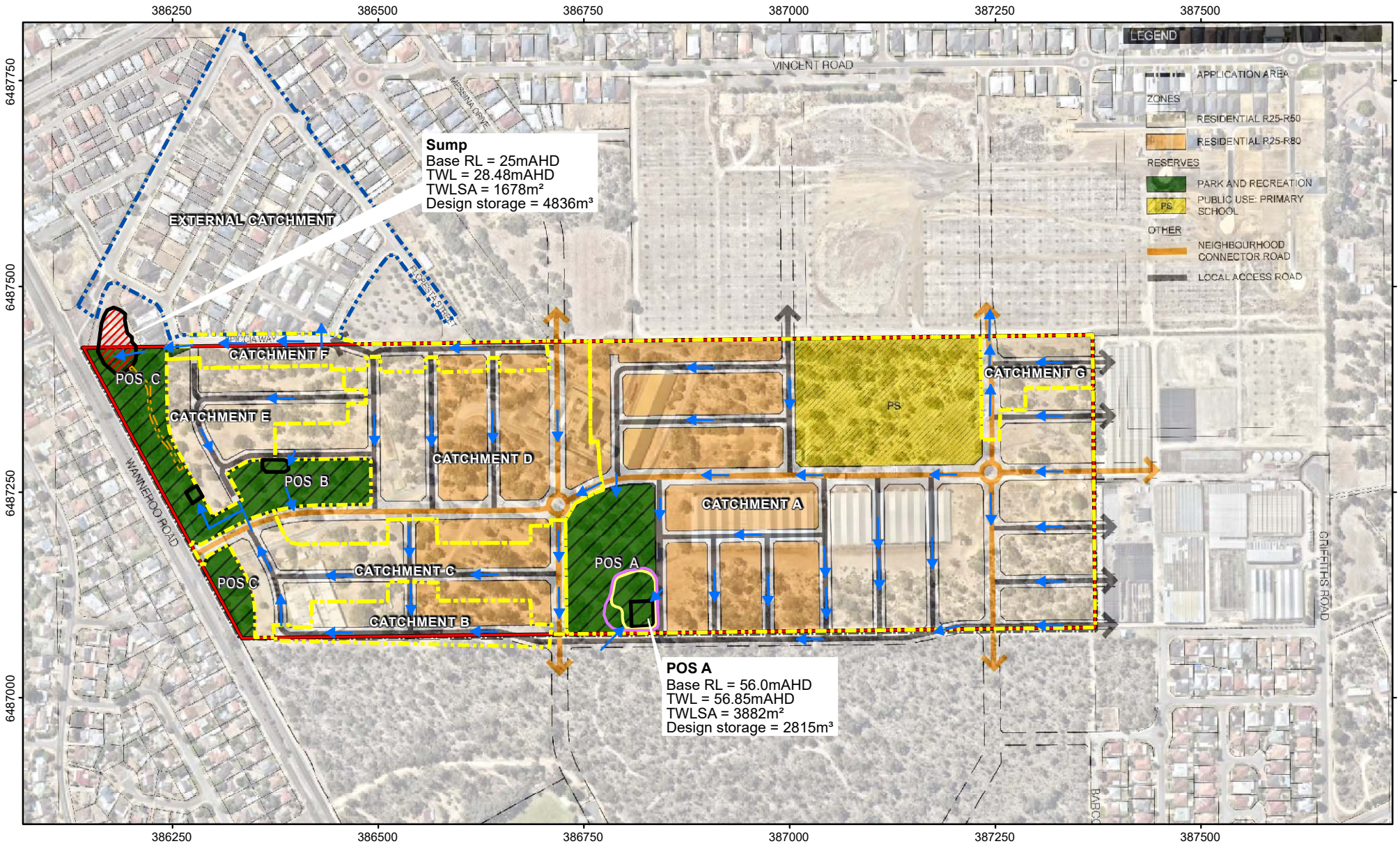

Figure 8: Surface water plan 1% AEP

Data source: Nearmap Imagery flown 2/2019
Structure plan - URBIS & MNG 2019

Coordinate System: GDA 94 zone 50
Date: 25/09/2019

Legend

- Lot 1665 Wanneroo Road, Sinagra
- Public open spaces
- Catchments
- External catchment
- 1% AEP surface area (indicative)
- 18% AEP surface area (indicative)
- Bioretention
- Indicative swale location
- Sump
- Flow path

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6.1.1 Catchment runoff modelling and storage sizing

Modelling of runoff and storage sizing was performed using the rational method in accordance with AR&R and basin and sump sizing using the approach outlined by Cocks (2007).

The requirements of the City of Wanneroo were also implemented in the modelling as outlined in City of Wanneroo (CoW, 2015). Runoff coefficients used were:

- Road <40m reserve 0.8
- Road > 40m reserve 0.65
- POS/school 0
- Standard lot 0
- Medium/high density lot 0.95.

Catchment areas for the site and other modelling parameters are provided in Table 7.

Table 7: Catchment parameters

Catchment	Road (ha)	POS/school (ha)	Standard lots (ha)	Medium/high density lot (ha) < 300m^2	Total area (ha)
A	5.281	5.323	4.805	6.03	21.438
B	0.641	0.384	0.399	0.48	1.904
C	1.241		1.689	0.72	3.650
D	1.883		4.146	0.42	6.449
E	0.608	2.448	1.565	0.24	4.861
F	0.519		0.561	0.27	1.350
G	0.402		0.119	0.51	1.031
External *	1.840	1.040	5.160	-	8.040
Total	12.414	8.155	13.282	8.670	40.682

*External catchment

Table 8: 1 yr, 1 hr (15mm) events - bioretention

Parameter	Catchment A (POS A)	Catchments B, C and E POS C North	Catchment D . (POS B)	Catchments F and Ext* (Sump)^
Water level rise (m)	0.49	0.45	0.46	n/a
Invert (mAHD)	55.5	32.0	TBC	25.0
TWL (mAHD)	56.0	32.5	(+0.49m)	n/a
TWL surface area (m^2)	811	315	318	n/a
Max volume in basin (m^3)	357	123	127	n/a
Time to empty from rain stopping (hrs)	1	2	1	n/a
Total runoff volume (m^3)	634	222	226	n/a

*External catchment

^ Infiltration exceeds inflow so there will be no ponding in the sump attributed to the site.

Table 9: 18% AEP event design

Parameter	Catchment A (POS A)	Catchments B,C,D,E,F +Ext* (Sump)
Water level rise (m)	0.35	0.89
Invert (mAHD)	56.0	25.0
TWL (mAHD)	56.35	25.89
Max water surface area (m^2)	2929	1130
Max volume in basin (m^3)	991	1331
Time to empty from rain stopping (hrs)	1	2
Total runoff volume (m^3)	1326	3003
Critical event (hr)	0.33	6

*External catchment

Table 10: 1% AEP event

Parameter	Catchment A (POS A)	Catchments B,C,D,E,F +Ext* (Sump)
Water level rise (m)	0.85	3.48
Invert (mAHD)	56	25.0
TWL (mAHD)	56.85	28.48
Max water surface area (m^2)	3882	1678
Max volume in basin (m^3)	2815	4483
Time to empty from rain stopping (hrs)	2	9
Total runoff volume (m^3)	5043	7283
Critical event (hr)	2	6

*External catchment

Side slopes of the bioretention areas, basin and sump are 1:3, 1:6 and 1:1.5 respectively.

The detention storage details shown in Table 8, Table 9 and Table 10 and Figure 6, Figure 7 and Figure 8 are indicative only and provided for comparison to the POS areas allocated on the Structure Plan, to ensure the POS area is capable of supporting the drainage function proposed. The final configuration and exact location of the storage areas will be dependent on final earthworks, drainage and road design levels for the development. The details will be refined at the sub-division stage and reported in the relevant Urban Water Management Plan (UWMP).

For events larger than 1year, 1 hour, the capacity of the bioretention areas in POC B and POS C north will be exceeded and excess stormwater from these areas will proceed overland through POS C north to sump. The design details of the conveyance system for this stormwater flow is to be included at next stage of the development process.

Stormwater runoff from Catchment G (0.402 ha) cannot be managed on the site due to the need to match road levels with site to the north and minimise earthworks. This catchment area has been minimised to ensure that as little stormwater leaves the site as is feasible. Expected runoff volumes from Catchment G are provided in Table 11.

Table 11: Catchment G runoff volumes

Event	Runoff Coefficient	Volume (m^3)
15mm	0.8	48
18%AEP	0.8	79
1% AEP	0.8	145

No allowance has been made for runoff from surrounding sites. Development of these sites needs to incorporate management of stormwater on their sites to prevent runoff onto the site for events up to the 1% AEP.

6.2 Groundwater management

Depth to groundwater is not a constraint to development on the site, and as such control of groundwater levels is not required on the site.

6.3 Water quality management

6.3.1 Assessment of proposed structural BMPs to design criteria

The development of the site will include implementation of structural and non-structural controls to improve the groundwater quality from predevelopment conditions. Structural source controls will include the use of bioretention systems to treat the first 15mm of runoff.

As part of the POS landscaping, the swale will be vegetated in a manner consistent with the *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia* (Monash 2014). This will include use of local species recommended by Monash (2014). At least 50% of plants within the biofilter should be species to be highly effective for nutrient removal.

Bioretention areas are to include:

- Amended soil media
  - Minimum 500 mm thick
  - Hydraulic Conductivity (sat) minimum 2 m/day
  - PRI 10
  - Light compaction only
  - Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program
- Plant selection
  - Tolerant of periodic inundation and extended dry periods
  - Spreading root system
  - Preferential selection of endemic and local native species
  - Planting to provide 70-80% coverage at plant maturity
- Planting density and distribution
  - Planting density appropriate for species selection usually 6 plants per m2
  - Even spatial distribution of plant species.

Export of nutrients from the site will also be minimised by the implementation of non-structural source controls. These controls will include many of the aspects outlined in Section 7.4 including:

1. Street sweeping to reduce particulate build up on road surfaces and gutters.
2. Maintenance of vegetation in bioretention systems/ storages as outlined in the UWMP.
3. Cleaning of sediment build up and litter layer on the bottom of storages as specified in the UWMP.
4. Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system.
5. Minimising application of fertilisers in the POS and other landscaped areas.

7. Implementation

7.1 Subdivision application process

Processes defined in Better Urban Water Management (WAPC, 2008) require an Urban Water Management Plan (UWMP) at subdivision stage.

Further work that is identified for inclusion in the UWMP:

- detailed design of treatment structures, swales, basins, bioretention areas, vegetated raingardens, other storages and associated infrastructure as outlined in the Stormwater Management Manual (DWER 2017)
- refinement of the final configuration (storage side slopes, type and invert level of underground storages etc) and exact location of the flood detention storage areas
- landscaping design, planting and POS water use
- implementation of water conservation strategies
- details of any proposed water efficiency initiatives.

7.2 Construction management

Construction will occur in a manner consistent with City of Wanneroo requirements. The subdivision will be developed in stages based on market demand. Urban Water Management Plan(s) will be prepared based on infrastructure construction schedules.

7.2.1 Dewatering

Dewatering is not expected to be required due to the depth of groundwater below the surface level.

7.2.2 Acid sulphate soils and contaminated sites

Management of ASS and contaminated sites will be addressed as a separate process to the urban water management document approvals process.

ASS and potentially contaminated sites will be investigated and managed in accordance with the applicable DWER guidance and requirements of dewatering licences as they arise. Mapping indicates a low risk of ASS within the site (Section 3.5.2).

7.3 Construction period management strategy

During construction, management will be required of various potential pollutants and nuisances (e.g. prevention of scouring, prevention of sediment, pollutant and nutrient transfer, collection of gross pollutants, clearing of blocked drainage infrastructure etc.). The management measures undertaken during the construction period will be addressed either in future UWMP or a separate Construction Management Plan (CMP).

7.4 Stormwater system operation and maintenance

Operation and maintenance of the drainage system will initially be the responsibility of the proponent, ultimately reverting to the local authority, excluding any proposed strata development areas. The proponent will be responsible for the maintenance of the POS, retention storage and bioretention systems for a two-year period. Prior to handover to City of Wanneroo, any BMPs constructed by the proponent must be assessed to confirm that these are in satisfactory condition and functioning appropriately.

The surface drainage system will require regular maintenance to ensure its efficient operation. Monitoring and maintenance shall be undertaken as outlined in Table 12.

Table 12: Maintenance and monitoring schedule

Item	Interval			
	Monthly	Quarterly	Six-monthly	As required
Street drainage				
Street sweeping	✓			
Evacuation of sediment and rubbish in manholes		✓		
Removal of debris to prevent blockages		✓		
Vegetated treatment areas (swale)				
Inspect for erosion			✓	
Weed removal		✓		
Assess vegetation health. Remove dead plants and replace where necessary			✓	
Inspect for standing water one week after rainfall events				✓
Remove sediment build up above invert level				Every three years
Assess presence of debris in outlet and remove to prevent blockages if required.		✓		

7.5 Monitoring program

A monitoring program is required to provide guidance on the future post-development monitoring based on the pre-development monitoring for the site. The monitoring will focus on comparing post-development conditions to baseline conditions, as well as monitoring the BMPs to assess their effectiveness and that these structures are fulfilling their function.

The monitoring program has been designed consistent with Joint Australian/ New Zealand Standards (2000) to allow quantitative assessment of hydrological impacts of proposed development within the Study Area.

All water quality testing will be conducted by a NATA approved laboratory. Laboratory analysis results will be typically obtained within 1 month of sample submission.

The timing of commencement of the monitoring program should be negotiated at UWMP stage with DWER and the City of Wanneroo. Typically, the monitoring program is commenced at practical completion of the subdivision.

7.5.1 Post-development monitoring

Post development monitoring will be undertaken by the proponent based on the monitoring schedule outlined in Table 13 at monitoring bores to be installed during POS construction. Water quality assessment criteria and contingency actions will be undertaken as outlined in Table 14.

Table 13: Monitoring schedule

Monitoring type	Location	Method	Frequency and timing	Parameters
Hydraulic conductivity	Five locations (in base of basins/sump)	Permeameter/ infiltration ring	Annually for two years	Hydraulic conductivity (Ksat)
Groundwater level	Five locations (one adjacent to each main basin)	Electrical depth probe or similar	Annually for two years (October)	Water level (m AHD).
Surface water level	n/a	n/a	n/a	n/a
Groundwater quality	Five locations (one adjacent to each main basin	Pumped bore samples	Annually for two years (October)	In situ: pH, EC, temperature Laboratory: TN, Kjeldahl nitrogen, ammonia, nitrate, nitrite, TP, filterable reactive phosphorus, total dissolved salts, selected heavy metals
Surface water quality	n/a	n/a	n/a	

Annual monitoring reports will be prepared by the proponent for review by DWER a period of two years following construction of the relevant storages. At the end of the two-year period, the monitoring results will be reviewed against the criteria identified in Table 14. If performance is not considered satisfactory and the criteria are not met, remedial actions may be required, and additional two years' monitoring may be required.

Table 14: Criteria for assessment and contingencies

Monitoring type	Criteria for assessment	Criteria assessment frequency	Possible contingency actions
Hydraulic conductivity	Within five times more or less than specified value, excessive ponding	Annual review	1. Determine reason for excessive ponding or Ksat out of range. 2. Remediation of soil if required.
Surface water levels	Surface water exceeds levels anticipated, flooding of POS	Annual review of water levels	3. Review design and operation of stormwater drainage system. 4. Perform maintenance as required.
Groundwater quality	Nutrient levels within the site should not exceed the maximum recorded pre-development level.	Annual review	1. Identify and remove any point sources. 2. Review operational and maintenance measures. 3. Asses surface water quality. Consider modifications to stormwater system. 4. Consider reinforcement of community education/awareness programs. 5. Consider initiation of community based projects.

7.5.2 Monitoring reporting

Reporting is proposed to be annually, co-ordinated by the proponent and submitted to City of Wanneroo and DWER for review.

The report will compare the monitoring results with the interim water quality criteria and performance objectives and determine what, if any, further actions may be necessary, and provide ongoing assessment of the suitability of existing monitoring and reporting frequencies.

Monitoring and reporting outcomes will be used in a continual improvement capacity to review proposed WSUD, and inform the planning and design approaches for subsequent stages of development.

8. Summary and conclusions

The proposed development as outlined in the Local Structure Plan, is suited to the site based on an examination of hydrological, hydrogeological, environmental and engineering constraints related to water management.

Groundwater is not expected to constrain development with depths greater than 4m below ground level across the site. Nor is the development expected to have any significant impact on the pre-development water balance. Groundwater quality will be maintained or improved using WSUD principles.

The site is capable of managing stormwater for small, minor and major events and is able to treat the runoff to manage water quality within its POS areas. The extension of the existing sump by the proponent, to contain the additional runoff from the site is an efficient and effective approach to stormwater management, allowing the retention of mature trees in POS by minimising the water management area.

The site will have access to sufficient scheme water supply and sewer capacity provided by the local water and waste water service provider, the Water Corporation. There is also sufficient groundwater for irrigation of POS areas based on the secured groundwater license allocation.

Table 15 below summarises how the water management principles and objectives for the site will be met.

Table 15: Compliance with water management principles and objectives

Category	Principles	Objectives	Methods for achievement
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target • mandate Water Efficiency Labelling and Standards rated water efficient products, water efficient irrigation, waterwise landscaping and rainwater storage tanks for individual green title lots.	• potable water use estimated at 66 kL/day through mandating water efficient fittings and appliances and reduced garden areas • irrigation volumes for POS and schools will be kept within the current licenced allocation volume • POS design will maximise retention of native bushland, include extensive rehabilitation and minimise the use of turf in POS where not required.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and water-logging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% AEP event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010) • adopt 'at source' stormwater management approach and consider reducing pit and pipe drainage system significantly. Treat polluted runoff by installing appropriate treatment systems where required • consider managing stormwater runoff by providing overland flowpaths and opportunities for infiltration of runoff on lots, road reserves and public open space where site conditions permit • pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.	• Contain first 15mm of rainfall on lots and as high in the catchment as possible • control of groundwater levels on the site is not proposed and thus impacts on groundwater regimes will be limited • maintain pre-development flows off the site through detention and retention on site, while minimising land take for drainage to improve public amenity • no identified predevelopment flow from the site due to high infiltration rates. Small post development flow from the site due to design constraint of road network.
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality • retain and/or detain, and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.	• use of biofiltration areas • minimisation of turf areas and POS fertiliser use to reduce nutrient discharge to the environment • investigation and redevelopment of Brand Road landfill to manage and mitigate potential impacts to groundwater.

9. References

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Appendix 1
LWMS checklist

Checklist for assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide a brief description of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals.

LWMS item	Deliverable	Included?	Location in text
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMPs and critical control points	✓	Table 1 Sections 1 and 2
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		✓	Sections 1 and 2
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	✓ ✓	Section 1.1 and 3.2 Figures 1 and 2
Landscape - proposed POS areas, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape Plan	✓	Appendix 3 and Figure 3
Design criteria			
Agreed design objectives and source of objectives		✓	Section 2
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		✓	Sections 2 and 3
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	✓	Figures 1, 2 and 3
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	✓	Section 2.5, Figures 5, Appendix 8
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	✓	Section 2
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	n/a	No surface waters or flooding
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus site investigation	✓	Section 2.5-2.10 Figure 3
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		✓	Section 4
Water supply (fit-for-purpose), agreed actions and implementation		✓	Section 4
Wastewater management		✓	Section 4

LWMS item	Deliverable	Included?	Location in text
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detention storage areas	100yr event plan Long section of critical points	✓ ✓	Section 5 Figure 8
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5 yr event plan	✓	Section 5 Figure 7
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	✓ ✓	Section 5 Figure 6
Groundwater management strategy			
Post development groundwater levels, existing and likely final surface levels, outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil plan	n/a	No subsoil, good depth to GW
Actions to address acid sulfate soils or contamination		n/a	No ASS
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before to detailed design.		✓	Section 6
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		✓	Section 6.4
Implementation			
Developer commitments		✓	Section 6
Roles, responsibilities, funding for implementation		✓	Section 6
Review		✓	Section 6

Appendix 2
Groundwater monitoring communication

Carlie Slodecki
Senior Natural Resource Management Officer
Land Use Planning – Swan Avon Region
Department of Water and Environment Regulation
7 Ellam Street
VICTORIA PARK WA 6100

Our reference: STO18073.01

Dear Carlie

LOT 1665 WANNEROO ROAD SINAGRA, GROUNDWATER MONITORING TO SUPPORT LOCAL WATER MANAGEMENT STRATEGY

Strategen is preparing a Local Water Management Strategy (LWMS) for residential development of Lot 1665 Wanneroo Road Sinagra (the Site, Attachment 1). We wish to seek clarification regarding the adequacy of the groundwater information on the site for the endorsement of a LWMS.

The site comprises a total area of 39.95 ha and is located approximately 24 km north-northwest of Perth.

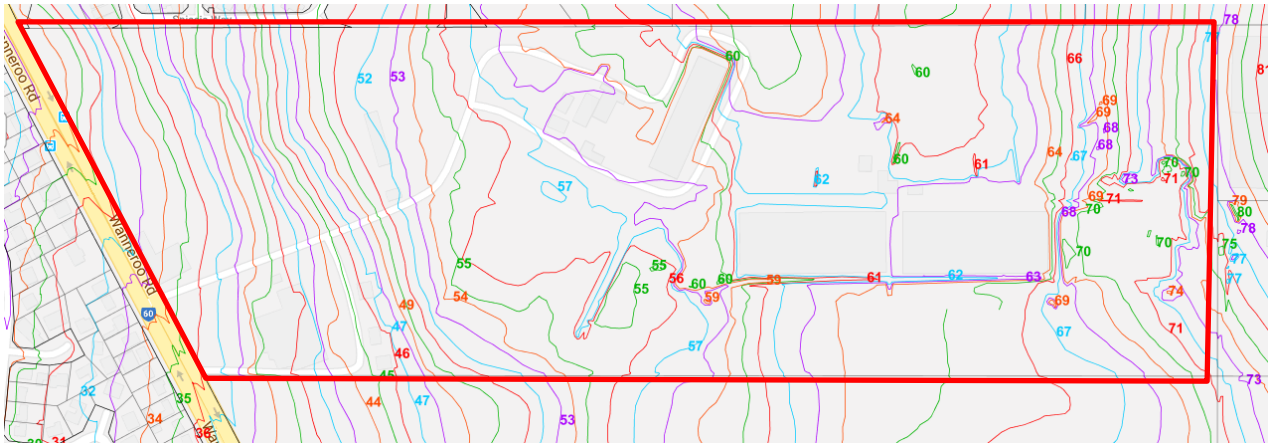
Current land use

The site is currently operated as a poultry farm. The poultry farm will be relocated prior to urban development. The site is not located in a Public Drinking Water Source Area.

Topography

The height of the site varies from approximately 27 mAHD in the northwest corner of the site to 78 mAHD in the northeast.

Figure 1: Topography



Soils and geology

The site lies within the Swan Coastal Plain which comprises of two main geological units, the Tamala Limestone and the Safety Bay Sand, both belonging to the early Pleistocene to Holocene Kwinana Group (Playford et al. 1976).

The site is solely comprised of the following unit:

- S7: SAND - pale and olive-yellow, medium to coarse-grained, angular to sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.

The soil profile encountered during the Detailed Site Investigation (DSI) at the site is broadly consistent with this description.

Once proposed basin locations are identified, hydraulic conductivity testing will be conducted at these locations.

Surface hydrology and wetlands

No surface water or wetlands are found within the site. The closest wetland of conservation significance is Lake Joondalup (Conservation Category Wetland; UFI 7954) approximately 450 m to the west of the site.

No known surface water has been observed during site inspections.

Because of the high hydraulic conductivity of the local soils (>10 m/day) and depth to groundwater, surface water features are not anticipated to occur on the site.

Groundwater levels

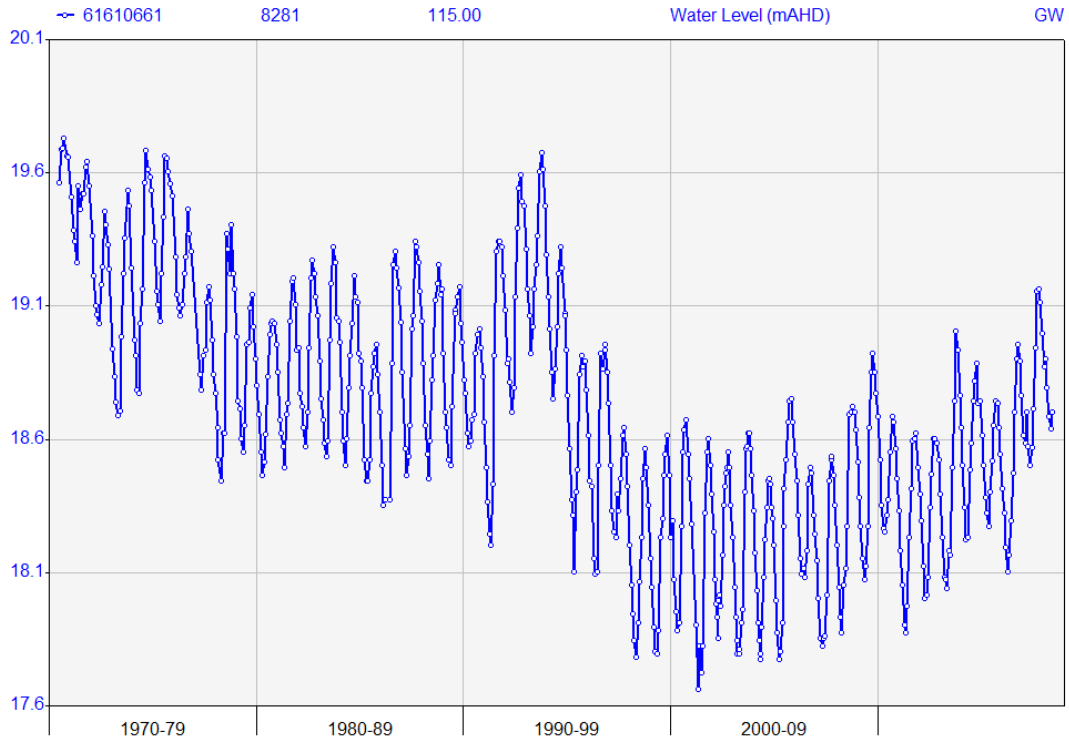
The DWER Perth Groundwater Map indicates the following:

- depth to groundwater beneath the site ranges from approximately 40 metres below ground level (mbgl) at the eastern property boundary, to approximately 5 mbgl at the western property boundary
- groundwater is inferred to flow to the west beneath the site towards Lake Joondalup
- groundwater is considered fresh with salinity is estimated at 250 – 500 mg/L of total dissolved solids (TDS).

Groundwater level and quality monitoring was undertaken as part of the DSI for the site on 8 September 2017 at GW1 and GW2 (Attachment 1). Logs for these bores are provided in Attachment 2.

The water levels in GW1 and GW2 were compared to the levels in the local superficial aquifer DWER Bore 8281, approximately 300 m west of the site (Attachment 1) to determine a Maximum Groundwater Level. DWER Bore 8281 (WIN ID 61610661) has been monitored at least six times per year since 1970, a period of 48 years (Figure 2). The levels in the DWER bore have also been utilised in developing the groundwater contours.

Figure 2: DWER bore record



The maximum water level recorded at the DWER bore is 19.728 mAHD recorded in September 1970. This level was used to determine a maximum groundwater levels for the bores on the site as presented in Table 1 through linear extrapolation. The MGL at this location was 0.574 m higher than the levels recorded in September 2017.

Table 1: Maximum groundwater level

	Easting	Northing	Top of casing (mAHD)	Level 8/9/17 (mAHD)	MGL (mAHD)
GW1	386339	6487103	36.56	25.016	25.59
GW2	387315	6487359	74.334	37.665	38.239
DWER 8281	385935	6487238	21.374	19.154	19.728

The MGL on the site is presented in Attachment 1. The MGL varies from 23 to 39 mAHD over the site. The depth to MGL is greater than 8 m over the majority of the site. The minimum depth to MGL is 4.4 m at the low point in the north-eastern corner of the site. The maximum depth to groundwater is 39.7 m in the north-east.

The separation of greater than 4 m, which is considered to provide adequate clearance to groundwater for finished floor levels and infiltration of stormwater at this location.

The monitoring confirms the generally westerly flow of groundwater towards Lake Joondalup, approximately 450 m to the west of the site.

Groundwater quality

Groundwater quality monitoring was undertaken at GW1 (downgradient of poultry activities) and GW2 (upgradient of poultry activities) as part of the DSI for parameters including nutrients, hydrocarbons and heavy metals. Results were compared to the relevant guidelines (Table 2, Table 3).

The concentrations of nutrients in groundwater were broadly similar at both the upgradient and downgradient monitoring locations, indicating that historical operations at the site has not resulted in an increase in nutrient concentration in groundwater. The data suggests that elevated concentrations of nutrients in groundwater is reflective of regional groundwater conditions and or groundwater quality migrating onto the site. This may be due to the large-scale nursery operations immediately upgradient of the site. Remediation of groundwater and soils on the site is anticipated to be limited to removal of soil asbestos contamination.

The quality of groundwater on the site is not considered to impact upon the methods selected for stormwater management on the site.

Conclusion

On the basis of the above information:

1. The depth to the maximum groundwater level on the site is greater than 4 m over the whole site, with depths less than 8 m only experienced in the north-west of the site. This is considered adequate clearance to finished floor levels and for infiltration of stormwater on the site.
2. Groundwater quality on the site is understood. Poultry farming activities on the site do not appear to have impacted upon groundwater quality. The quality of groundwater on the site is not considered to impact upon the methods selected for stormwater management on the site.

We trust the above information is sufficient for DWER to consider the proposed approach for the site. Should you have any queries please contact the undersigned.

Yours sincerely

Margaret Dunlop
SENIOR CONSULTANT

29 August 2018

Enclosure: Attachment 1, Attachment 2

Table 2: Nutrients and physico-chemcial parameters

		Physico-chemical Parameters				Nutrients						
		pH	Electrical Conductivity	Redox	Dissolved Oxygen	Total Nitrogen	NOx (as N)	Total Phosphorus	Fliterable Reactive Phosphorus	Nitrate-N	Ammonia (as N)	Sulphate (as SO_4)
ANZECC Freshwater guidelines		**6.5-8.5[1]**	**300-1,500 [2]**	**NE**	**NE**	**1**	**0.1**	**0.1**	**NE**	**NE**	**0.9**	**NE**
Non-potable use guidelines		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**113**	**NE**	**1,000**
	Limits of Reporting (LOR)	-	-	-	-	**0.1**	**0.005**	**0.05**	**0.01**	**0.005**	**0.02**	**1**
Sample ID	**Date Sampled**	**-**	**µs/cm**	**mV**	**ppm**	**mg/L**						
GW1	8/09/2017	6.78	783	117	6.72	**8.2**	**3.4**	**6.9**	0.04	3.4	<0.02	82
GW2	8/09/2017	7.42	1399	76	3.51	**4.1**	**2.4**	**6.8**	<0.01	2.3	0.03	210

Table 3: Dissolved metals results

		Dissolved Metals									
		Aluminium	Arsenic	Cadmium	Chromium*	Copper	Iron	Lead	Mercury	Nickel	Zinc
ANZECC Freshwater guidelines		**0.055**	**NE**	**0.0002**	**0.001***	**0.0014**	**NE**	**0.0034**	**0.00006**	**0.011**	**0.008**
Non-potable use guidelines		**0.2**	**0.1**	**0.02**	**0.05**	**20**	**0.3**	**0.1**	**0.01**	**0.2**	**NE**
	Limits of Reporting (LOR)	**0.01**	**0.001**	**0.0001**	**0.001**	**0.001**	**0.01**	**0.001**	**0.0001**	**0.001**	**0.005**
Sample ID	**Date Sampled**	**mg/L**									
GW1	8/09/2017	0.02	<0.001	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.0001	<0.001	<0.005
GW2	8/09/2017	<0.01	0.002	0.0002	<0.001	**0.002**	<0.01	0.001	<0.0001	0.003	**0.014**

Attachment 1

Created by ENVIRONMAPS | e. simoncrofts@environmaps.com.au | p. 0406 590 006

Legend

- Site Boundary
- Cadastre
- Groundwater Monitor Bore (Groundwater Level mAHD)
- Maximum Groundwater Level Contour (mAHD)

Depth to Groundwater (m)

- < 1.2
- 1.2 - 2.0
- 2.0 - 4.0
- 4.0 - 8.0
- 8.0 - 40.0

Scale: 1:5,000 @ A3

0 20 40 80 120 160 200 Meters

Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 28/08/2018
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2018
Orthophoto - Nearmaps, 17.06.18

GW2 (38.239 mAHD)
GW1 (25.59 mAHD)
DWER 8281 (19.728 mAHD)

Sinagra

Depth to Groundwater

Attachment 1

strategen ENVIRONMENTAL

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Attachment 2

GROUNDWATER LOG GW1

PROJECT NUMBER STO17087
PROJECT NAME Sinagra DSI
CLIENT Stockland
ADDRESS 1040 Wanneroo Road

DRILLING DATE 28/08/2017
TOTAL DEPTH 12.8
DIAMETER 50
CASING uPVC
SCREEN uPVC Factory Slotted

COMMENTS Southwest corner of the site. Stand pipe constructed approximately 1.0m above ground surface

LOGGED BY PM
CHECKED BY MT

PID	Samples	Analysed	% Recovery	Depth (m)	Graphic Log	Moisture	Material Description	Well Diagram
				0		D	SAND: fine grained, grey to white, well sorted, well graded, dry.	A: concrete; cement grout
				1				
				2			SAND: orange, medium grained, moderately sorted, moderately graded, dry.	backfill
				3				
				4				
				5				
				6				
				7				
				8				bentonite
				9				
				10				
				11				filter pack
				12				
				13			Termination Depth at: 12.8mbgl	
				14				

GROUNDWATER LOG GW2

PROJECT NUMBER STO17087
PROJECT NAME Sinagra DSI
CLIENT Stockland
ADDRESS 1040 Wanneroo Road

DRILLING DATE 28/08/2017 - 30/08/2017
TOTAL DEPTH 39.0
DIAMETER 50
CASING uPVC
SCREEN uPVC Factory Slotted

COMMENTS Northeast corner of the site. Stand pipe constructed approximately 1.0m above ground surface

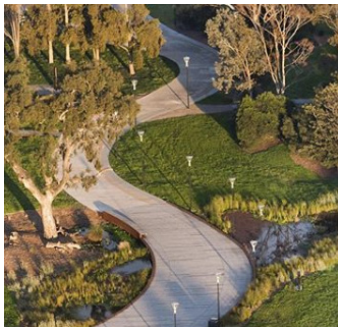
LOGGED BY PM
CHECKED BY MT

PID	Samples	Analysed	% Recovery	Depth (m)	Graphic Log	Moisture	Material Description	Well Diagram
				0		D	SAND: medium grained, orange, poorly sorted, moderately graded, dry.	cement grout
				16			GRAVELLY SAND: fine grained, pale yellow, poorly sorted, poorly graded, dry, limestone fragment / gravels.	backfill
				18			SAND: medium grained, orange, poorly sorted, moderately graded, dry.	
				20			GRAVELLY SAND: fine grained, pale yellow / white, poorly sorted and graded, dry, limestone gravels.	
				26			SAND: fine to medium grained, orange, poorly sorted and graded, dry.	bentonite
				38		W	SAND: medium grained, orange, poorly sorted and graded, wet.	filter pack
				40			Termination Depth at: 39 mbgl	

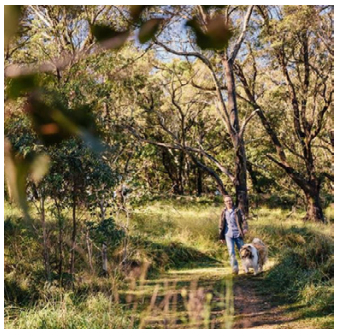
Disclaimer This bore log is intended for environmental not geotechnical purposes.
produced by ESlog.ESdat.net on 03 Oct 2017

Appendix 3
Landscaping and irrigation plans







Sinagra LWMS Landscape Inputs

Stockland

LD TOTAL
LEADERS IN LANDSCAPING

LANDSCAPE MASTER PLAN

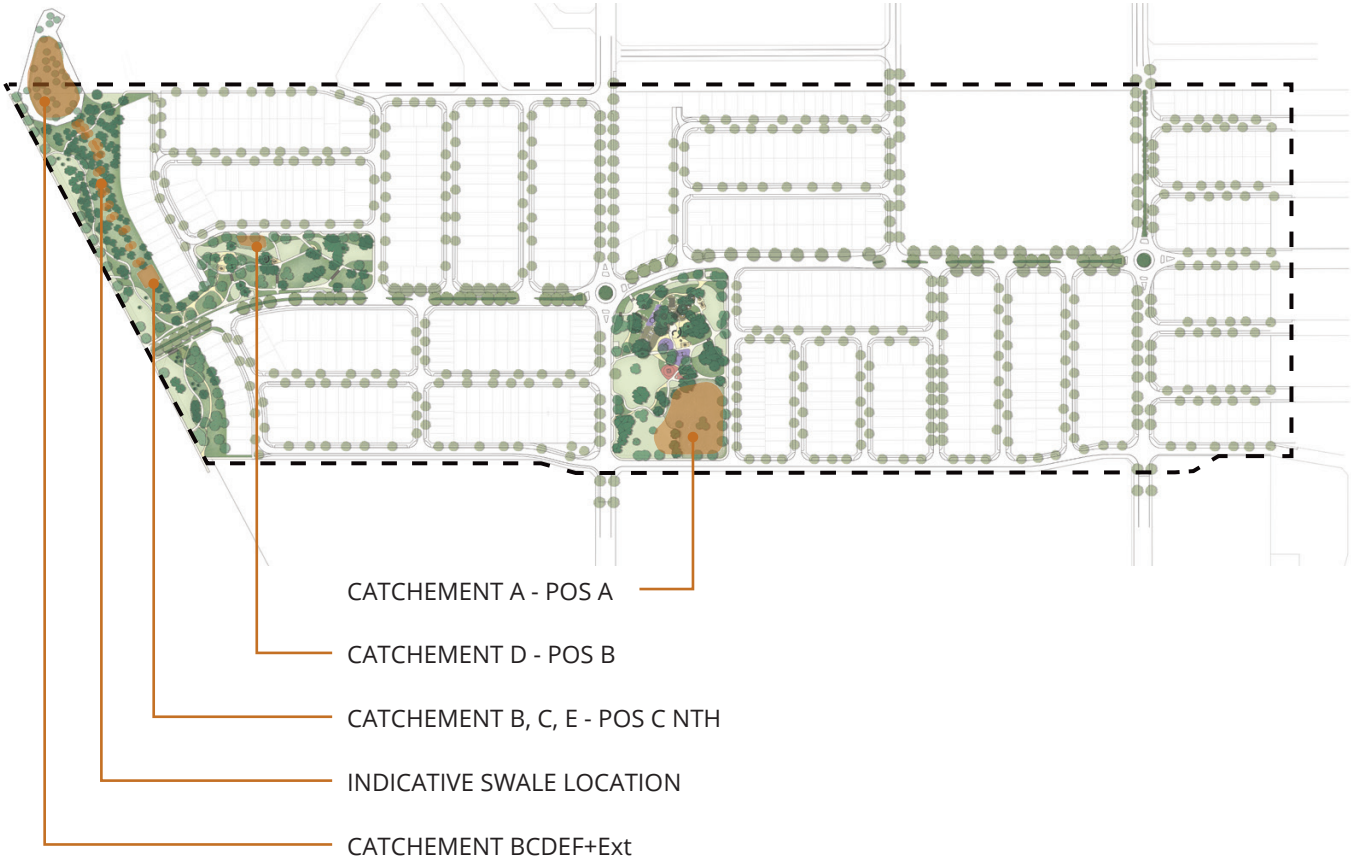
CONCEPT DESIGN

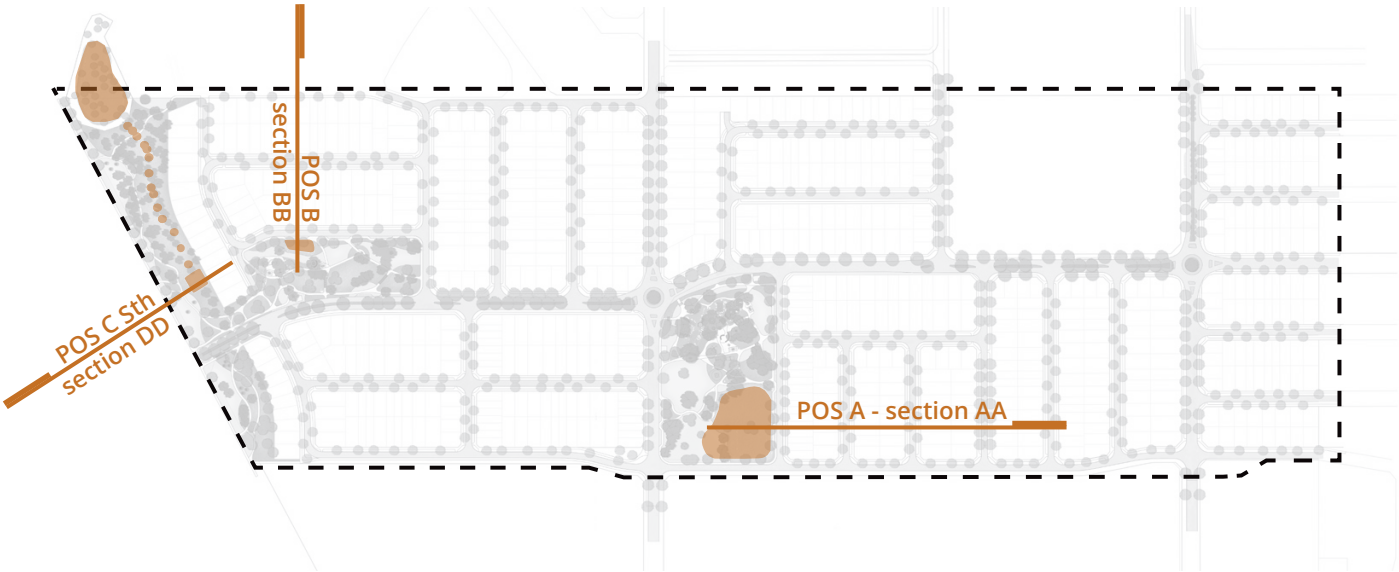
LEGEND

- A POS A - Neighbourhood Hero Park
- B POS B - Linear Park
- C POS C - Entry Park
- 1 Primary School co-located with DOS
- 2 Ultimate drainage sump
- 3 Future planted drainage basin
- 4 Entry boulevard
- 5 Connector streets
- Secondary streets
- POS trees
- Existing trees
- Proposed drainage
- Indicative swale location

POS DRAINAGE CATCHEMENTS

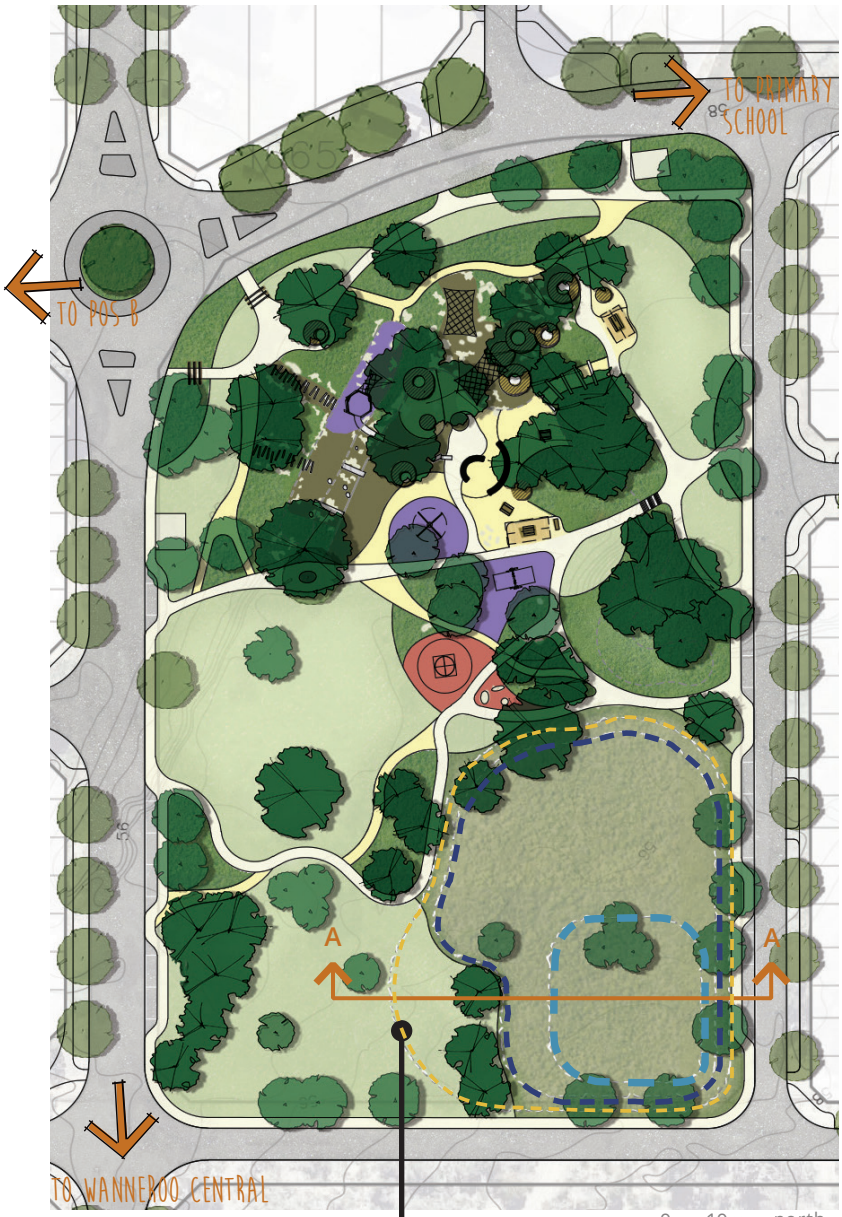
KEY PLAN





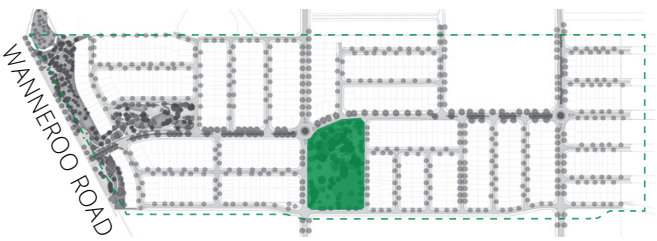
CATCHMENT A

POS A - NEIGHBOURHOOD HERO PARK

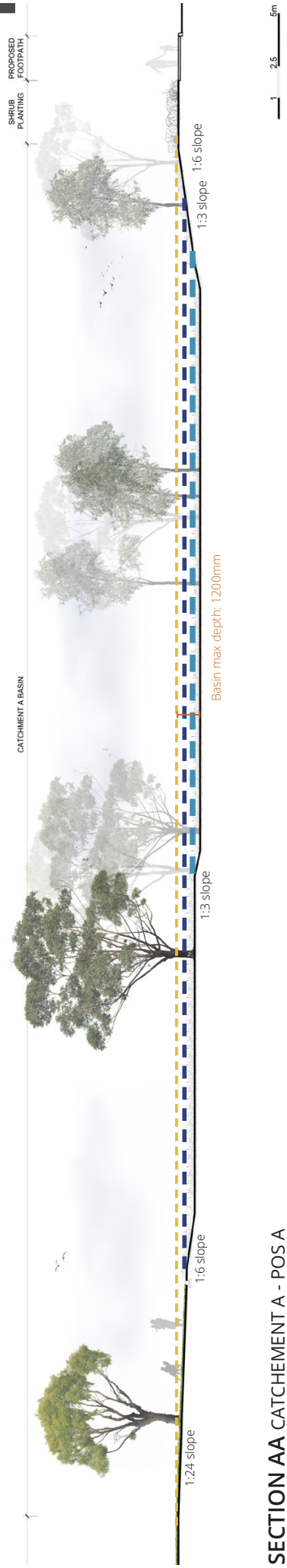


DRAINAGE

1yr 1hr	Area 811m²	Volume 357m³
18% AEP	Area 2929m²	Volume 991m³
1% AEP	Area 3882m²	Volume 2815m³



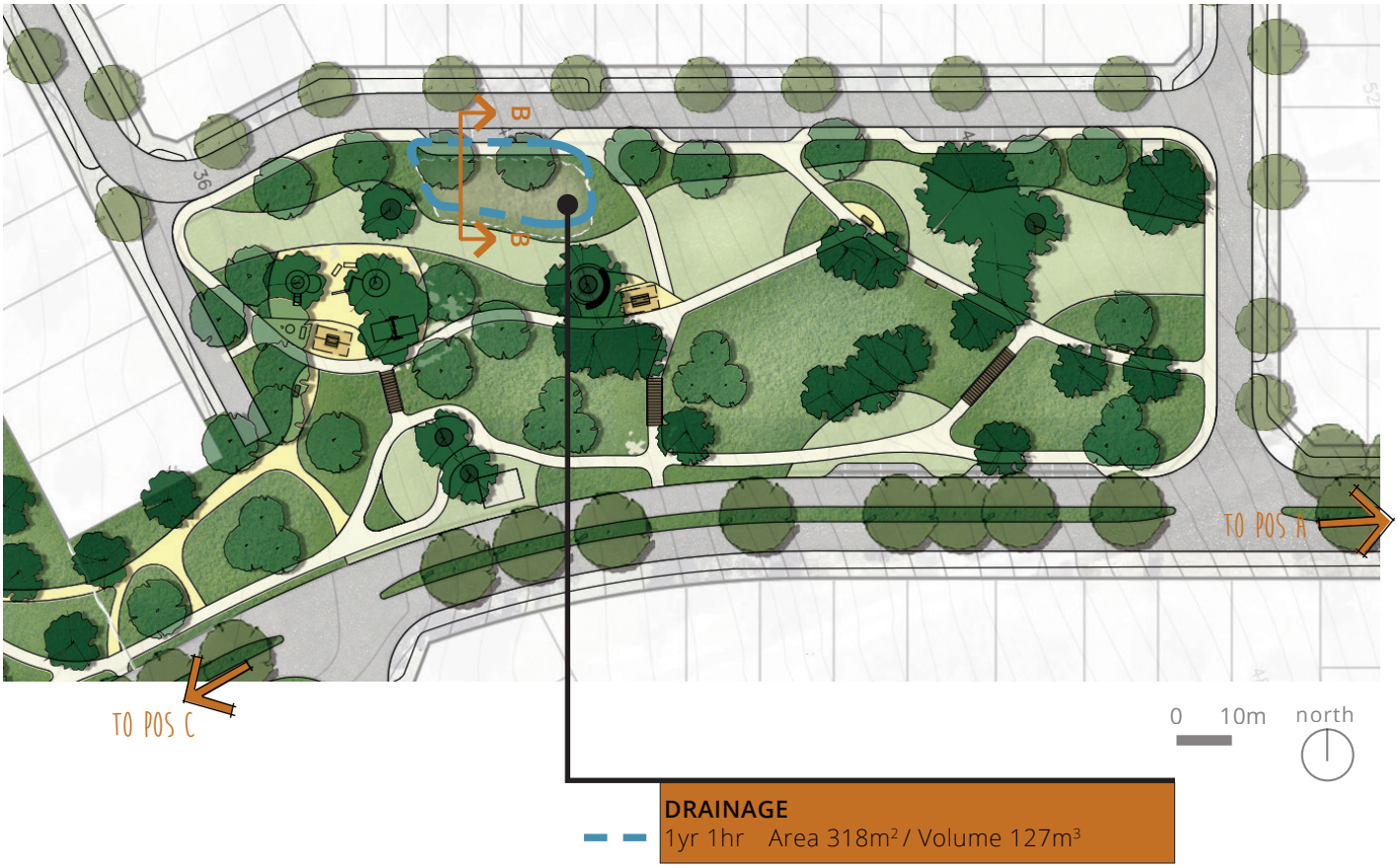
Sinagra LWMS Landscape Inputs

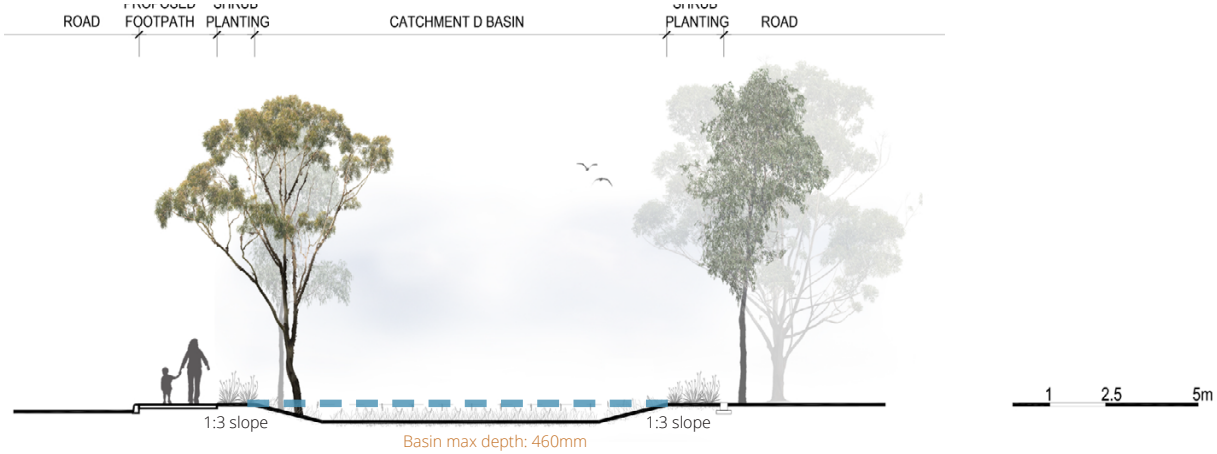


SECTION AA CATCHEMENT A - POS A

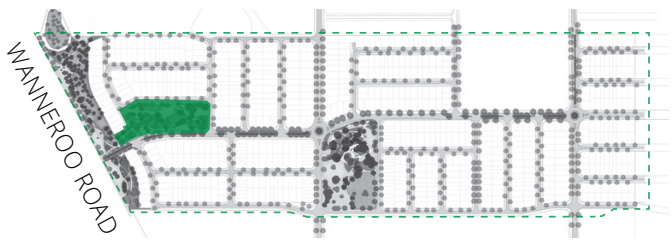
CATCHMENT D

POS B - LINEAR PARK





SECTION BB CATCHEMENT D - POS B



DRAINAGE
1yr 1hr
18% AEP
1% AEP

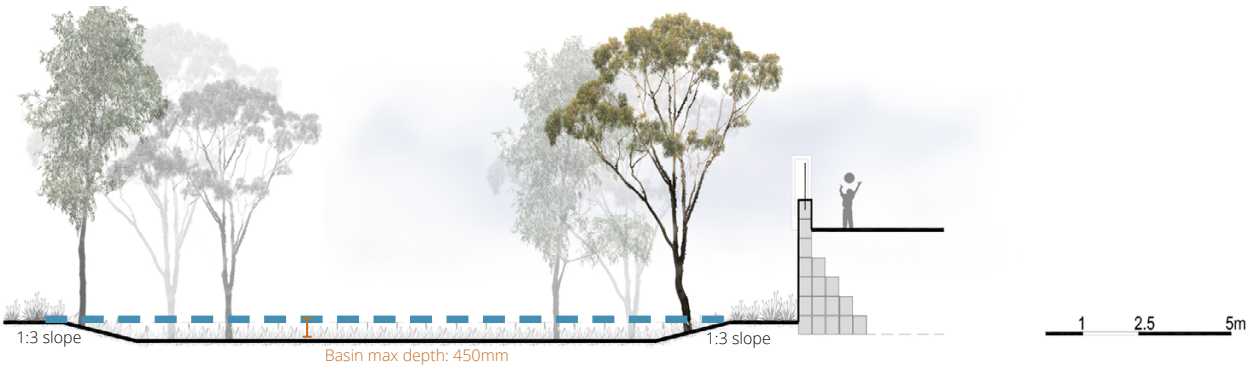
CATCHMENT B, C and E

POS C NORTH - ENTRY POS

0 10m north

POS DRAINAGE SECTIONS

CATCHEMENT B, C, E



SECTION CC CATCHEMENT B,C, E - POS C NTH

DRAINAGE
1yr 1hr

POS PLANTING PALETTE FOR BIOFILTERS

BIODIVERISTY IN LOCAL, WATERWISE AND ENDEMIC PLANTS

PROPOSED TREES

Eucalyptus gomphocephala
Tuart

Agonis flexuosa
WA Peppermint

Eucalyptus rudis
Flooded gum

Hakea laurina
Pin cushion Hakea

Melaleuca lanceolata
Rottnest Tea Tree

Melaleuca preissiana
Moonah

Melaleuca rhaphiophylla
Freshwater paperbark

Melaleuca teretifolia
Banbar








WETLAND SPECIES

Ficinia nodosa
Knotted Club Sedgerass

Juncus pallidus
Pale Rush

Lepidosperma gladiatum
Coastal Saw Sedge

Patersonia occidentalis
Purple Flag




POS PLANTING PALETTE FOR BIOFILTERS

BIODIVERISTY IN LOCAL, WATERWISE AND ENDEMIC PLANTS

PROPOSED SHRUBS

Conospermum stoechadis
Common Smokebush

Eremophila glabra
Tar Bush

Grevillea preissii
Grevillea Preissii

Guichenotia ledifolia
Guichenotia

Hakea lissocarpha
Honey bush

Hakea prostrata
Harsh Hakea

Hypocalymma angustifolium
White myrtle

Kunzea ericifolia
Spearwood

Kunzea glabrescens
Spearwood









Lot 1665 (#1040) Wanneroo Road, Sinagra

Irrigation Schedule to Support the LWMS - Landscape Master Plan

6,750kL/ha/a	Drainage Area	Total POS area m2 (including verges)	POS type (Passive)	Irrigated turf area % Long-term	Total POS turf area (m^2) Long-term	Long-term Volume (kL/yr)	Irrigated Planting area % Establishment (2yrs)	Irrigated POS planting area (m2) Establishment (2yrs)	Establishment (2yr) Volume (kL/yr)	TOTAL VOLUME (kL/yr)
PUBLIC OPEN SPACE (POS)										
POS A - including north portion of POS area	**YES**	22,485	Neighbourhood Park	33%	7420	**5,009**	53%	11,917	**8,044**	**13,053**
POS B	**YES**	11,870	Neighbourhood Park	33%	3917	**2,644**	50%	5,935	**4,006**	**6,650**
POS C - made up of north and south	**YES**	20,950	Neighbourhood Park	33%	6914	**4,667**	53%	11,104	**7,495**	**12,161**
SS - including blvd median	**NO**	3,500	NA	0%	0	**0**	100%	3,500	**2,363**	**2,363**
Total m2		58,805			18,251			32,456		
TOTAL VOLUME (kL/yr)						**12,319**			**21,907**	**34,227**

**Total water license allocation for site is 74,250kL/yr*

Appendix 4
Stormwater modelling data and results

Table 1: Modelling parameters and results

			Catch A	Catch B	Catch CE	Catch D	CDE+Ext
			1,5,100yr	1,5,100yr	1yr	1 yr	5,100yr
			POS A	POS C Sth	POS C Nth	POS B	Sump
		Soil permeability (m/d)	10	10	10	10	10
		Base RL (mAHD)	55.5	35.5	32	TBC	25.0
Biofiltration		Biofiltration area base width (m)	25	8	15	15	-
		Biofiltration area base length (m)	26	8	15	15	-
		Basin max depth (m)	0.5	0.5	0.5	0.5	-
		Side slope (1 in ?)	3	3	3	3	-
	AEP 63%	Max water level (m)	0.49	0.50	0.45	0.46	-
		Max water surface area (m2)	811	121	315	318	-
		Max volume in basin (m3)	357	46	123	127	-
		Time to empty from rain stopping (hrs)	1	1	2	1	-
		Total runoff volume (m3)	634	77	222	226	-
Basin or sump		Basin base width (m)	52	20	-	-	29
		Basin base length (m)	52	20	-	-	30
		Basin slope (1 in ?)	6	3	-	-	1.5
		Basin max depth (m)	0.9	0.5	-	-	3.5
		Basin capacity surface area (m2)	3944	529	-	-	1600
		Basin capacity volume(m3)	2974	232	-	-	4258
	AEP 18%	Max water level (m)	0.14	0.19	-	-	0.89
		Max water surface area (m2)	2891	447	-	-	1035
		Max volume in basin (m3)	467	86	-	-	1077
		Time to empty from rain stopping (hrs)	1	0	-	-	2
		Total runoff volume (m3)	2246	121	-	-	3088
	AEP 1%	Max water level (m)	0.85	0.50	-	-	3.43
		Max water surface area (m2)	3882	529	-	-	1585
		Max volume in basin (m3)	2815	230	-	-	4176
		Time to empty from rain stopping (hrs)	2	1	-	-	9
		Total runoff volume (m3)	5043	302	-	-	6669

Table 2: Catchment Areas

Catchment areas	Road (ha)	POS/school (ha)	Std lots (ha)	Small lot subdivision (ha) (<300m2)	Total area (ha)
A	5.281	5.323	4.805	6.03	21.438
B	0.641	0.384	0.399	0.48	1.904
C	1.241		1.689	0.72	3.650
D	1.883		4.146	0.42	6.449
E	0.608	2.448	1.565	0.24	4.861
F	0.519		0.561	0.27	1.350
G	0.402		0.119	0.51	1.031
External (north)	1.840	1.040	5.160		8.040
Total	12.414	8.155	13.282	8.670	40.682

Table 3: Runoff coefficients (City of Wanneroo, 2015)

Catchment	Road (ha)
Road <40m reserve	0.8
Road > 40m reserve	0.65
POS/school	0
Low density lot	0
Medium density lot	0.95
High density lot <300m2	0.95-1

Table 4: Frequency Factor

ARI	Fy
1	0.8
5	0.95
100	1.2

Appendix 5
East Wanneroo Cell 2 Adopted Structure Plan No 4

EAST WANNEROO CELL 2 - ADOPTED STRUCTURE PLAN No.4

Includes Amendment No. 2- 5, 7, 9 -12, 14

CAPORN STREET

ROAD

2A Public Open Space 3.8514 ha

2F P.O.S. 7159 sqm

2G P.O.S. 4975 sqm

2B P.O.S. 6308 sqm

PINJAR

VINCENT ROAD

2C Public Open Space 5.1772 ha

2H P.O.S. 7515 sqm

Primary School 3.5 ha

GRIFFITHS

2D Public Open Space 3.0404 ha

2E Public Open Space 2.6710 ha

WANNEROO ROAD

N

GDA

WANNEROO TOWN CENTRE

Subject to Agreed Structure Plan No. 23

MAJOR DISTRICT CENTRE

ROAD

DUNDEBAR ROAD

MAJOR DISTRICT CENTRE & EXISTING SHOPPING CENTRES

Legend

- CELL BOUNDARY
- PUBLIC OPEN SPACE
- SCHOOL
- DRAINAGE SUMP
- R10
- R25
- R30
- R40
- SPECIAL RESIDENTIAL

NOTE: Unless otherwise denoted the residential code is R20.

0 100 200 400 Metres

City of Wanneroo

Produced by Planning & Sustainability

22/10/2015

Appendix 6
City of Wanneroo sump drainage

REMOVE EXISTING CROSSOVER & CONSTRUCT NEW CONCRETE CROSSOVER TO COUNCIL STANDATD AT NEW LOCATION AS DETIRMEND ON SITE TO THE SATISFACTION OF THE SUPERINTENDENT, COUNCIL & LANDOWNER. (BRICK WALL/FENCE TO BE REMOVED & RECONSTRUCTED ON NEW BOUNDARY IN CONJUNCTION WITH NEW X-OVER)

PINJAR ROAD

TEMPORARILY CAP & SEAL OUTLET

REMOVE EXISTING CROSSOVERS CONSTRUCT NEW CONCRETE CROSSOVERS TO COUNCIL STANDARD

TEMPORARILY CAP & SEAL OUTLET

ROAD WIDENING ALONG PINJAR ROAD REFER DETAIL

EXISTING EDGE OF SEAL

REMOVE EXISTING SINGLE SLAB PATH & CONSTRUCT 2.1m D.U.P.

REMOVE EXISTING CROSSOVER CONSTRUCT NEW CONCRETE CROSSOVER TO COUNCIL STANDARD

REMOVE EXISTING PATH

REMOVE EXISTING SINGLE SLAB PATH & CONSTRUCT 2.1m D.U.P.

CONSTRUCT CONCRETE X-OVER AND LIMESTONE ACCESS

EXTEND DUP TO LINK WANNEROO ROAD DUP

SUMP BASE 25.50

VINCI ENTRANCE

1.8m PATH

PINTABONA DRIVE

FLORESTA STREET

FALCONE CR

2.1m DUP

EXISTING U/S 44.85 375/2/120 D 42.1 D/S 44.50

EXISTING 45.81

EXISTING 46.43

EXISTING U/S 45.25 300/2/157 D 55.0 D/S 44.90

EXISTING U/S 46.10 300/2/69 D 55 D/S 45.30

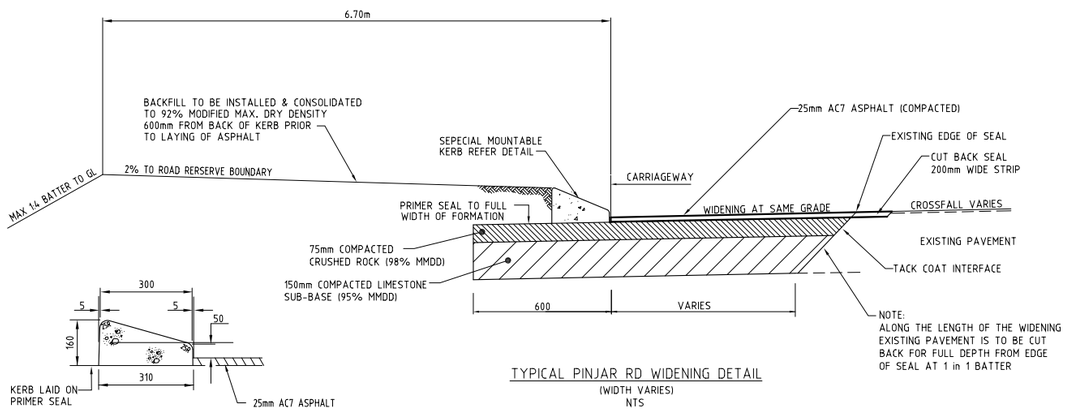
EXISTING 46.81

502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 547

MATCHLINE JOINS DRG No R-02

ROADWORKS & DRAINAGE LAYOUT

SCALE 1:500



TYPICAL PINJAR RD WIDENING DETAIL

(WIDTH VARIES)

NTS

'SPECIAL' MOUNTABLE KERB

1:10

AS CONSTRUCTED

AS CONSTRUCTED SURVEYOR	M.MATTABONI	DATE 19/6/07
AS CONSTRUCTED ENGINEER		DATE

DRAIN AND SEWER CLEARANCES

POINT NUMBER	DIL	SIL	CLEAR
1	32.03	31.64	0.19
2	33.47	33.05	0.22
3	34.45	33.38	0.87
4	35.65	35.00	0.45
5	36.44	35.81	0.43
6	36.96	37.23	0.07
7	38.28	37.61	0.47
8	40.11	39.35	0.56
9	34.85	34.37	0.28
10	35.00	34.40	0.40
11	35.17	34.86	0.11
12	39.49	38.79	0.50

(CLEAR = DIFF INV'S - PIPEØ - 0.050)

REFER DWG R-02 FOR NOTES AND LEGEND

1:500 (A1)

WAPC No : 128020

No.	DATE	BY	REVISION	
2	20/6/07	HJW	DRAINAGE AS CONSTRUCTED	SRA
1	18/04/07	JTH	LINE S3 TO S32 AMENDED TO CLEAR SERVICES	SRA
0	10/10/06	BWB	ISSUED FOR CONSTRUCTION	SRA
D	21/9/06	BWB	PATHS AMENDED, 2.1m DUP ALONG FLORESTA ST.	SRA
C	5/9/06	BWB	AMENDED TO COUNCILS APPROVAL. ISSUED FOR TENDER	SRA
B	17/8/06	BWB	DRAINAGE REVISED	SRA
A	10/07/06	BWB	ISSUED FOR APPROVAL/TENDER	S.R.A.

CLIENT: JAZNA PTY LTD

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: LOTS 23 TO 26 PINJAR ROAD SINAGRA STAGE 2

W.A.P.C. No. -

DRAWING: ROADWORKS AND DRAINAGE LAYOUT PLAN SHEET 1 OF 2

CAD DRAWING DO NOT MANUALLY ALTER

SCALE	DRAWN	CHECK	REV No.
1:500	JTH	S.R.A.	2
DATE	DESIGNED	APPROVED	
MAR 06	BWB	S.R.A.	

PROJECT NUMBER: SINJAZ02 R-01ASC

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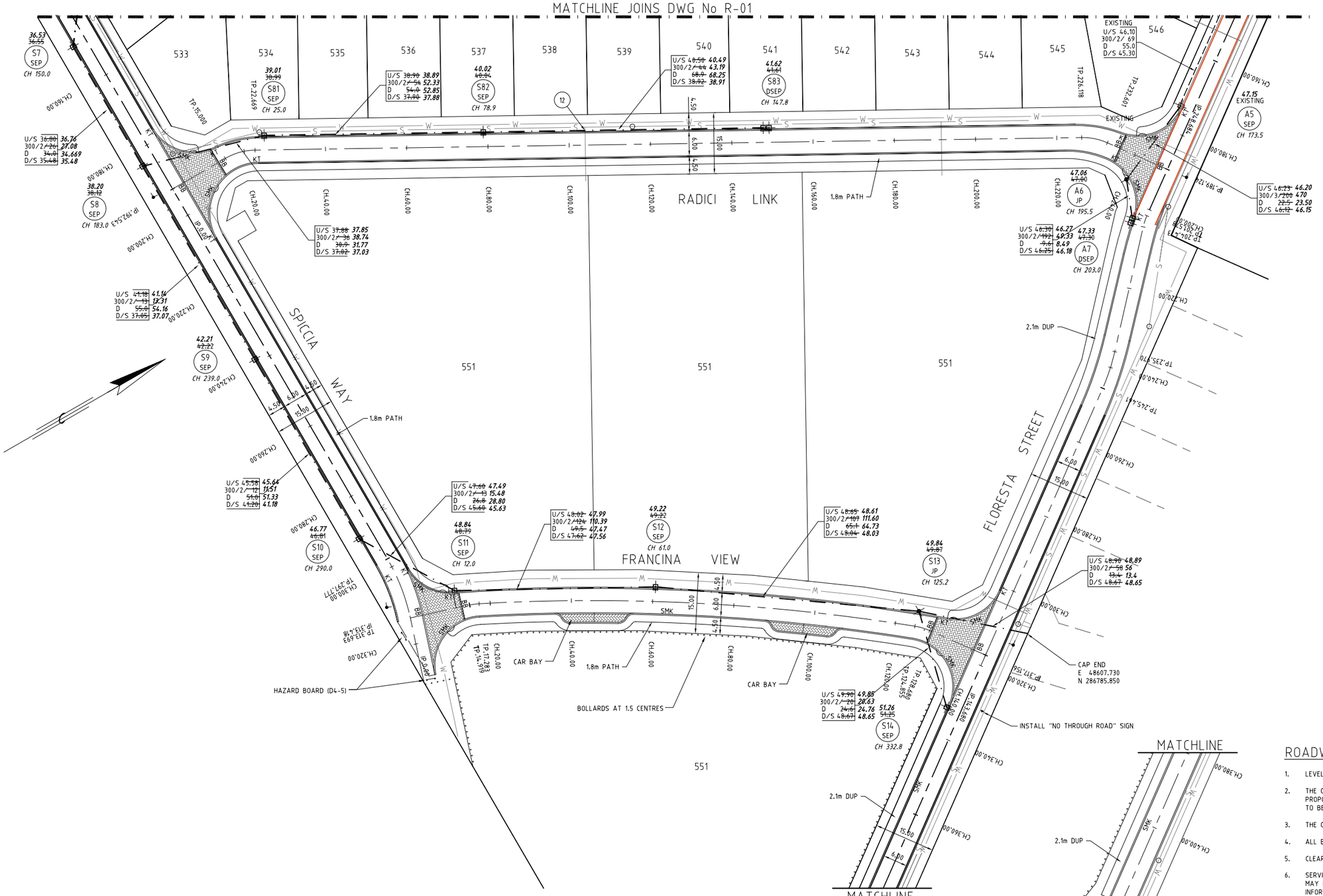
MATCHLINE JOINS DWG No R-01



ROADWORKS & DRAINAGE LAYOUT

SCALE 1:500

LEGEND

- PROPOSED WATER
- PROPOSED SEWER PIT & PIPE
- ℄ CHAINAGE MARK AND TANGENT POINT
- PROPOSED DRAINAGE PIPE MANHOLE & SIDE ENTRY PIT
- DENOTES PRAM RAMP REFER TO DETAIL ON DWG R15
- PROPOSED BRICK PAVEMENT
- BOND BEAMS
- MOUNTABLE KERB M-1 U.O.N
- BLACK ASPHALT AC7 U.O.N
- FLUSH KERB
- ROAD SIGN AS PER COUNCIL STANDARDS AND SHOWN IN SPECIFICATIONS
- HAZARD BOARD (D4-5)
- BRICK PAVING

SM	SEMI MOUNTABLE KERB
BB	BOND BEAM
FK	FLUSH KERB
KT	KERB TRANSITION

DRAINAGE STRUCTURES

- (1) POINT No OF SEWER CROSSING
- U/S 00.00 — UPSTREAM INVERT LEVEL
- 300/2/200 — PIPE DIA/ CLASS/ GRADE
- D- 00.0 — PIPE LENGTH
- D/S 00.00 — DOWNSTREAM INVERT LEVEL
- 23.25 — LEVEL OF PIT LID/GRATE
- (A1 SEP) — PIT NUMBER / PIT TYPE
- CH23.5 — CHAINAGE

- (GP) GULLY PIT (CIRCULAR U.N.O)
- (JP) JUNCTION PIT (CIRCULAR U.N.O)
- (SEP) SIDE ENTRY PIT
- (SEPG) SIDE ENTRY PIT / GULLY COMBINATION
- (HW) HEADWALL
- (LCP) LOT CONNECTION PIT
- (SW) SOAKWELL - 1800Ø
- SOAKAGE PIT
- (RO) ROD OUT

ROADWORKS NOTES

1. LEVEL DATUM - AUSTRALIAN HEIGHT DATUM.
2. THE CONTRACTOR SHALL CO-ORDINATE THE LOCATION OF ALL EXISTING AND PROPOSED SERVICES PRIOR TO COMMENCEMENT OF WORK. ANY CONFLICTS ARE TO BE REPORTED TO THE SUPERINTENDENT IMMEDIATELY.
3. THE CONTRACTOR SHALL LOCATE ALL LEVELS FROM EXISTING BENCH MARKS.
4. ALL BENCH MARKS ARE TO BE PROTECTED.
5. CLEARING SHALL BE KEPT TO AN ABSOLUTE MINIMUM
6. SERVICES, SUCH AS WATER, GAS, TELEPHONE, ELECTRICITY, AND DRAINAGE MAY BE ENCOUNTERED DURING CONSTRUCTION OF THE WORKS. SERVICES INFORMATION SHOWN ON DRAWINGS IS INDICATIVE ONLY AND MAY NOT BE COMPLETE. BEFORE EXCAVATION COMMENCES THE LOCATION OF ALL SUCH SERVICES SHALL BE OBTAINED FROM THE RELEVANT AUTHORITIES
7. DESIGN LEVELS SHOWN SHALL BE ON THE FINISHED SURFACE INCLUDING TOPSOIL.
8. SIGN POSTS AND STREET NAME PLATES SHALL BE SUPPLIED AND INSTALLED TO COUNCIL REQUIREMENTS.
9. BRICK PAVING IN ROADS & LOT ACCESS SHALL BE BGC 80mm DEKOPAVE IN HERRINGBONE PATTERN WITH EASIPAVE HEADER - COLOUR ANTIQUE BLEND
10. BRICK PAVING IN ISLAND SHALL BE BGC 60mm EASIPAVE IN HERRINGBONE PATTERN WITH EASIPAVE HEADER - COLOUR CHARCOAL
11. ALL KERBING TO BE MOUNTABLE (TYPE 1) U.O.N.

1:500 (A1)

AS CONSTRUCTED

AS CONSTRUCTED SURVEYOR	M.MATTABONI DATE 19/6/07
AS CONSTRUCTED ENGINEER	DATE

WAPC No : 128020

No.	DATE	BY	REVISION
2	19/6/07	HJW	DRAINAGE AS CONSTRUCTED
1	21/03/07	JTH	LINE ACROSS FLORESTA STREET FROM S13 ADDED
0	10/10/06	BWB	ISSUED FOR CONSTRUCTION
D	21/9/06	BWB	PATHS AMENDED, 2.1m DUP ALONG FLORESTA ST, 1.8m PATH ALONG ROAD THREE.
C	5/9/06	BWB	AMENDED TO COUNCILS APPROVAL. ISSUED FOR TENDER
B	17/8/06	BWB	DRAINAGE REVISED
A	10/07/06	BWB	ISSUED FOR APPROVAL/TENDER

	SRA	
	SRA	
	SRA	
	SRA	
	SRA	
	SRA	
	S.R.A.	

CLIENT: JAZNA PTY LTD

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: LOTS 23 TO 26 PINJAR ROAD SINAGRA STAGE 2
W.A.P.C. No. -

DRAWING: ROADWORKS AND DRAINAGE LAYOUT PLAN SHEET 2 OF 2
CAD DRAWING DO NOT MANUALLY ALTER

SCALE	DRAWN	CHECK	REV No.
1:500	JTH	S.R.A.	2
DATE: MAR 06	DESIGNED: BWB	APPROVED: S.R.A.	

PROJECT NUMBER: SINJAZ02 R-02ASC
S:\Dat\SINJAZ02\DRAWINGS\SINJAZ02 R-02ASCON.dwg 22/06/2007

CATCHMENT	AREA	(IMP)
WANNEROO ROAD	~4.46ha	3.57ha (PROVIDED BY COW)
PINJAR REALIGNMENT CH 0.00 - CH 300	1.19ha	0.95ha
TOTAL	5.19ha	4.52ha
REQUIRED STORAGE	100yr	6015m³

CATCHMENT	AREA	(IMP)
SUBDIVISION LOTS 23,24,25 &26	2.07ha	1.66ha
REQUIRED STORAGE	100yr	2208m³
PINJAR REALIGNMENT CH 300 - CH 500	0.78ha	0.62ha
CH 500 - CH 1250	3.30ha	2.64ha
EXIST. PINJAR RD (NORTH SIDE)	0.45ha	0.36ha
SUB-TOTAL	4.53ha	3.62ha
TOTAL	6.60ha	5.28ha
REQUIRED STORAGE	100yr	7022m³

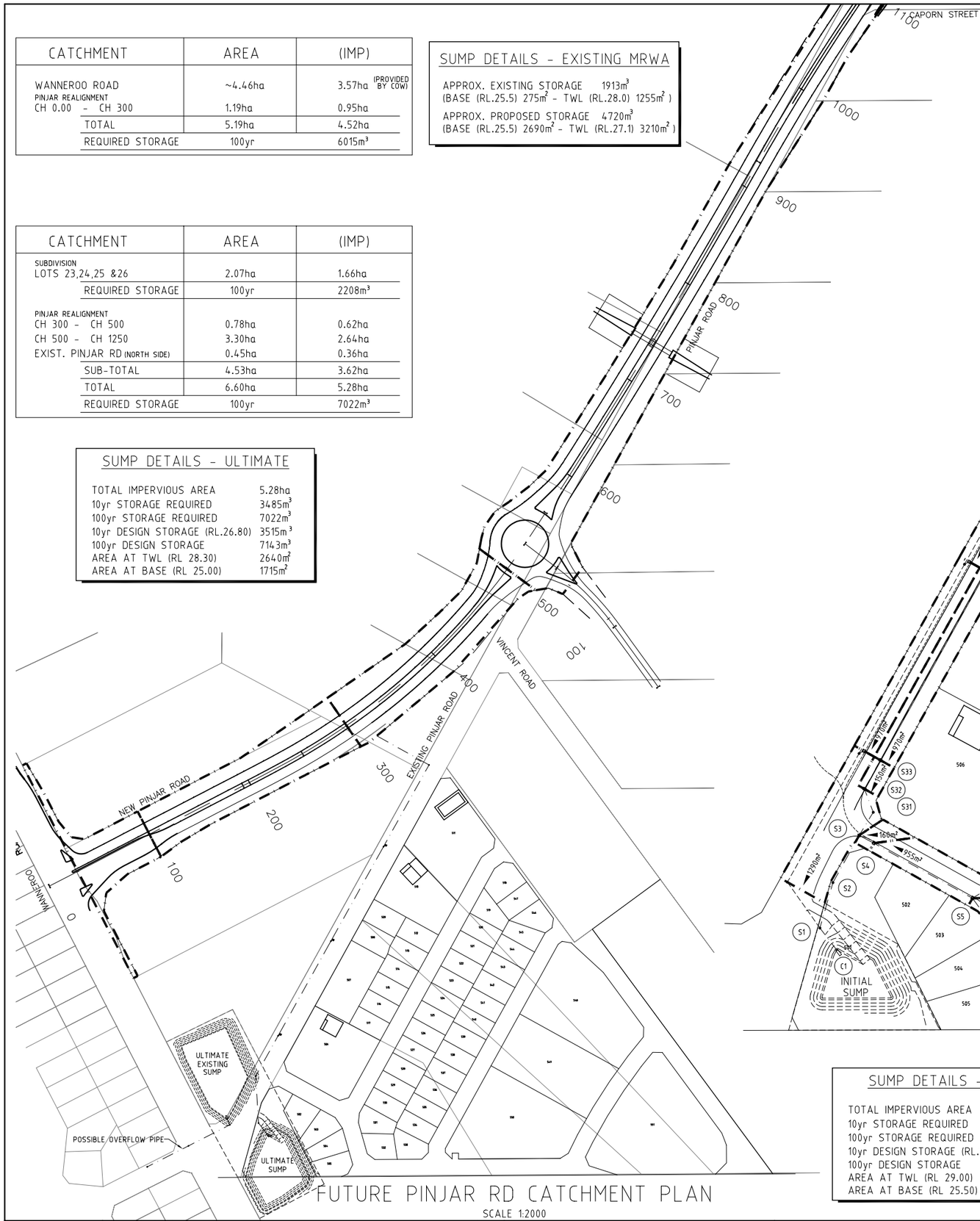
SUMP DETAILS - ULTIMATE

TOTAL IMPERVIOUS AREA	5.28ha
10yr STORAGE REQUIRED	3485m³
100yr STORAGE REQUIRED	7022m³
10yr DESIGN STORAGE (RL.26.80)	3515m³
100yr DESIGN STORAGE	7143m³
AREA AT TWL (RL 28.30)	2640m²
AREA AT BASE (RL 25.00)	1715m²

SUMP DETAILS - EXISTING MRWA

APPROX. EXISTING STORAGE 1913m³
(BASE (RL.25.5) 275m² - TWL (RL.28.0) 1255m²)

APPROX. PROPOSED STORAGE 4720m³
(BASE (RL.25.5) 2690m² - TWL (RL.27.1) 3210m²)



FUTURE PINJAR RD CATCHMENT PLAN

SCALE 1:2000

SUMP DETAILS - INITIAL

TOTAL IMPERVIOUS AREA	1.66ha
10yr STORAGE REQUIRED	1096m³
100yr STORAGE REQUIRED	2208m³
10yr DESIGN STORAGE (RL.27.5)	1172m³
100yr DESIGN STORAGE	2545m³
AREA AT TWL (RL 29.00)	1025m²
AREA AT BASE (RL 25.50)	429m²

SUBDIVISION CATCHMENT PLAN

SCALE 1:1000

1:1000 (A1)

1:2000 (A1)

CAD DRAWING DO NOT MANUALLY ALTER

No.	DATE	BY	REVISION	APPROVED
D	29/8/07	BWB	ULTIMATE SUMP DETAILS REVISED TO AMENDED SUPM DESIGN	RDG
C	11/9/06	BWB	CATCHMENTS AMENDED TO SUIT NEW DRAINAGE LAYOUT (S1 TO S7)	RG
B	11/7/06	BWB	IMPERVIOUS AREA CALCULATION ADJUSTED	RG
A	10/7/06	BWB	ISSUED FOR APPROVAL	RG

CLIENT: **JAZNA PTY LTD**

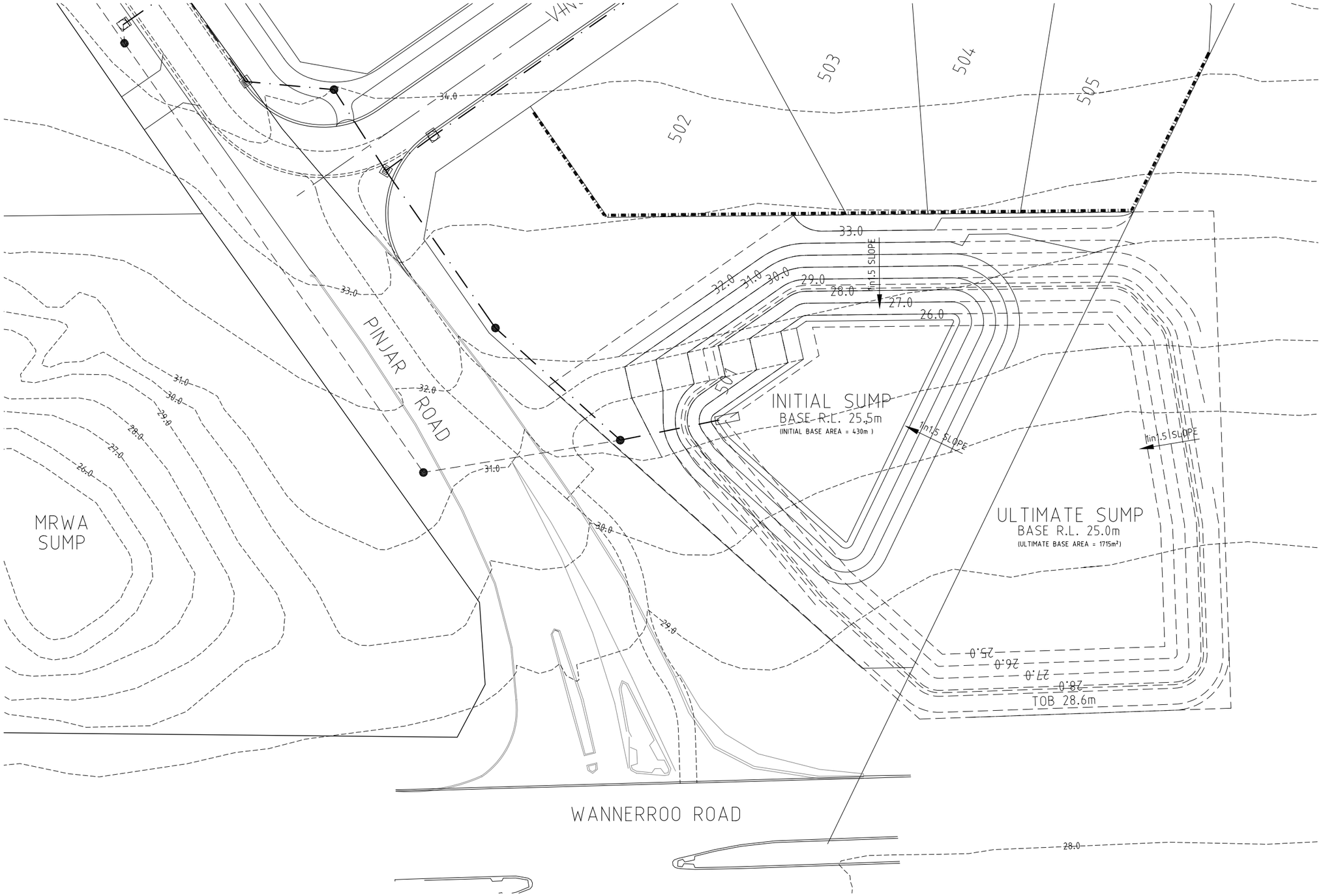
DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 23 TO 26 PINJAR ROAD SINAGRA**

DRAWING: **DRAINAGE OVERALL CATCHMENT PLAN**

SCALE: AS SHOWN	DRAWN: BWB	CHECK: S.R.A.	REV No. D
DATE: JUNE 06	DESIGNED: BWB	APPROVED: S.R.A.	

PROJECT NUMBER: **SINJAZ02 D01**



SUMP DETAILS - INITIAL

TOTAL IMPERVIOUS AREA	1.66ha
10yr STORAGE REQUIRED	1096m³
100yr STORAGE REQUIRED	2208m³
10yr DESIGN STORAGE (RL.27.5)	1172m³
100yr DESIGN STORAGE	2545m³
AREA AT TWL (RL 29.00)	1025m²
AREA AT BASE (RL 25.50)	429m²

SUMP DETAILS - ULTIMATE

TOTAL IMPERVIOUS AREA	5.28ha
10yr STORAGE REQUIRED	3485m³
100yr STORAGE REQUIRED	7022m³
10yr DESIGN STORAGE (RL.26.80)	3515m³
100yr DESIGN STORAGE	7143m³
AREA AT TWL (RL 28.30)	2640m²
AREA AT BASE (RL 25.00)	1715m²

1:250 (A1)

No.	DATE	BY	REVISION	
A	29/08/07	BWB	ISSUED FOR INFORMATION	RDG

CLIENT: **JAZNA Pty. Ltd.**

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 23 TO 26 PINJAR ROAD SINAGRA**

DRAWING: **DRAINAGE SUMP PLAN**

CAD DRAWING DO NOT MANUALLY ALTER

SCALE	DRAWN	CHECK	REV No.
1:250	BWB	RDG	A
DATE: AUGUST 07	DESIGNED: BWB	APPROVED: RDG	

PROJECT NUMBER: **SINJAZ02-D02**

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Appendix 7
Geotechnical report

Report on

DUE DILIGENCE LEVEL GEOTECHNICAL STUDY PROPOSED RESIDENTIAL SUBDIVISION INGHAM CHICKEN SITE LOT 1665 WANNEROO ROAD, SINAGRA

Submitted to:

Stockland
C/- Cossill and Webley Consulting Engineers
B12, 431 Roberts Road
SUBIACO, WA 6008

www.galtgeo.com.au
4/15 Walters Drive
OSBORNE PARK WA 6017
T: +61 (8) 6272-0200

J1701214 001 R Rev0

09 October 2017

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This report presents Galt Geotechnics Pty Ltd's (Galt's) proposal for a due diligence geotechnical study for a proposed residential development on the Ingham Chicken site on Lot 1665 Wanneroo Road, Sinagra ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The work was authorised by Troy Boekeman of Cossill and Webley Consulting Engineers (C&W) on behalf of Stockland in an email dated 12 September 2017.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the site is approximately rectangular in plan with an area of about 40.13 hectares. It is bounded by residential developments and an olive orchard to the north, commercial activities to the east, undeveloped land to the south and Wanneroo Road (Charles Street) to the west.

The site is currently an operating chicken farm and about half of the site is occupied by infrastructure associated with the Chicken Farm including two long steel framed sheds located centrally in the eastern half of the site, a process plant and associated shed located midway along the northern boundary, sheds and other infrastructure in the south west corner and access roads and other pavements. The remainder of the site is relatively open ground covered with occasional isolated and groups of trees.

Information provided shows that the site surface slopes up from about RL 29 m AHD at Wanneroo Road to about RL 80 m AHD at the rear (eastern extent) of the site. This is generally in line with our observations made in a site walkover. However it was also noted that:

- fill had been placed to accommodate various structures and car parking areas across the site;
- significant excavation had been conducted to accommodate the two long steel framed sheds located centrally in the eastern half of the site; and
- an area about midway along the southern boundary had been lowered by excavation and numerous limestone pinnacles were exposed at the surface (refer to Figure 1).

A preliminary layout plan provided (Appendix A) shows that the development is to comprise:

- about 695 lots ranging in size from 187 m^2 to 450 m^2;
- a primary school site about 3.5 hectares;
- areas of Public Open Space totalling about 4.21 hectares; and
- a drainage area of about 0.5 hectares.

We assume that the proposed structures will typically be of single to double storey brick masonry or steel framed construction supported on shallow footings. We also assume that:

- retaining walls will be constructed to provide level lots;
- stormwater will be disposed on-site by infiltration into the ground.

A preliminary earthworks plan shows that significant excavation is required (up to about 8 m).

3. PROJECT OBJECTIVES

The objectives of the study were to address the following at a high level, for the assessment of project risk (but not for detailed design):

- broadly assess subsurface soil and groundwater conditions across the site including the presence of rock;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide preliminary recommendations and geotechnical design parameters for earth retaining structures;
- provide preliminary site preparation procedures including compaction criteria;
- broadly assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others.

4. FIELDWORK

Fieldwork was conducted over three days from 25 September 2017 through to 28 September 2017 and comprised:

- a walkover survey of the site including taking photographs;
- clearing of each of the test sites for services;
- cone penetration tests (CPT) at 10 locations extending to depths of up to 8.2 m;
- excavation of 20 test pits (TP01 to TP20), extending to depths of up to 2.9 m;
- drilling of 8 hand auger boreholes (HA01 to HA08) , to a depth of 2.0 m;
- testing with a Perth sand penetrometer (PSP) adjacent to each test pit and borehole;
- Infiltration tests using the inverse auger hole' method at 8 locations, at depths ranging from approximately 0.5 m to 1.0 m; and
- collection of representative samples for laboratory testing

General

A senior geotechnical engineer from Galt conducted the walkover survey. A geotechnical engineer from Galt positioned and located the test positions, observed the CPTs and excavation of the test pits, logged the soils encountered in the test pits and boreholes, performed the penetrometer and infiltration testing, and collected samples for inspection and laboratory testing.

The test locations are shown on Figure 1 and are summarised in Table 1: Summary of Tests. Photographs of the site are presented in Appendix B, Site Photographs.

Table 1: Summary of Tests

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
CPT01	5.7	GNE	Refusal	SAND overlying inferred Limestone
CPT02	8.2	5.2	Target depth	SAND
CPT03	8.2	GNE	Target depth	
CPT04	2.1	GNE	Refusal	SAND overlying inferred Limestone
CPT05	8.2	GNE	Target depth	SAND
CPT06	8.2	GNE	Target depth	
CPT07	8.2	GNE	Target depth	
CPT08	8.2	GNE	Target depth	
CPT09	8.2	GNE	Target depth	
CPT10	8.2	GNE	Target depth	
TP01	2.6	GNE	Target depth	SAND

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
TP02	2.6	GNE	Target depth	
TP03	2.7	GNE	Target depth	
TP04	2.6	GNE	Target depth	SAND with some Limestone gravel overlying SAND
TP05	2.6	GNE	Target depth	SAND
TP06	2.6	GNE	Target depth	
TP07	1.7	GNE	Collapse	
TP08	0.7	GNE	Services encountered	
TP09	2.9	GNE	Target depth	
TP10	2.5	GNE	Target depth	SAND with some Limestone gravel overlying SAND
TP11	2.6	GNE	Target depth	
TP12	2.4	GNE	Target depth	SAND
TP13	2.8	GNE	Target depth	SAND with some Limestone gravel overlying SAND
TP14	0.4	GNE	Services encountered	SAND
TP15	2.0	GNE	Collapse	SAND with Limestone gravel and cobbles
TP16	2.0	GNE	Collapse	Gravelly SAND with Limestone gravel and cobbles. Limestone pinnacles present on south and east side of test pit from 0.3 m depth to termination.
TP17	1.8	GNE	Collapse	SAND
TP18	1.9	GNE	Collapse	
TP19	1.6	GNE	Collapse	
TP20	1.5	GNE	Collapse	
HA01	2.0	GNE	Target depth	SAND
HA02	2.0	GNE	Target depth	
HA03	2.0	GNE	Target depth	
HA04	0.7	GNE	Refusal	SAND overlying inferred Limestone
HA05	2.0	GNE	Target depth	SAND
HA06	2.0	GNE	Target depth	
HA07	1.7	GNE	Refusal	SAND overlying inferred Limestone
HA08	2.0	GNE	Target depth	SAND

Notes **1.** GNE – groundwater not encountered

2. Stratigraphy below 2.8 m inferred from CPT results

Cone Penetration Tests

Cone penetration tests (CPTs) were undertaken using a 7 tonne track mounted CPT rig supplied and operated by Probedrill Pty Ltd. The testing was undertaken in accordance with AS 1289.6.5.1. The results of the CPTs are presented in Appendix C, Cone Penetration Test Results, along with a method of interpretation proposed by Robertson et al. (1986).

Test Pits

Test pits were excavated using a JCB 3CX backhoe equipped with a 0.5 m wide bucket supplied and operated by Galt. Test pit reports are presented as Appendix D, Test Pit reports, along with a list of notes and abbreviations, the method of soil description and the method of cementation classification used on the reports.

Hand Auger Boreholes

Hand auger boreholes were drilling using a 90 mm nominal diameter auger. Hand auger borehole reports are presented in Appendix E, Summary Hand Auger Borehole Reports along with the method of soil description used in the reports. A photograph of the spoil recovered for each borehole is also included in the reports.

Perth Sand Penetrometer (PSP) Testing

Perth sand penetrometer (PSP) tests were conducted in accordance with AS 1289.6.3.3 although to a greater depth than the 0.45 m covered in the standard. Furthermore, blow counts were recorded per 150 mm interval. Results of the PSP testing are presented in Appendix F, PSP Test Results.

Infiltration Testing

Infiltration testing was carried out using the inverse auger hole method described by Cocks[1]. The results of the unsaturated permeability testing are presented in Appendix G, Infiltration Test Results and are summarised in Table 2, Summary of Infiltration Test Results.

Table 2: Summary of Infiltration Test Results

Test Location	Test Depth (m)	Stratigraphy[1]	Minimum Unsaturated Permeability[1], k (m/day)		
			Test 1	Test 2	Test 3
IT01	0.85	SAND	>15	>15	>15
IT02	1.00		>15	>15	>15
IT03	0.75		>15	>15	>15
IT04	0.70		>15	>15	>15
IT05	1.10		>15	>15	>15
IT06	1.00		11.8	10.8	8.3
IT07	0.80		>15	>15	>15
IT08	1.00		>15	>15	>15

Notes: 1. The minimum permeabilities shown are typically recorded towards the end of the test, with pressure head varying between about 0.0 m and 0.9 m.

5. LABORATORY TESTING

Laboratory testing of soil samples was undertaken by Liquid Labs WA Pty Ltd in their Welshpool based NATA accredited laboratory and comprised determination of particle size distribution of five samples.

Laboratory test results along with the test methods followed are presented in Appendix H and are summarised in Table 3: Summary of Laboratory Test Results.

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114.

Table 3: Summary of Laboratory Test Results

Test ID	Depth (m)	Unified Soils Classification	% Gravel	% Sand	% Fines
HA01	0.4-1.0	SP	0	99	1
TP06	0.8-1.5	SP	0	96	4
TP09	0.2-1.0	SP	0	97	3
TP10	0.7-1.7	SP	1	94	5
TP16	0.5-1.0	SP	1	94	5

6. SITE CONDITIONS

6.1 Geology

The Muchea sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by sand derived from the weathering of Tamala Limestone.

This description is in line with our observations during the study.

6.2 Subsurface Conditions

The subsurface profile was consistent across the site, and can be summarised as:

- SAND (SP)/Silty SAND (SM), fine to coarse grained, sub-angular to sub-rounded, dark grey, trace rootlets and areas of some low plasticity fines, generally loose, extending from the ground surface to depths ranging from approximately 0.2 m to 0.3 m; overlying
- SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming yellow-brown, in situ density varies with depth as follows:
    - 0.3 m – 3.0 m very loose/loose
    - 3.0 m – 5.5 m loose/medium dense
    - 5.5 m – 8.2 m medium dense.

Due to the very loose/loose condition of the sand collapse occurred in many of the test pits.

Several localised areas of limestone and limestone pinnacles were encountered during our study. These tended to occur in the western and southern sections of the site. The tests where limestone was observed or inferred to be present were as follows:

- CPT01 - Limestone inferred at 5.2 m depth;
- CPT04 – Limestone inferred at 2.1 m depth;
- TP16 – Limestone pinnacles observed below 0.3 m depth;
- BH04 – Limestone observed at 0.7 m depth; and
- BH07 – Limestone observed at 1.7 m depth

Limestone pinnacles were observed to be present at the surface and at shallow depth around and adjacent test locations CPT04, TP16 and BH04. This area is located in the south western part of the site adjacent to the southern boundary. The approximate areal extent of this area is shown in Figure 1. It should be noted that excavation of this area appears to have been conducted as the ground surface area is significantly lower than the surrounding area. Based on this it is likely that limestone pinnacles are present below the sand over most of the site.

6.3 Groundwater

The Perth Groundwater Atlas (1997) shows the maximum historical groundwater level ranges from an elevation of around RL 26 m AHD at the west end of the site (about 3 m below existing surface) to about RL 40 m AHD at the east end of the site (about 40 m below existing surface).

Groundwater was only encountered at one test location namely CPT02 (in the far west of the site) at 5.2 m depth.

7. PRELIMINARY GEOTECHNICAL ASSESSMENT

7.1 Site Classification

We consider that the site is geotechnically capable of supporting the proposed residential subdivision.

We have assessed the site in accordance with AS 2870-2011 "Residential Slabs and Footings". We consider that a preliminary site classification of "Class A" is appropriate for the site provided that the site preparation measures given in Section 7.3 are adopted.

7.2 Site Subsoil Class

We have assessed the site subsoil class in accordance with AS 1170.4-2007, "Earthquake Design Actions in Australia". We consider that a site subsoil class of "C_e" is appropriate for the site.

7.3 Site Preparations

The site preparation measures outlined below are aimed at improvement of the site prior to construction of single and double storey structures, including on-ground slabs, shallow footings (including retaining wall footings) and pavement subgrades.

- Demolish and remove all existing structures and services from the site.
- Remove trees including grubbing out roots and other vegetation.
- Strip topsoil (root zone) to a depth of 200 mm (or deeper as required) and remove all vegetation, roots etc.
- Any zones disturbed by the removal of large tree roots must be remediated as below.
- Shape surface to required level and backfill any holes left after extraction of tree roots, below ground services, etc using approved backfill placed and compacted in layers of no greater than 300 mm loose thickness compacted to the density specified in Section 0.
- Moisture condition and compact the exposed surface to the density specified in Section 0 to a depth of **at least 1.5 m** below finished surface. This may require over-excavation and compaction depending on the compaction method adopted.
- Any areas of loose sand or unsuitable material must be removed and replaced with approved fill as outlined in Section 7.5.
- Where fill is required to build up levels, use approved fill (Section 7.5), placed and compacted in layers of no greater than 300 mm loose thickness. Each layer must be compacted to the density specified in Section 0.

We note that limestone pinnacles are exposed in a lowered section of the site adjacent the southern boundary. We consider it likely that a significant portion of the remainder of the site will also be underlain by limestone pinnacles. In light of this, we expect limestone pinnacles and/or massive limestone will be encountered where significant excavation is conducted.

This study has not characterised the strength of the limestone as no sampling of the limestone rock was proposed or undertaken.

7.4 Compaction

*A*pproved granular fill and the *in-situ* sand fill must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% of maximum modified dry density (MMDD) as determined in accordance with AS 1289.5.2.1 and within 2% of optimum moisture content (OMC).

Where clean sand (<5% gravel, <5% fines) is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control. The following minimum PSP blow counts may be assumed to correlate to the required DDR:

- 150 mm-450 mm: 8
- 450 mm-750 mm: 10
- 750 mm-900 mm: 6 (or 750 mm-1050 mm: 12)

If difficulties are experienced in achieving the required blow count, an on-site PSP calibration should be undertaken to determine the site-specific blow count correlating to the required DDR of 95% MMDD. The correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each of the NDG test points; and
- be plotted on a chart of PSP blow count vs DDR.

If on site limestone is proposed to be re-used as fill compaction control using a NDG or PSP is not likely to be possible. We suggest use of a method specification for placement and compaction of limestone. Cossill and Webley have successfully developed specifications for placement and compaction of limestone for similar projects, typically included in their Standard Specification.

Over-excavation and replacement of loose materials must be performed where the minimum dry DDR cannot be achieved.

Fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

Care will need to be taken when compacting in the vicinity of existing services and structures. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[3] provides assistance with the selection of compaction equipment for use adjacent to services.

Test Frequency

After compaction, verify that the required level of compaction has been achieved by testing at the base of the topsoil strip and through the full depth of any fill and to a minimum depth of 0.9 m. The frequency of testing should be as follows:

- on each lift of fill at the rate of 1 test per 500 m^3;
- at each spread footing location;

[3] Tynan (1973) Ground Vibration and Damage Effects on Buildings, Australia Road Research Board, Special Report No. 11.

- at 5 m centres along gravity retaining wall footings and strip footings (where present); and
- at 10 m centres below on-ground slabs and pavements.

7.5 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments".

Generally, the sandy material present at the site is suitable for re-use as inert structural fill. Any organic-rich sand or sand containing significant proportions of fines (>5% of material less than 0.075 mm in size) must not be used as inert structural fill.

Where oversize material is present (> 1 mm in diameter), this must be either screened out or crushed to a lesser size prior to inclusion in the approved fill.

Re-use of Limestone

Limestone removed during development of the site could be suitable for re-use as structural fill provided it can be broken down to a maximum particle size of less than 150 mm. Based on our experience in similar terrain we would expect the limestone should be able to be broken down suitably using equipment such as a dozer and a pad foot roller.

It needs to be borne in mind that limestone when compacted commonly has a low permeability (or at least, significantly lower than free-draining, clean sand). The limestone should not be used in the top 2 m to 3 m of the profile where disposal of stormwater into the ground is proposed, depending on the parameters of the civil design.

Re-use of Topsoil

We expect that sandy topsoil can be suitably blended with clean sand to produce a permeable structural fill, once organics are removed (by screening). The blended topsoil material should have a fines content less than 5% and an organic content less than 2%, however the specified characteristics of the material will depend on its proposed use and civil design requirements.

Where the blended topsoil fill is to be used in areas where stormwater disposal is proposed, permeability testing of material must be carried out to ensure it meets the specified requirements prior to use. This typically involves the construction of a compacted trial pad approximately 1 m thick of the blended topsoil at different ratios.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

7.6 Excavations and Slopes

Based on the soil profile encountered, we expect that excavations on site will generally be achievable to depths of about 2.0 m below the current surface level using conventional earthmoving equipment (i.e. with a 10 tonne or larger excavator with a toothed bucket). A larger excavator (20-30 tonne machine) fitted with a hydraulic rock breaker or dozer may be required to remove limestone pinnacles.

Limestone encountered below 2 m depth may also include massive limestone which may require the use of heavy equipment such as a D10 Caterpillar dozer equipped with a tine to remove. As we have not sampled and tested the material we do not know the strength of the material. We therefore cannot comment with any certainty about its excavatability. This may need to be addressed in a detailed investigation at a later stage.

Excavations in sand are prone to instability unless support is provided.

Note: Collapse occurred in most of the test pits.

Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing structures and infrastructure.

We recommend batter angles no steeper than 1V:2H for temporary slopes and 1V:3H for permanent slopes at least 1 m above groundwater in sand, where no external restraint is provided to the slope (suitable for slope heights up to 2 m with no surcharge at the crest of the slope). Even at these slope angles, rilling and erosion of the slope may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

Temporary slopes up to 1V:2H require the following:

- No surcharge (machinery, stockpiles, etc) is present at the crest of the slope.
- A maximum slope height is 2 m.

Steeper temporary slopes (1V:1H) are possible in variably cemented limestone and consistently moderately- to well-cemented limestone may have temporary slopes up to 1V:0.5H (maximum height: 5 m). With the information available at this stage, we do not consider that definitive locations/depths for such steeper slopes can be developed, therefore it would be prudent to assume all batters are in sand for design purposes at this stage.

Surcharges (such as plant and soil stockpiles) must not be placed at or close to the crest of unsupported excavations.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

7.7 Earth Retaining Structures

Retaining structures may be designed in accordance with AS 4678-2002 “Earth-Retaining Structures”. Permeable granular fill must be used as gravity retaining wall backfill. The following parameters may be assumed for approved granular fill that is compacted to the requirements of Section 0.

- Angle of internal friction, $\phi = 34°$
- Coefficient of active earth pressure $K_a = 0.28$
- Coefficient of passive earth pressure $K_p = 3.54$
- At rest coefficient of earth pressure $K_o = 0.44$
- Bulk unit weight: 18 kN/m^3 above the water table

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement is to be expected behind any soil retaining system, including gravity retaining walls.

7.8 Stormwater Disposal

The results of the infiltration tests show that the minimum unsaturated permeabilities generally exceed 15 m/day, although IT06 shows a lower infiltration rate of 8.3 m/day.

We note that the tests were carried out in typically loose and moist to dry sand.

We consider that sands at the site are suitable for on-site disposal of stormwater by infiltration, assuming that the site preparation requirements outlined in Section 7.3 have been carried out.

We recommend a design value of permeability (k) not greater than 5 m/day for the *in-situ* sand (assuming bases of drainage basins and soak wells are at least 0.2 m above the maximum historical groundwater elevation) to allow for the variability in materials and reduced permeability as a consequence of:

- densification of sand during site preparation works;
- natural variation in sands; and
- clogging of the sand around soak wells and soakage basins over time with fines.

It should be noted that the permeability of any imported fill must be confirmed by testing of compacted trial pads.

7.9 Pavement Subgrades

Where site preparation measures have been completed in pavement subgrade areas (i.e. pavement subgrades comprise compacted *in situ* sand or sand backfill), pavement thickness design may be undertaken assuming a subgrade California bearing ratio, CBR of 12%.

8. CLOSURE

We draw your attention to Appendix I of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

Yours Faithfully,

GALT GEOTECHNICS PTY LTD

Fred Davenport CPEng

Geotechnical Engineer

Kieran Harris

Geotechnical Engineer

Legend

- Site Boundary
- Approximate Extent of Outcropping/ Surface Limestone
- Cone Penetration Test
- Hand Auger Borehole
- Test Pit

N

0 80 160 240 320 400

Meters

SCALE	1:5,000	(A3)
DRAWN	DAC	
DATE DRAWN	6/10/2017	
CHECKED	FAD	
DATE CHECKED	06/10/2017	
PROJECTION	GDA 1994 MGA Zone 50	

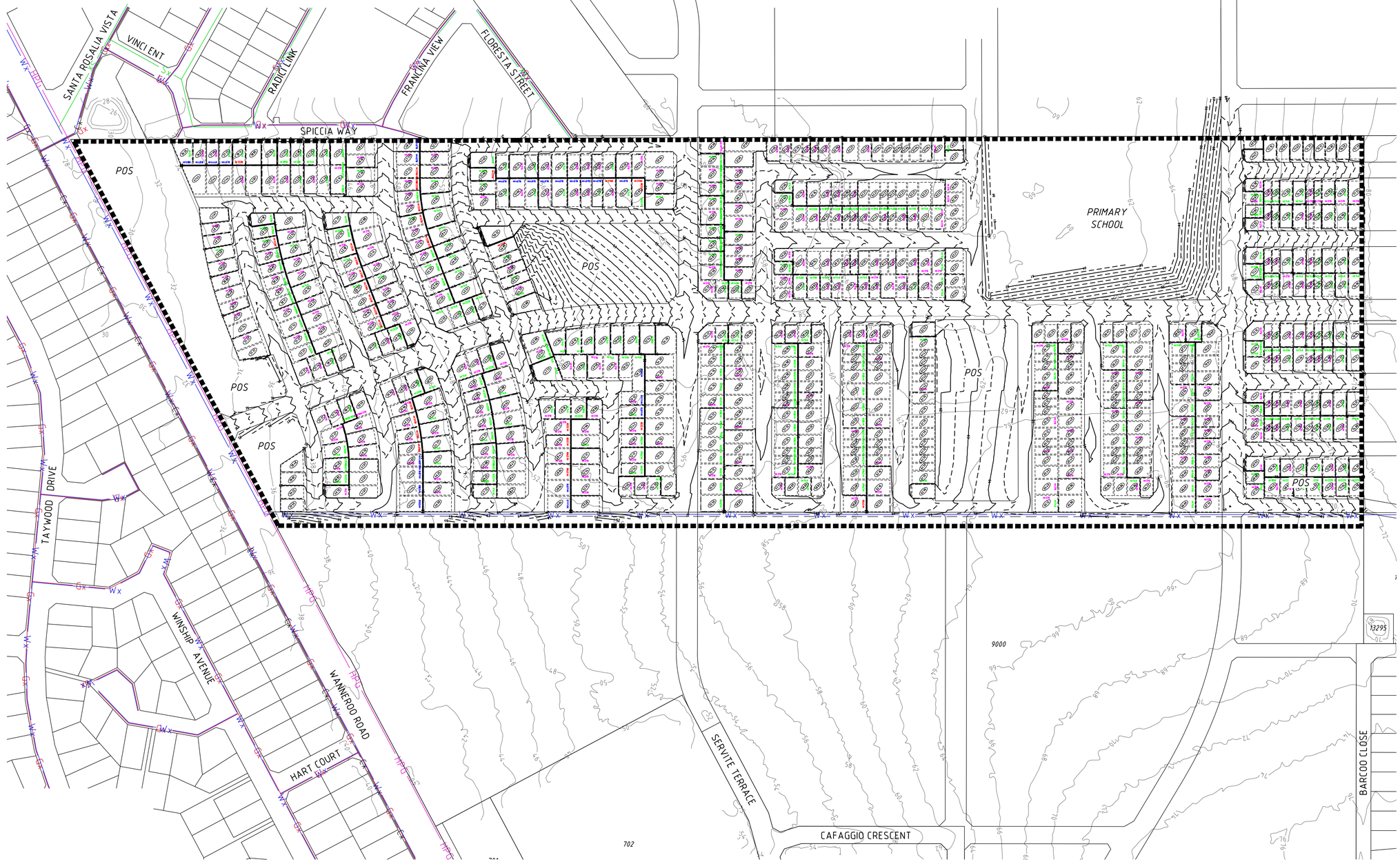
Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Address : Unit 4, 15 Walters Drive
Osborne Park WA 6017

CLIENT	**COSSILL & WEBLEY**
PROJECT	PROPOSED DEVELOPMENT
LOCATION	LOT 1665 (1004) WANNEROO ROAD SINAGRA
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J1701214	FIGURE 1	**A**

O:\Jobs\2017\J1701214 - C&W SI Sinagra\09 GIS\04 MXD\J1701214-001.mxd (damonclark) 6/10/2017 2:54:35 PM

Appendix A: Supplied Subdivision Plan



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1:2000

DIAL BEFORE YOU DIG www.1100.com.au

REV	DATE	DRN	CKD	APP	AMENDMENT
A	21.06.17	ARH	AB		ISSUED FOR INFORMATION

Cossill & Webley CONSULTING ENGINEERS
Mailing Address: PO Box 680, Subiaco WA 6904
Street Address: B12 (Level 2) 431 Roberts Road, Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: STOCKLAND
APPROVED: 21.06.17
DESIGNED: ARH
SCALE: 1:2000
PROJECT: INGHAMS WANNEROO
TITLE: PRELIMINARY EARTHWORKS PLAN
WAPC No.
DRAWING No.: 6239-SK-SK01
REVISION: A
ORIGINAL SIZE: A1

P:\6239 Ingham Wanneroo\Stockland\Acad\6239-SK-SK01.dwg, 21/06/2017 10:00:46 AM, alistairh, Digital Signing PDF.pc3, 1:1, - CW Reference

Appendix B: Site Photographs

Photograph 1: View of building in south-western section of the site

Photograph 2: View of existing residences at the south-western section of the site

Photograph 3: View of surface limestone near test pit TP16

Photograph 4: View of surface limestone near hand auger borehole HA04

Photograph 5: View looking west towards existing chicken sheds. The area in view appears to have been previously excavated.

Photograph 6: View of excavated part of site east of chicken sheds.

Photograph 7: Typical view of vegetation in north east section of site.

Photograph 8: Typical view of infiltration test set up.

Photograph 9: View of native bushland in the southern area of the site

Photograph 10: View looking south east to plant site, test pit TP04 in foreground.

Appendix C: CPT Results

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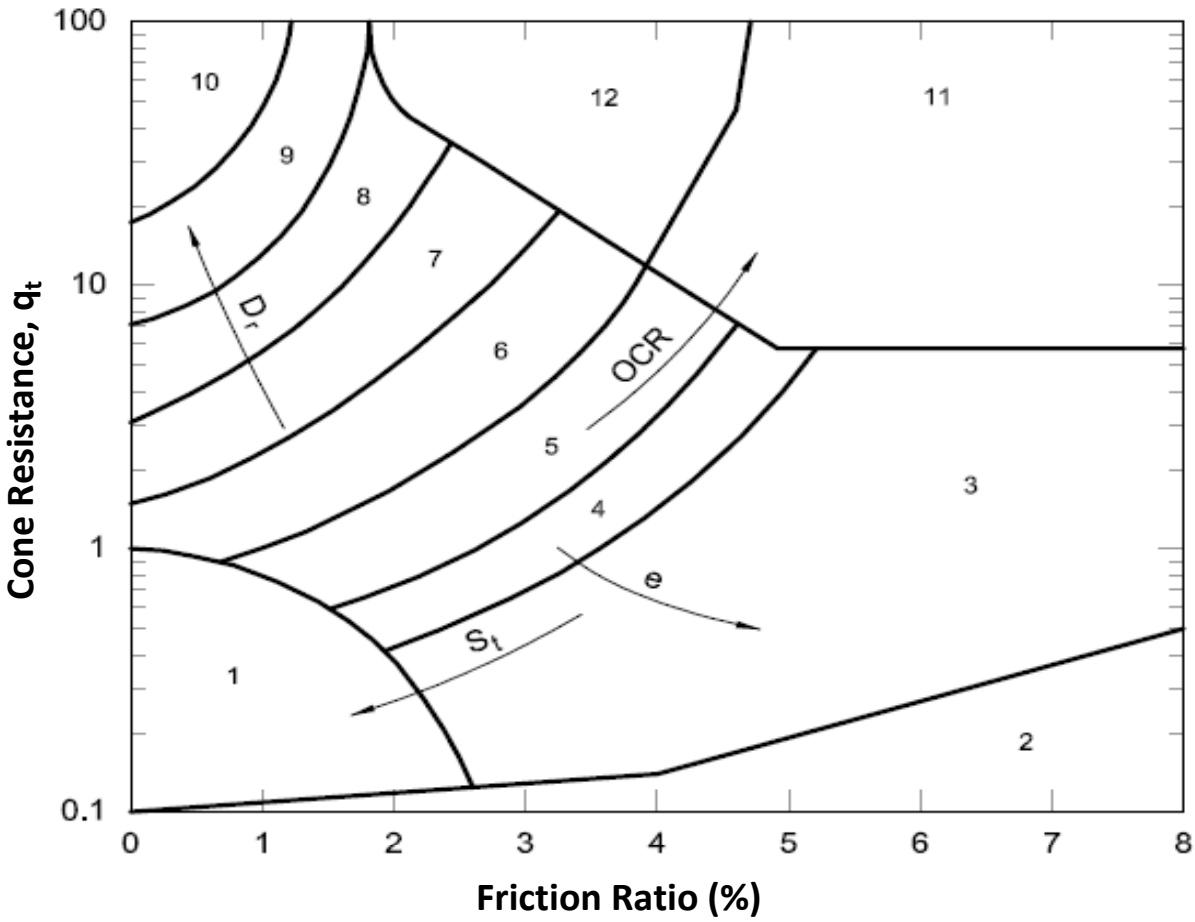
4/15 Walters Drive OSBORNE PARK WA 6017
ABN: 64 625 054 729



DEFINITIONS

q_t : Cone tip resistance corrected for pore water pressure
S_t : Sensitivity
e : Void ratio
D_r : Relative density
OCR : Overconsolidation ratio
OC : Overconsolidated

SOIL BEHAVIOUR TYPE ZONES

1. Sensitive fine grained
2. Organic material
3. Clay
4. Silty clay to clay
5. Clayey silt to silty clay
6. Sandy silt to clayey silt
7. Silty sand to sandy silt
8. Sand to silty sand
9. Sand
10. Gravelly sand to sand
11. Very stiff fine grained material (OC/cemented)
12. Sand to clayey sand (OC/cemented)

NOTES

A. Some overlap in type zones is expected
B. Local correlations are preferred and may indicate soil type boundaries that are different from those shown above

Reference: Robertson, P.K., Campanella, R.G., Gillespie, D. and Grieg, J. (1986) "Use of Piezometer Cone Data". Proceedings of the ASCE Speciality Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, pp 1263-80, American Society of Civil Engineers (ASCE)

Galt GEOTECHNICS

CONE PENETRATION TESTING (CPT) SOIL TYPE INTERPRETATION

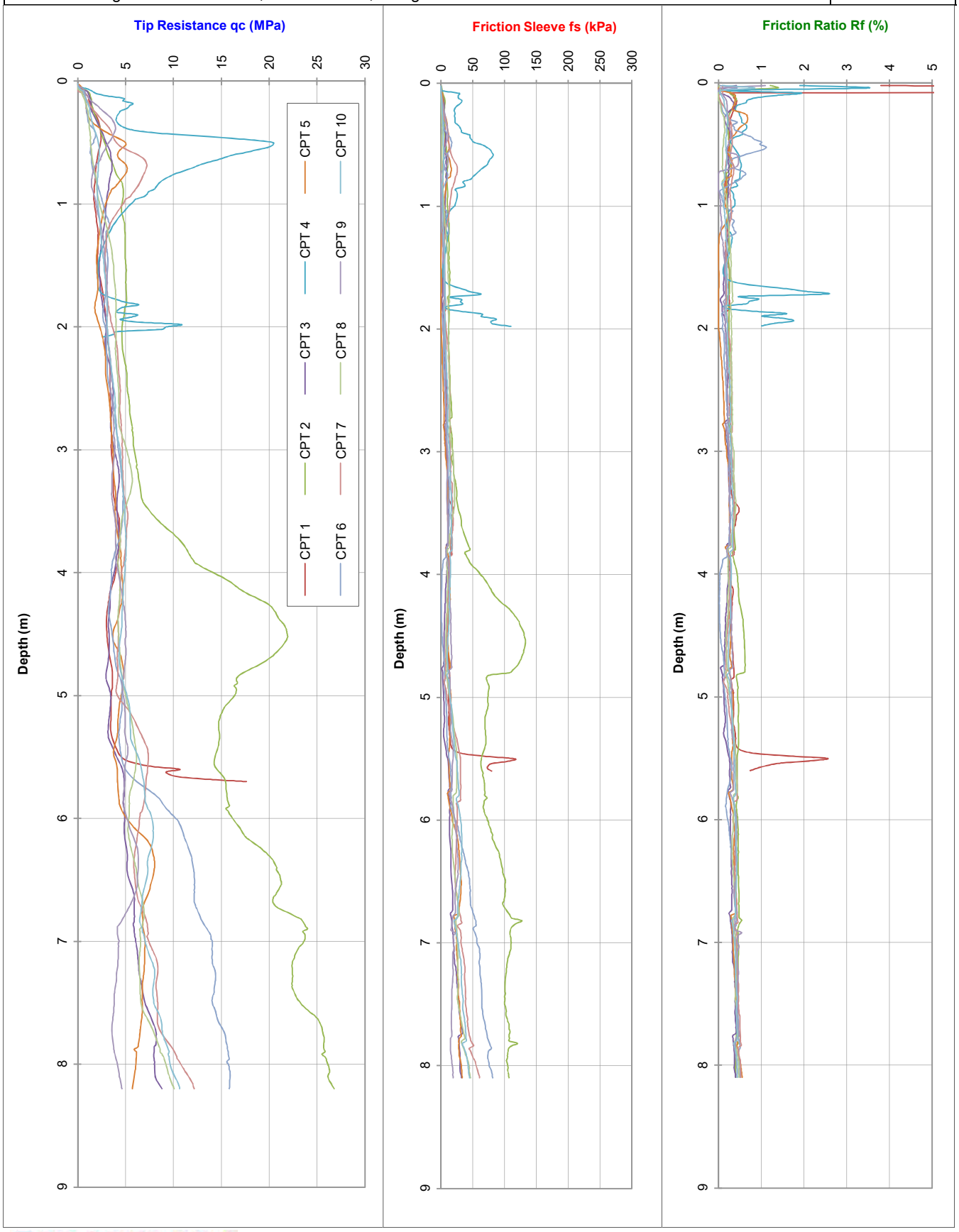
ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland Job No.: J1701214

PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development Date/s: 29/09/2017

LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra

ALL DATA



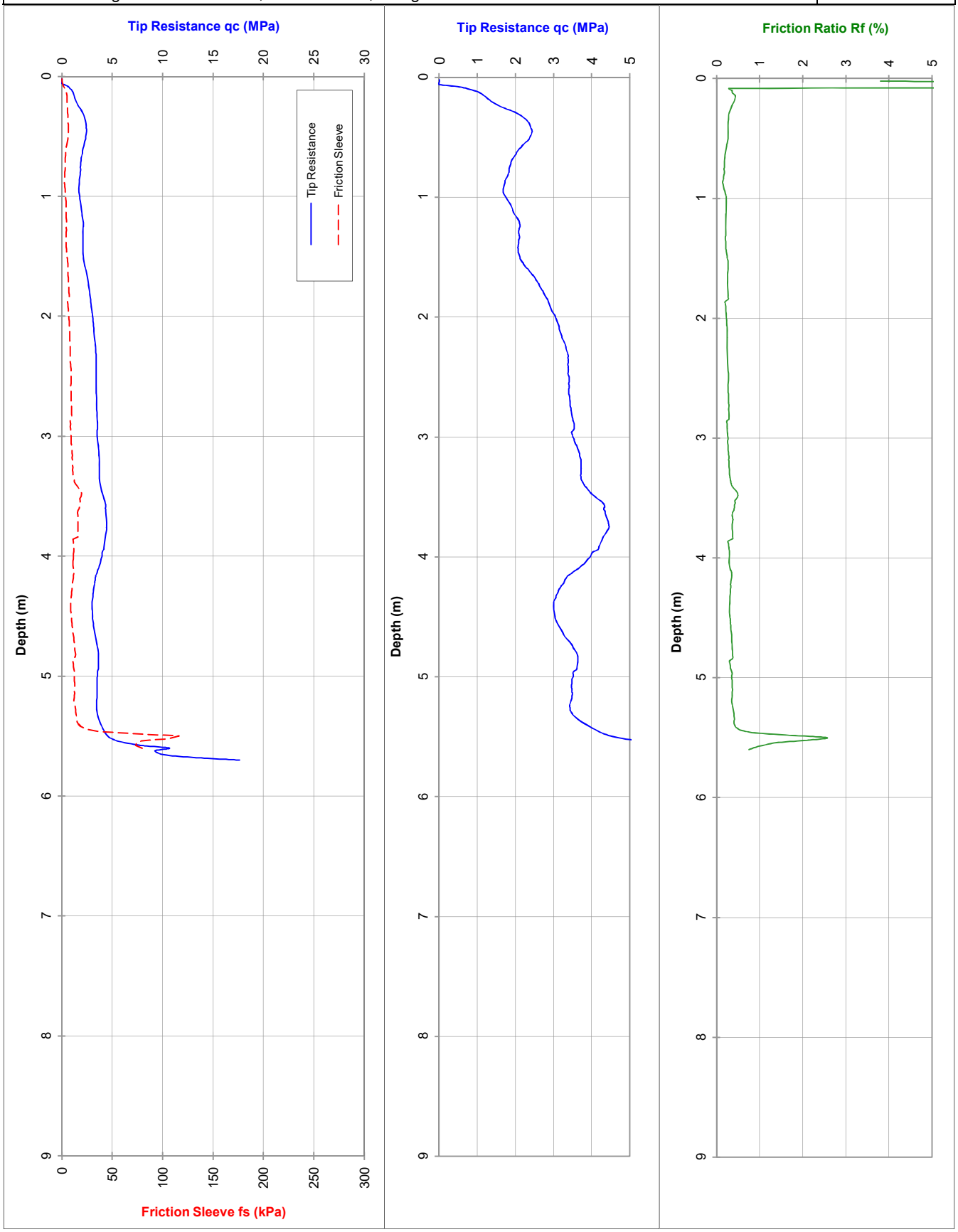
PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999
and IRTP 2001 for friction reducer

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 1**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 5.7

Dummy probe to (m):

Refusal: Inclination (Limestone on tip)

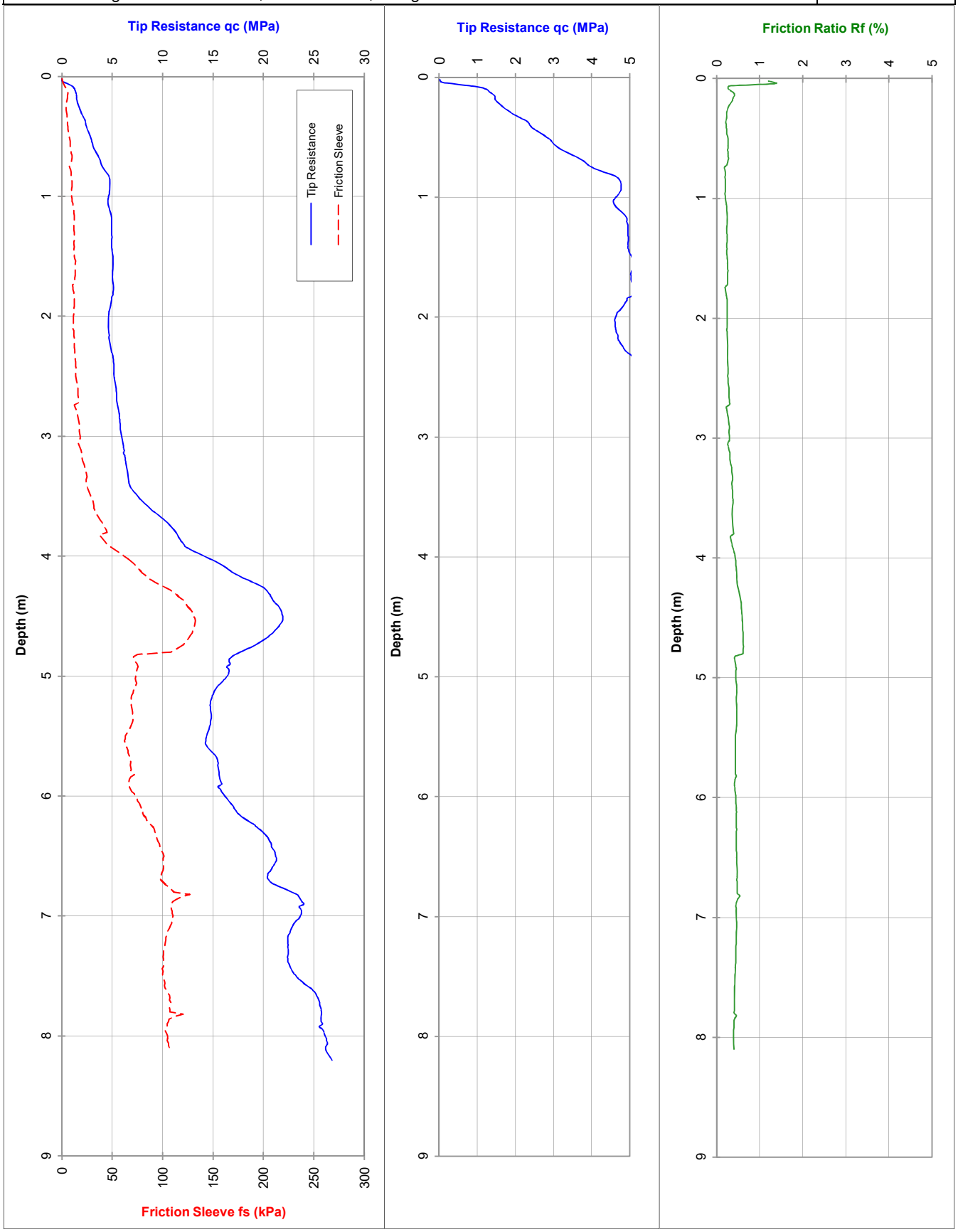
Cone I.D.: EC04

File: GL0447M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 2**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 5.2

Dummy probe to (m):

Refusal:

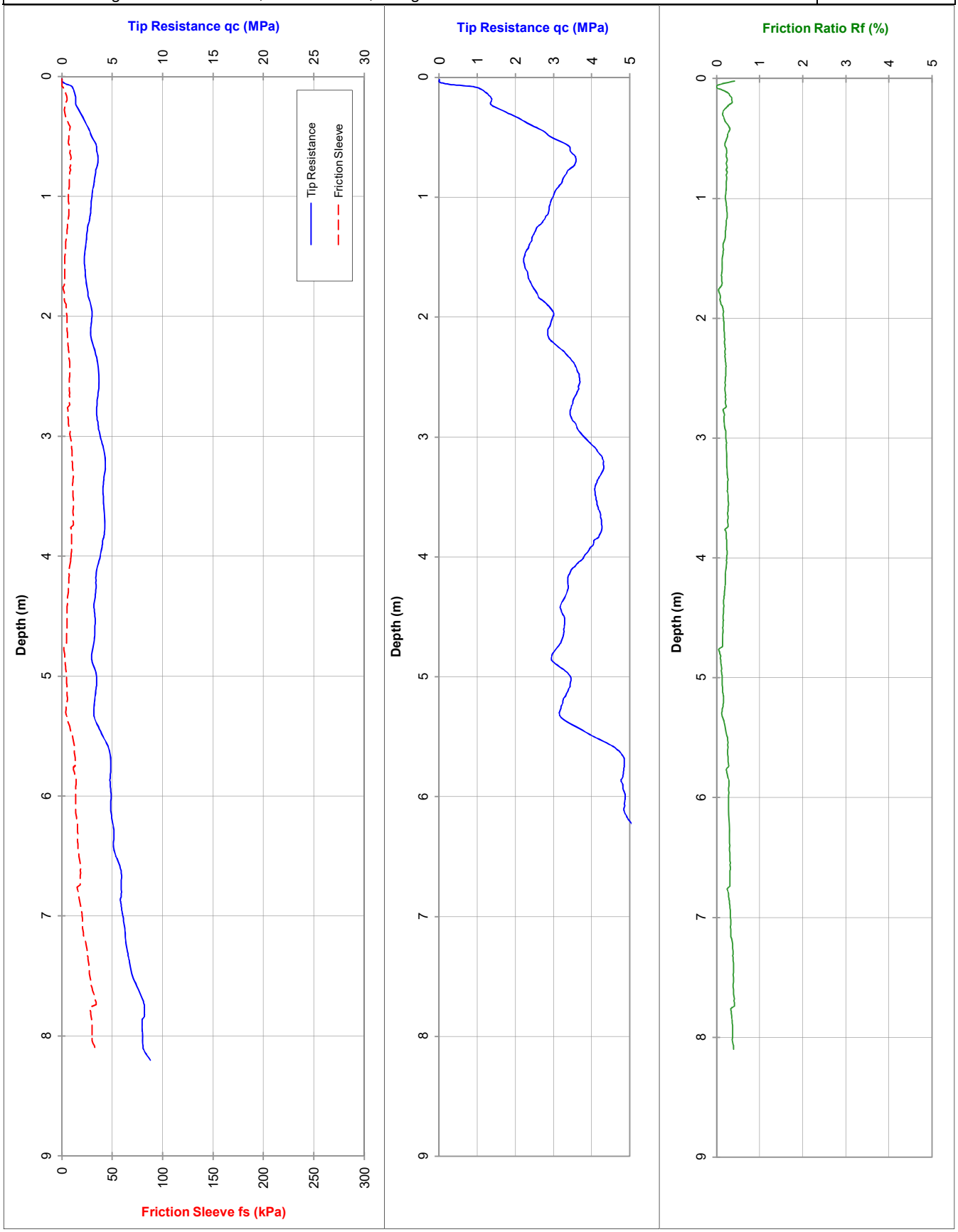
Cone I.D.: EC04

File: GL0448M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 3**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

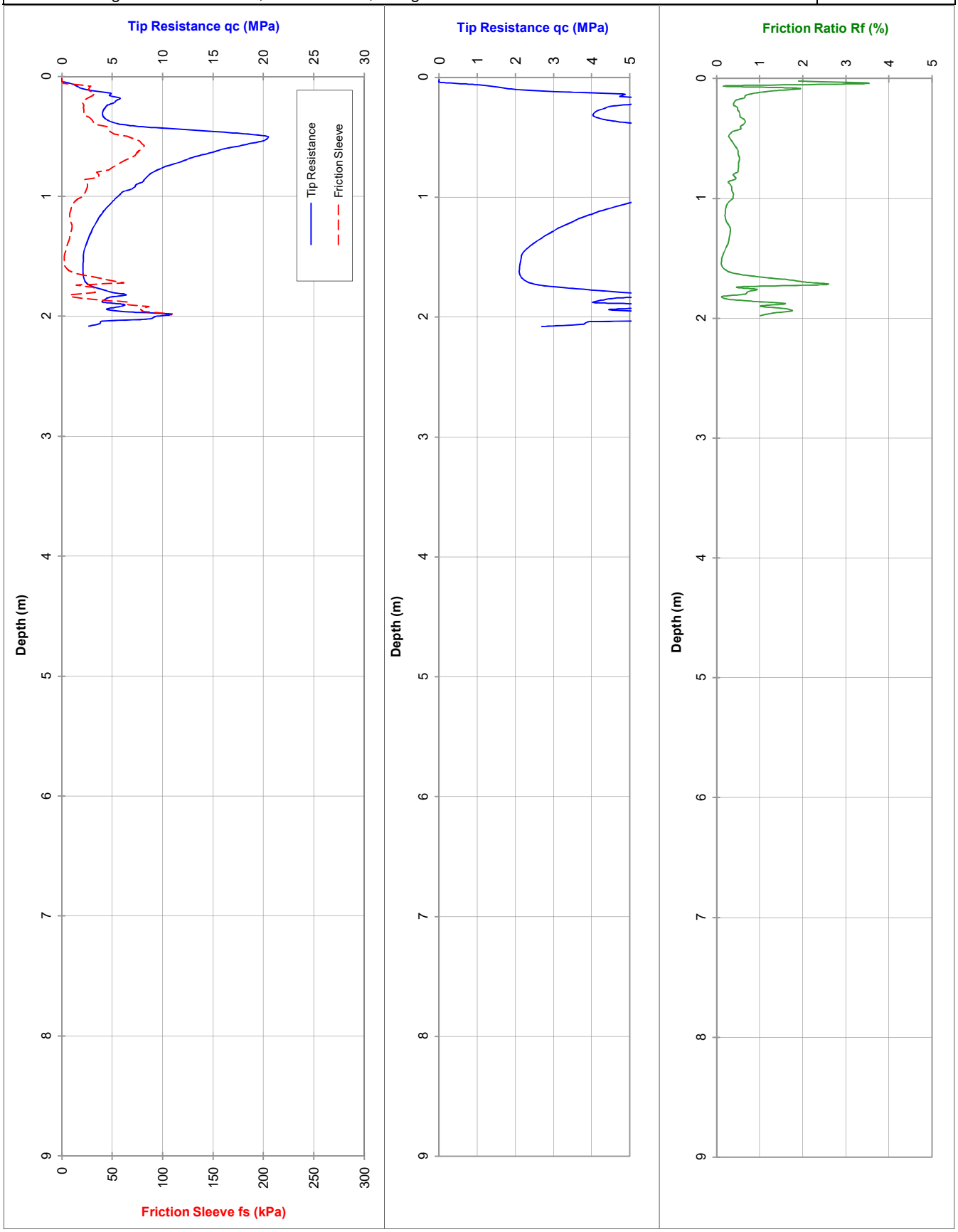
Cone I.D.: EC04

File: GL0449M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 4**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 2.0

Dummy probe to (m):

Refusal: Inclination (Limestone on tip)

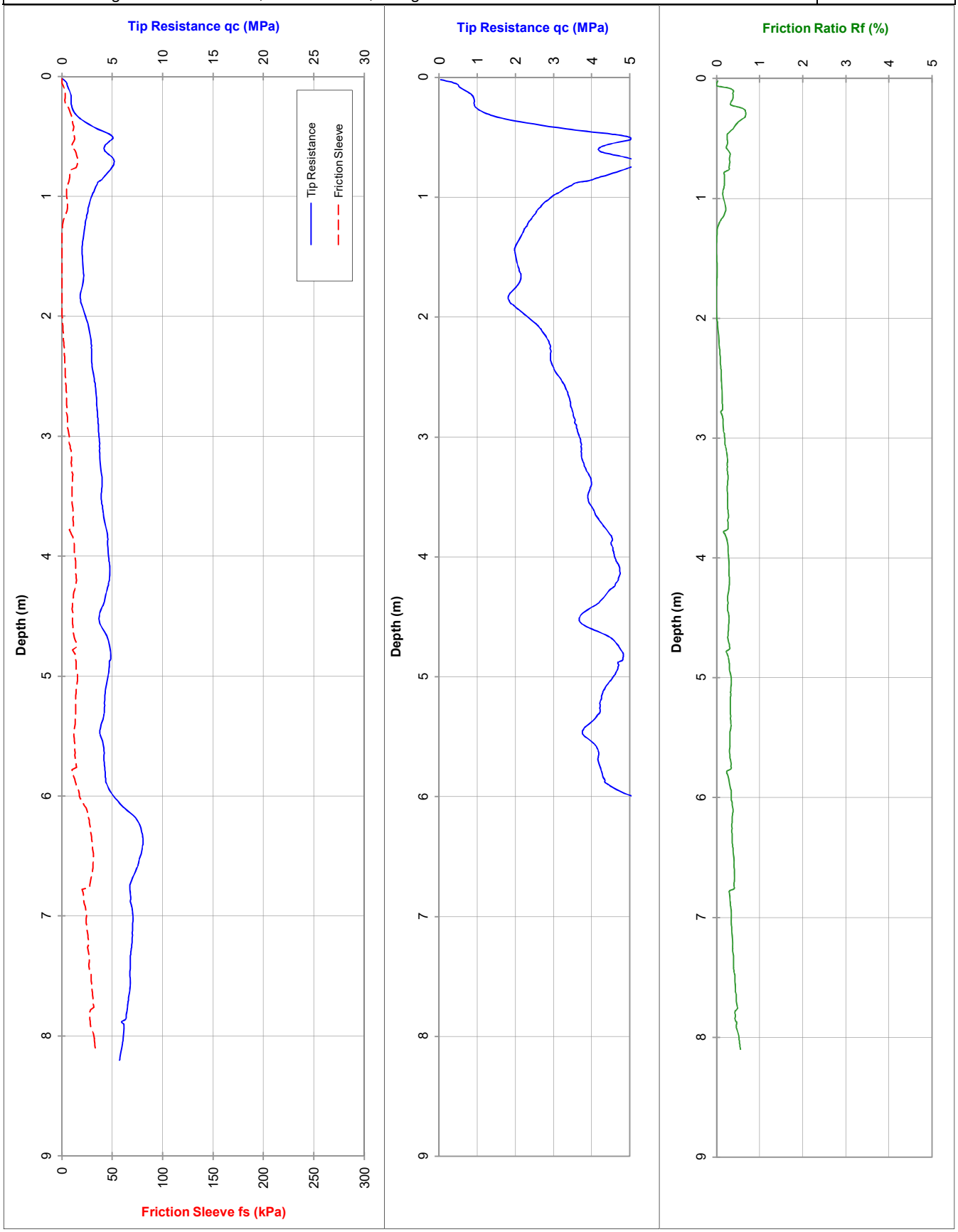
Cone I.D.: EC04

File: GL0450M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 5**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.1

Dummy probe to (m):

Refusal:

Cone I.D.: EC04

File: GL0451M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

Probe I.D

CPT 6

CLIENT: Stockland

Job No.: J1701214

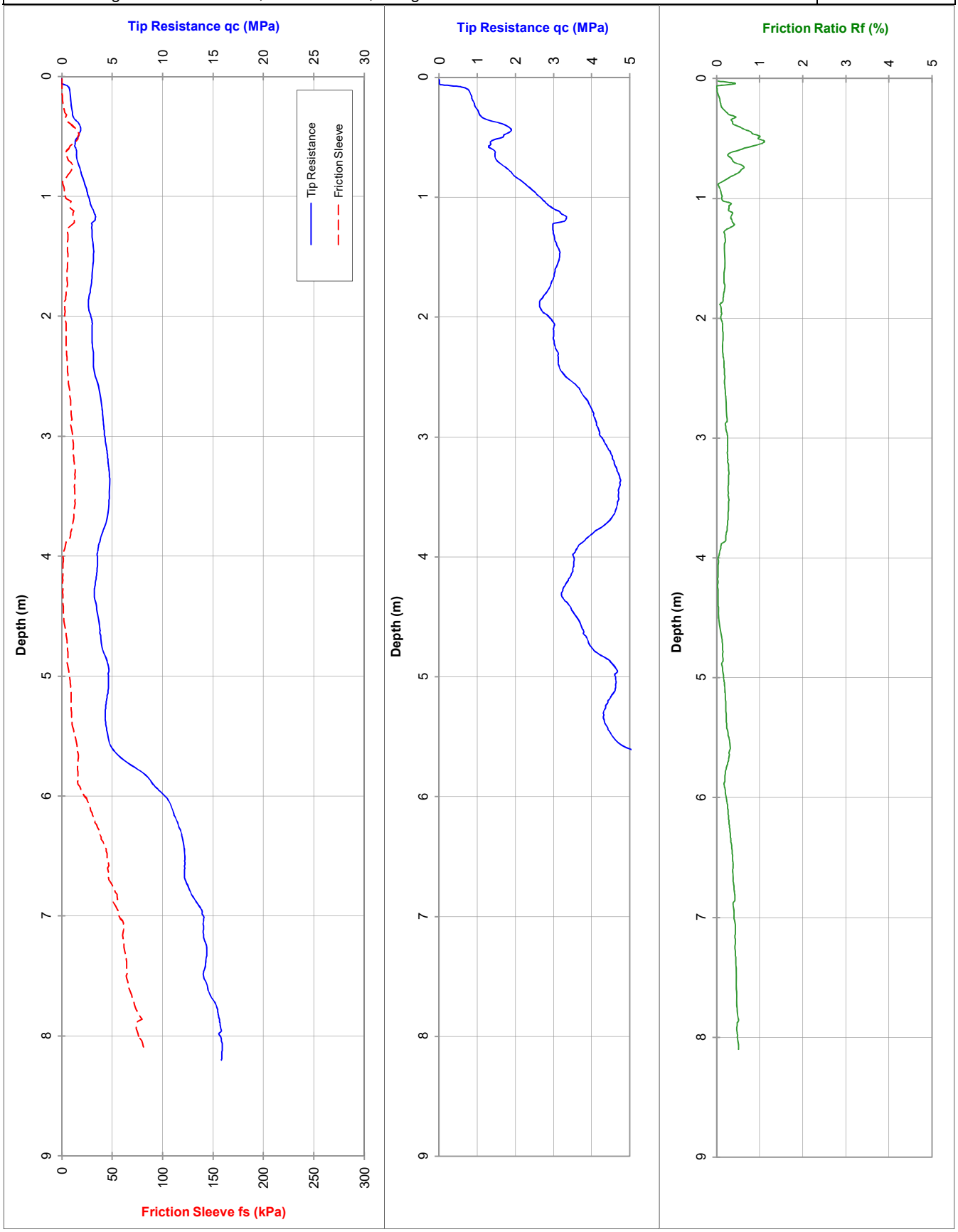
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development

RL (m):

LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra

Co-ords:

29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

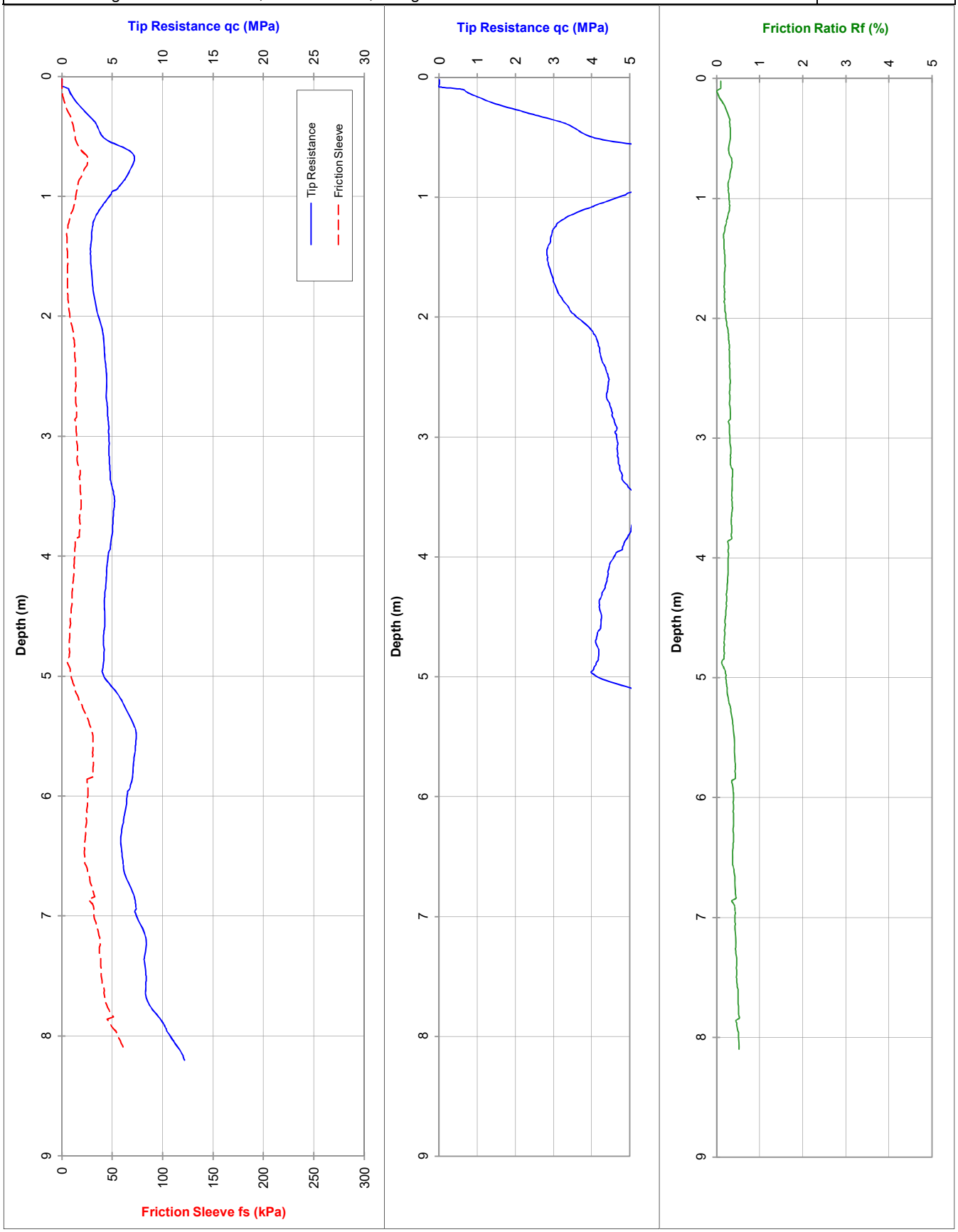
Cone I.D.: EC04

File: GL0452M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 7**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

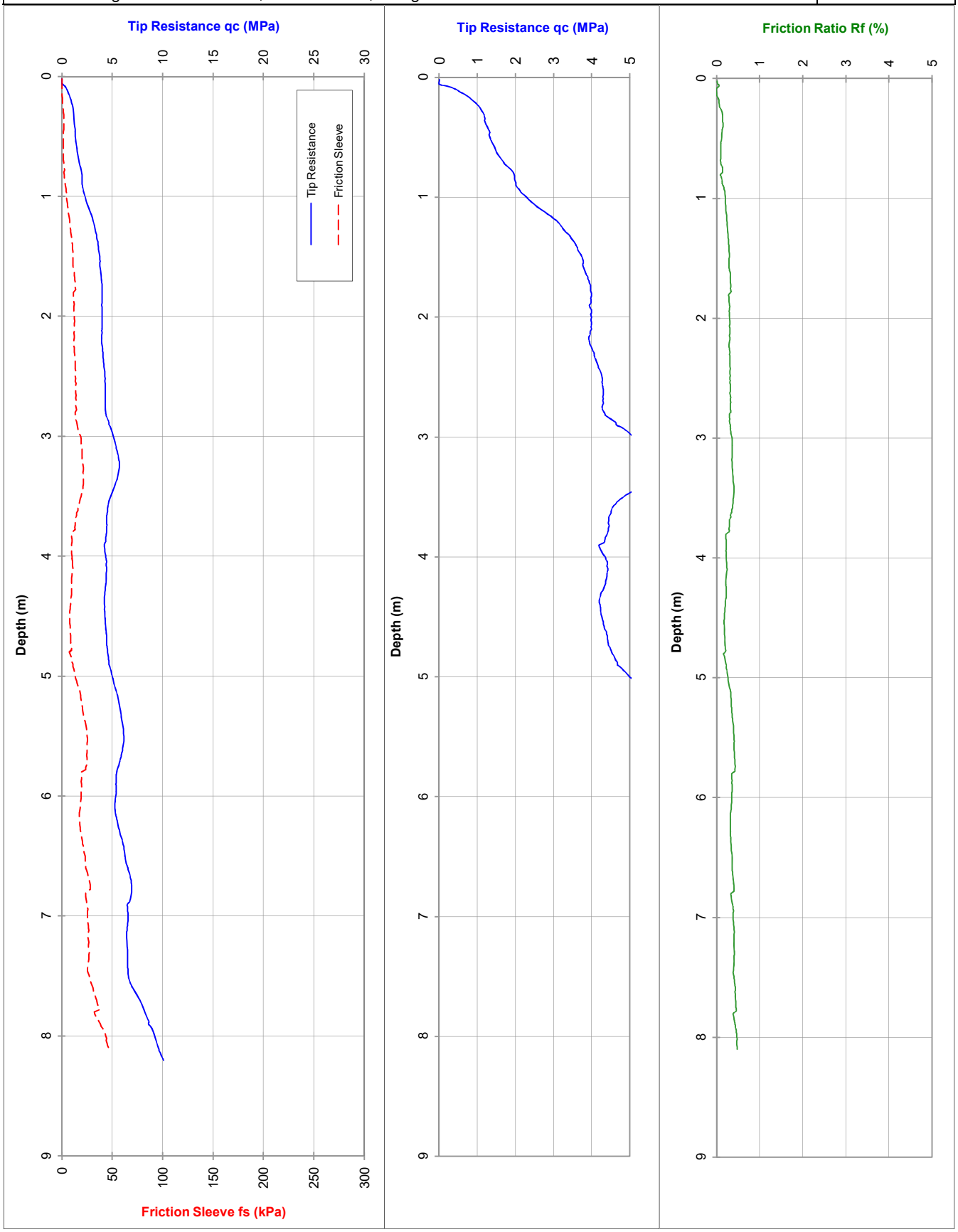
Cone I.D.: EC04

File: GL0453M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 8**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

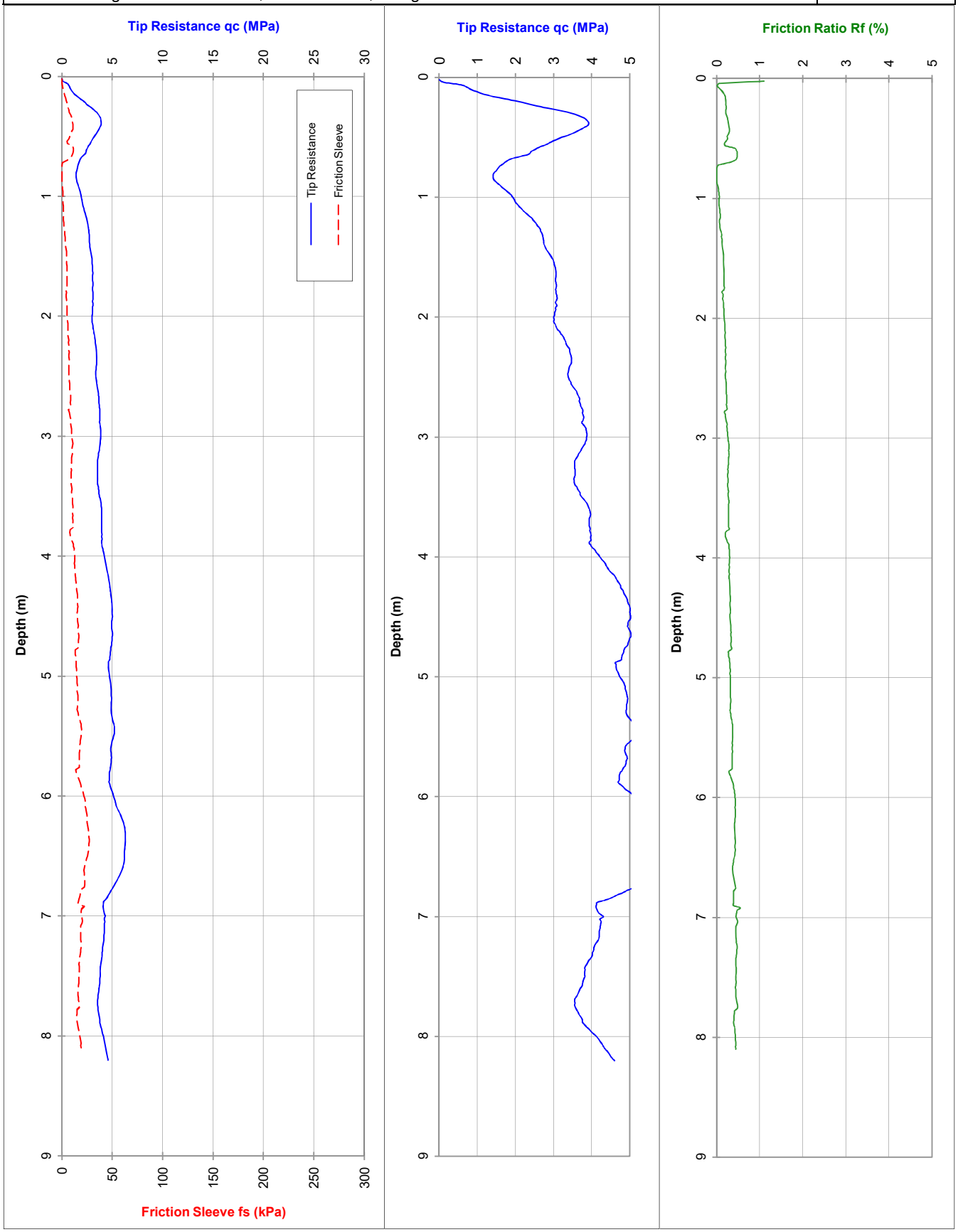
Cone I.D.: EC04

File: GL0454M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 9**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

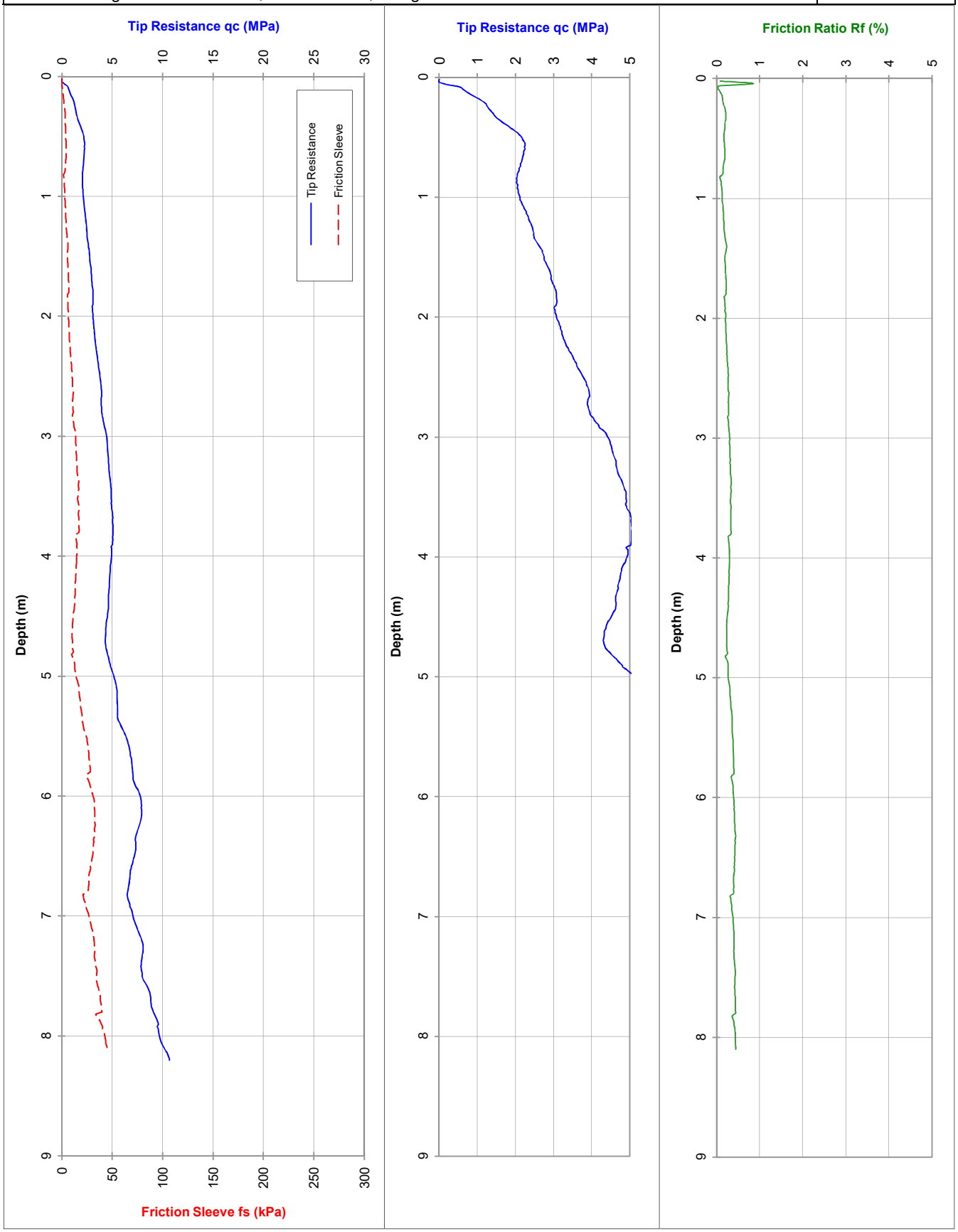
Cone I.D.: EC04

File: GL0455M

Rig Type: 12 tonne track (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: Stockland	Job No.: J1701214	Probe I.D
PROJECT: Due Diligence Geotechnical Study for Proposed Residential Development	RL (m):	**CPT 10**
LOCATION: Ingham Chicken Farm, Wanneroo Rd, Sinagra	Co-ords:	29-Sep-17



PROBEDRILL GEOTECHNICAL SURVEY

Tested in accordance with AS 1289.6.5.1-1999 and IRTP 2001 for friction reducer

Approx. Water (m): Dry to 8.2

Dummy probe to (m):

Refusal:

Cone I.D.: EC04

File: GL0456M

Rig Type: 12 tonne track (M1)

Appendix D: Test Pit Reports

www.galtgeo.com.au
4/15 Walters Drive OSBORNE PARK WA 6017
ABN: 64 625 054 729

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

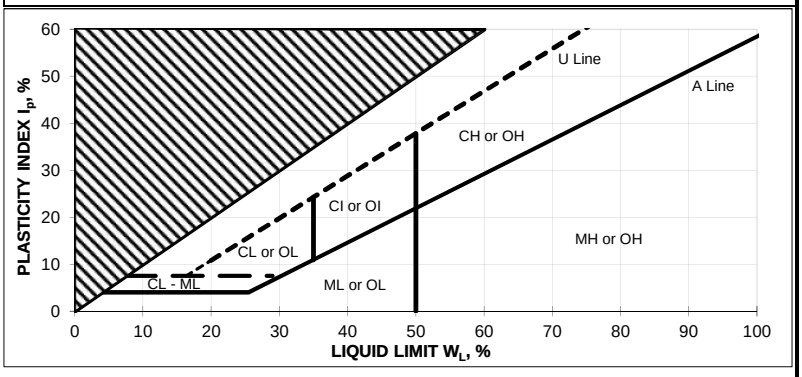
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		**Particle Size (mm)**
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION		
Symbol	**Term**	**Description**
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION	
Symbol	**Term**
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	**Description**
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	**Term**	**Undrained Shear Strength (kPa)**
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	**Organic Content % of dry mass**
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	**Term**	**Density Index (%)**
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

TEST PIT: TP01

Job Number:	J1701214	**Easting:**	387312 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487404 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some fine roots			
									SAND: fine to medium grained, sub-angular, brown to yellow			Trace roots to 0.2m
			0.5									
			1.0									Hole collapsing
	VE							SP		M	L	
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 2.60 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP02

Job Number:	J1701214	**Easting:**	387133 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487401 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			
	VE		0.5					SP	SAND: fine to medium grained, sub-angular, yellow with trace roots	M	L	Hole collapsing
			1.0									
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 2.60 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP03

Job Number:	J1701214	**Easting:**	386910 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487389 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			
					B(TP03-1)				SAND: fine to medium grained, sub-angular, yellow, with trace roots			
			0.5									
			1.0									Hole collapsing
	VE							SP		M	VL	
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 2.70 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP04

Job Number:	J1701214	**Easting:**	386692 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487410 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	SAND: fine to medium grained, sub-angular, pale brown with some roots			Possibly imported fill
								SP	Gravelly SAND: fine to coarse grained, sub-angular, pale yellow with some limestone gravel			
								SP	SAND: fine to coarse grained, sub-angular, brown with trace gravel			
			0.5					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with trace roots			
									SAND: fine to medium grained, sub-angular, yellow with trace roots			
			1.0									Hole collapsing
	VE									M	MD	
			1.5					SP				
			2.0									
			2.5									
									Hole terminated at 2.60 m Target depth Groundwater not encountered			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP05

Job Number:	J1701214	**Easting:**	386494 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487394 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			
									SAND: fine to medium grained, sub-angular with trace roots			
			0.5									
			1.0									
								SP		M	L	
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 2.60 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP06

Job Number:	J1701214	**Easting:**	386283 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487389 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			
									SAND: fine to medium grained, sub-angular, yellow with trace roots			
			0.5									
			1.0									Hole collapsing
	VE							SP		M	L	
			1.5									
			2.0									
			2.5									
									Hole terminated at 2.60 m Target depth Groundwater not encountered			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP07

Sheet 1 OF 1

Job Number:	J1701214	**Easting:**	386296 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487249 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0					SM	Silty SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, some low-plasticity fines in 0.3m, rootlets to top 0.3m	M	MD	
			0.5						Dark grey becoming pale grey to pale yellow/brown at 0.5m SAND: fine to coarse grained, sub-angular to sub-rounded Dark grey becoming pale grey to pale yellow/brown at 0.5m			
			1.0					SP				
			1.5									
			2.0						Hole terminated at 1.70 m Terminated due to collapse. Groundwater not encountered			
			2.5									
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP08

Job Number:	J1701214	**Easting:**	386483 m	**Contractor:**	Galt	**Date:**	27/09/2017
Client:	Cossill & Webley	**Northing:**	6487252 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 0.5					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey in top 0.4m, becoming yellow-brown mottled with pale grey, rootlets to top 0.2m	M	L - MD	
			0.5 – 3.0						Hole terminated at 0.70 m Terminated due to presence of services Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP09

Job Number:	J1701214	**Easting:**	386641 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487256 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			
					B(TP09-1)				SAND: fine to medium grained, sub-angular, brown becoming yellow with trace roots			
			0.5									
			1.0									Hole collapsing
	VE		1.5					SP		M	MD	
			2.0									
			2.5									
			3.0						Hole terminated at 2.90 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP10

Job Number:	J1701214	**Easting:**	386844 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487238 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots			Possibly imported fill
								SP	SAND: fine to medium grained, sub-angular, yellow with trace cobbles and boulders > 200			
			0.5		B(TP10-1)			SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with contains cobbles and boulders >100, trace limestone, trace steel and plastic			Weakly cemented clods of sand
	VE		1.0					SP	SAND: fine to medium grained, sub-angular, brown with trace very weakly cemented gravel size particles	M	MD	Hole collapsing
			1.5									
			2.0									
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP11

Job Number:	J1701214	**Easting:**	387267 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487260 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, pale yellow contains cobbles and boulders >150, 20 mm thick bitumen seal			Pavement
									SAND: fine to medium grained, sub-angular, mottled yellow sand, dark grey to 1.0m			
			0.5									
			1.0						Dark grey sand to 1.5m			Hole collapsing
	VE							SP		M	L - MD	
			1.5						Yellow sand to end of hole			
			2.0									
			2.5									
			3.0						Hole terminated at 2.60 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP12

Sheet 1 OF 1

Job Number:	J1701214	**Easting:**	387052 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487158 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with some roots	M		
								SP	SAND: fine to coarse grained, sub-angular, dark grey	D		
			0.5									
	VE		1.0					SP	SAND: fine to medium grained, sub-angular, pale yellow to yellow	M	MD	Hole collapsing
			1.5									
			2.0									
			2.5						Hole terminated at 2.40 m Target depth Groundwater not encountered			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP13

Sheet 1 OF 1

Job Number:	J1701214	**Easting:**	386733 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487190 m	**Machine:**	JCB 3CX	**Logged:**	BJ
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0					SM	Silty SAND: fine to coarse grained, sub-angular, dark grey with trace roots	M	MD - D	Hole collapsing
									COBBLES: pale yellow, limestone			
			0.5					SP	SAND: fine to coarse grained, sub-angular, dark grey with trace cobbles and boulders >200 mm			
			1.0						SAND: fine to medium grained, sub-angular, yellow with trace roots			
			1.5					SP				
			2.0									
			2.5									
			3.0						Hole terminated at 2.80 m Target depth Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP14

Sheet 1 OF 1

Job Number:	J1701214	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra	**Bucket:**	0.5 m	**Checked By:**	FAD
		Width:	1 m **Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, some low-plasticity fines, rootlets	M	L	
			0.5						Hole terminated at 0.40 m Terminated due to encountering leech drain Groundwater not encountered			
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP15

Job Number:	J1701214	**Easting:**	386482 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487083 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 1.0					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey to 0.3m becoming yellow-brown Some well cemented, low to medium strength boulders and cobbles of limestone	M	D	
			2.0						Hole terminated at 2.00 m Termindated due to collapse Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP16

Job Number:	J1701214	**Easting:**	386695 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487080 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 2.0		B(TP16-1)			SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey to 0.3-0.5m, becoming yellow-brown, some LIMESTONE recovered as well cemented, medium to high strength boulders and cobbles, LIMESTONE Pinnacles on south and east side of Test Pit from 0.3m to termination, large trace roots from 0.3m to 2.0m	M	L - MD	Limestone outcrops in vicinity
			2.0						Hole terminated at 2.00 m Terminated at 2.0 m due to collapse Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP17

Job Number:	J1701214	**Easting:**	386922 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487085 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 1.5					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey to 0.3m, becoming yellow-brown, large roots throughout	M	VL - L	
			2.0 – 3.0						Hole terminated at 1.80 m Terminated due to collapse. Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP18

Sheet 1 OF 1

Job Number:	J1701214	**Easting:**	387102 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487089 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 1.90					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey to 0.4m, becoming yellow-brown, trace roots throughout	M	L	
			2.0						Hole terminated at 1.90 m Terminated due to collapse. Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP19

Sheet 1 OF 1

Job Number:	J1701214	**Easting:**	387314 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487085 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 1.5					SP	SAND: fine to coarse grained, dark grey to 0.3m, becoming yellow-brown, trace roots throughout	M	L	
			1.5 – 3.0						Hole terminated at 1.60 m Terminated due to collapse. Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP20

Job Number:	J1701214	**Easting:**	387022 m	**Contractor:**	Galt	**Date:**	28/09/2017
Client:	Cossill & Webley	**Northing:**	6487354 m	**Machine:**	JCB 3CX	**Logged:**	KH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	BJ	**Checked Date:**	05/10/2017
Location:	Lot 1665 Wanneroo Road, Sinagra			**Bucket:**	0.5 m	**Checked By:**	FAD
				Width: 1 m	**Length:** 4 m		

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	VE		0.0 – 1.5					SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey to 0.3-0.5m, becoming yellow-brown, trace low-plasticity fines to 0.3m, rootlets to 0.5m	M	L - MD	
			1.5 – 3.0						Hole terminated at 1.50 m Terminated due to collapse. Groundwater not encountered			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix E: Summary Hand Auger Borehole Reports

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ABN: 64 625 054 729

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

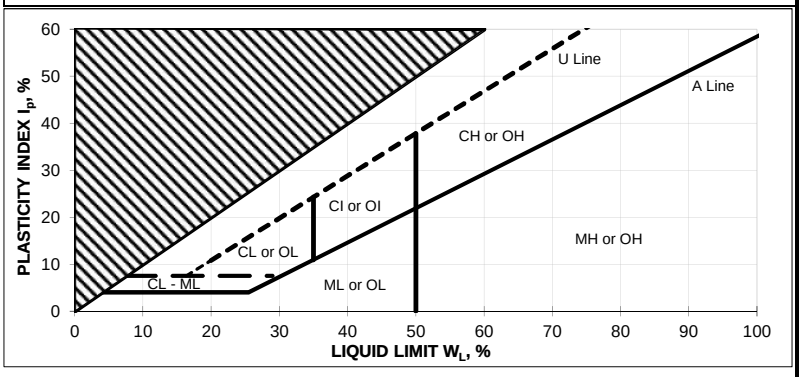
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		**Particle Size (mm)**
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION		
Symbol	**Term**	**Description**
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION	
Symbol	**Term**
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	**Description**
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	**Term**	**Undrained Shear Strength (kPa)**
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	**Organic Content % of dry mass**
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	**Term**	**Density Index (%)**
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

SUMMARY HAND AUGER BOREHOLE REPORT

Job Number:	J1701214	**Date Performed:**	28/9/2017
Client:	Cossill and Webley	**Excavated using:**	Hand Auger
Project:	Proposed Residential Subdivision	**Logged By:**	KH
Location:	Lot 1665 Wanneroo Road, Sinagra		

HA01

Test Depth (m)	Stratigraphy
0 - 2.0	SAND: Fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow – white below 0.4 m, loose to medium dense, dry.

End of borehole at 2.0 m
Target depth
Groundwater not encountered

HA01 spoil

HA02

Test Depth (m)	Stratigraphy
0 – 2.0	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey-brown becoming pale yellow – brown below 0.7 m, very loose to loose, dry becoming moist.

End of borehole at 2.0 m
Target depth
Groundwater not encountered

HA02 spoil

HA03

Test Depth (m)	Stratigraphy
0 – 2.0	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark brown becoming yellow – brown below 0.4 m, medium dense to dense, dry becoming moist.

End of borehole at 2.0 m
Target depth
Groundwater not encountered

HA03 spoil

HA04

Test Depth (m)	Stratigraphy
0 – 0.7	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey becoming yellow – brown below 0.3 m. Limestone gravel recovered between 0.5 m and 0.7 m depth, medium dense, moist.

End of borehole at 0.70 m
Refusal due to Limestone
Groundwater not encountered

HA04 spoil

SUMMARY HAND AUGER BOREHOLE REPORT

HA05

Test Depth (m)	Stratigraphy
0 – 2.0	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey becoming yellow – brown below 1.2 m. Some low plasticity fines top 0.2 m, dense to very dense**,** dry becoming moist.

End of borehole at 2.0 m
Target Depth
Groundwater not encountered

HA05 spoil

SUMMARY HAND AUGER BOREHOLE REPORT

HA06

Test Depth (m)	Stratigraphy
0 – 2.0	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey becoming yellow – brown below 0.8 m. Some organics and rootlets top 0.3 m, loose to medium dense, moist becoming dry below 0.3 m.

End of borehole at 2.0 m
Target Depth
Groundwater not encountered

HA06 spoil

HA07

Test Depth (m)	Stratigraphy
0 – 1.7	SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey becoming yellow – brown below 0.5 m. Some organics and rootlets top 0.3 m. Medium Dense to Dense, dry below 0.3 m.
End of borehole at 1.7 m Terminated due to inferred rock Groundwater not encountered	

HA07 spoil

SUMMARY HAND AUGER BOREHOLE REPORT

HA08

Test Depth (m)	Stratigraphy
0 – 2.0	0.0 – 0.2 m SAND: Fine to coarse grained, sub-angular to sub-rounded, dark grey with trace Limestone gravel; overlying: 0.2 – 0.6 m SAND: Fine to medium grained, generally sub-rounded, black inferred fill, overlying: 0.6 – 2.0 m SAND: Fine to coarse grained, sub-angular to sub-rounded, grey becoming brown to yellow-brown.
End of borehole at 2.0 m Target Depth Loose to Medium Dense Groundwater not encountered	

HA08 spoil

Appendix F: PSP Test Results

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PERTH SAND PENETROMETER FIELD TEST DATA
(AS 1289.6.3.3)

Client:	Cossill and Webley	**Job No:**	J1701214
Project:	Proposed Residential Subdivision	**Date:**	28/09/2017
Location:	Lot 1165 Wanneroo Road, Sinagra	**Engineer:**	KH

Test No:	PSP01	PSP02	PSP03	PSP04	PSP05	PSP06
Location:	TP01	TP02	TP03	TP04	TP05	TP06
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET	SET	SET	SET	SET
150-300	1	1	1	3	1	1
300-450	2	2	1	7	2	2
450-600	1	2	1	6	2	2
600-750	1	1	1	6	1	2
750-900	2	3	1	5	2	2
900-1050	2	2	1	6	1	2

Test No:	PSP07	PSP08	PSP09	PSP10	PSP11	PSP12
Location:	TP07	TP08	TP09	TP10	TP11	TP12
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET	SET	SET	SET	SET
150-300	3	2	2	3	1	3
300-450	4	2	4	3	1	4
450-600	5	3	7	4	4	6
600-750	5	5	3	3	6	6
750-900	6	5	3	3	9	5
900-1050						

Test No:	PSP13	PSP14	PSP15	PSP16	PSP17	PSP18
Location:	TP13	TP14	TP15	TP16	TP17	TP18
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET	SET	SET	SET	SET
150-300	4	1	5	1	1	1
300-450	9	1	6	1	1	1
450-600	12	1	6	1	1	2
600-750	15+	2	5	4	1	2
750-900		2	5	8	2	2
900-1050					2	2

Test No:	PSP19	PSP20				
Location:	TP19	TP20				
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET				
150-300	1	2				
300-450	1	2				
450-600	2	3				
600-750	1	3				
750-900	2	3				
900-1050	2					

Perth Sand Penetrometer tests done in accordance with AS 1289.6.3.3 (blow counts reported at 150 mm)
HB: Hammer bounce (refusal)
0 = Penetration due to hammer weight only
R: Refusal

PERTH SAND PENETROMETER FIELD TEST DATA
(AS 1289.6.3.3)

Client:	Cossill and Webley	**Job No:**	J1701214
Project:	Proposed Residential Subdivision	**Date:**	28/09/2017
Location:	Lot 1665 Wanneroo Road, Sinagra	**Engineer:**	KH

Test No:	PSP21	PSP22	PSP23	PSP24	PSP25	PSP26
Location:	HA01	HA02	HA03	HA04	HA05	HA06
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET	SET	SET	SET	SET
150-300	2	1	3	2	3	2
300-450	2	1	5	4	11	2
450-600	3	2	5	6HB	6	4
600-750	4	2	5		7	3
750-900	3	2	5		11	3
900-1050						

Test No:	PSP27	PSP28				
Location:	HA07	HA08				
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150	SET	SET				
150-300	3	2				
300-450	2	1				
450-600	4	3				
600-750	5	2				
750-900	7	2				
900-1050						

Test No:						
Location:						
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150						
150-300						
300-450						
450-600						
600-750						
750-900						

Test No:						
Location:						
Depth (mm)	**N°** of Penetrometer Blows per 150 mm Depth Interval					
0-150						
150-300						
300-450						
450-600						
600-750						
750-900						

Perth Sand Penetrometer tests done in accordance with AS 1289.6.3.3 (blow counts reported at 150 mm)

HB: Hammer bounce (refusal)

0 = Penetration due to hammer weight only

R: Refusal

Appendix G: Infiltration Test Results

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4/15 Walters Drive OSBORNE PARK WA 6017
ABN: 64 625 054 729

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

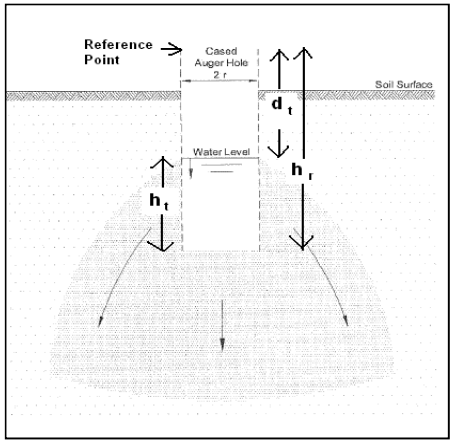
Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH

BH Name:	BH01	
Test Depth:	0.85	m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.03	m
t	time since start of measurement		s
h_r	reference point height above base	1.05	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

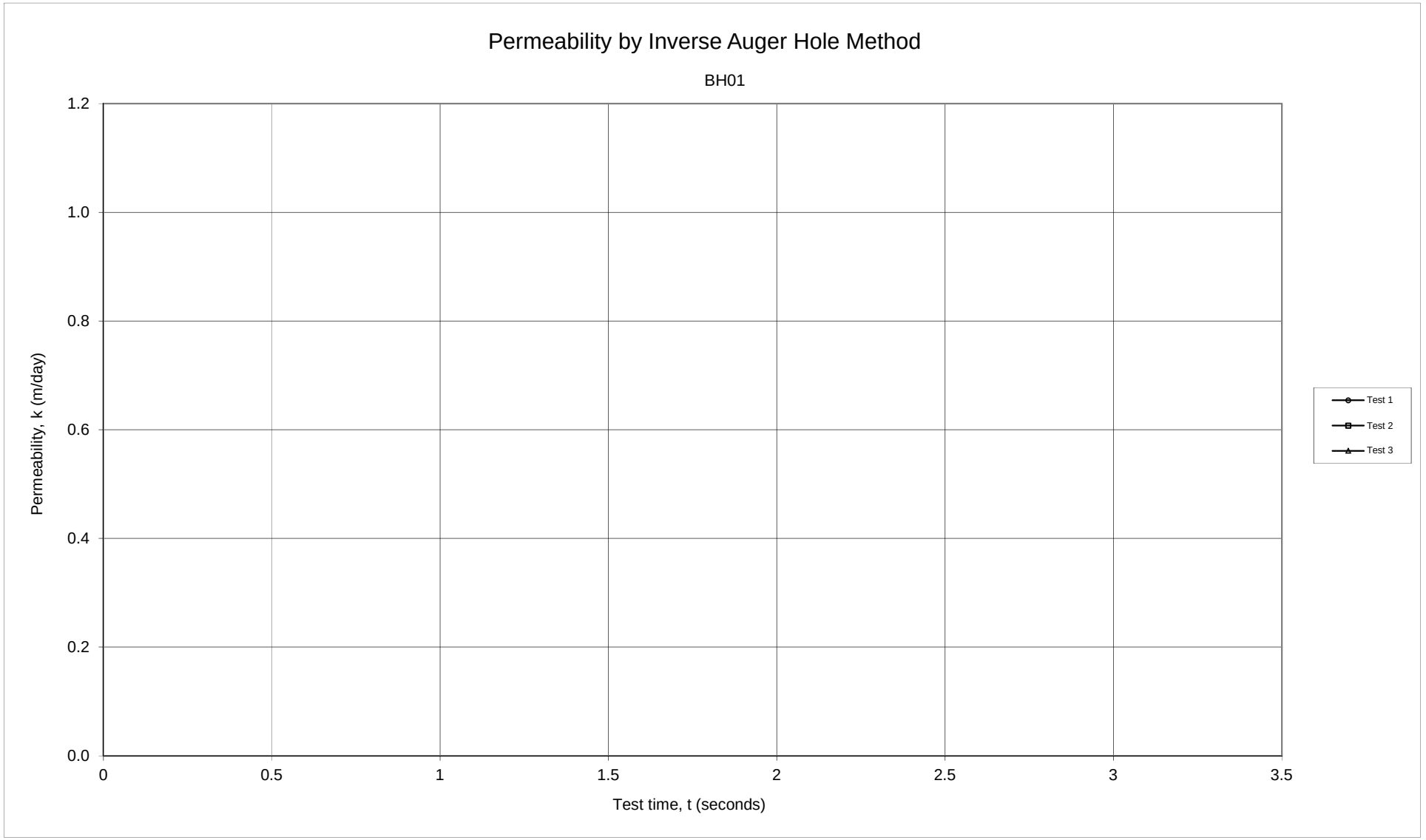
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15


Permeability by Inverse Auger Hole Method
BH01
Permeability, k (m/day)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
0.5
1
1.5
2
2.5
3
3.5
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

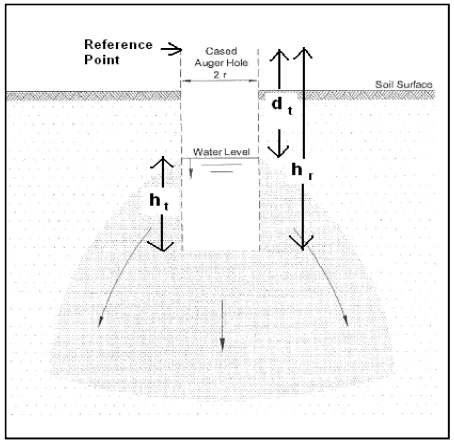
Galt Geotechnics

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH
BH Name:	BH02
Test Depth:	1.00 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	1.05	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

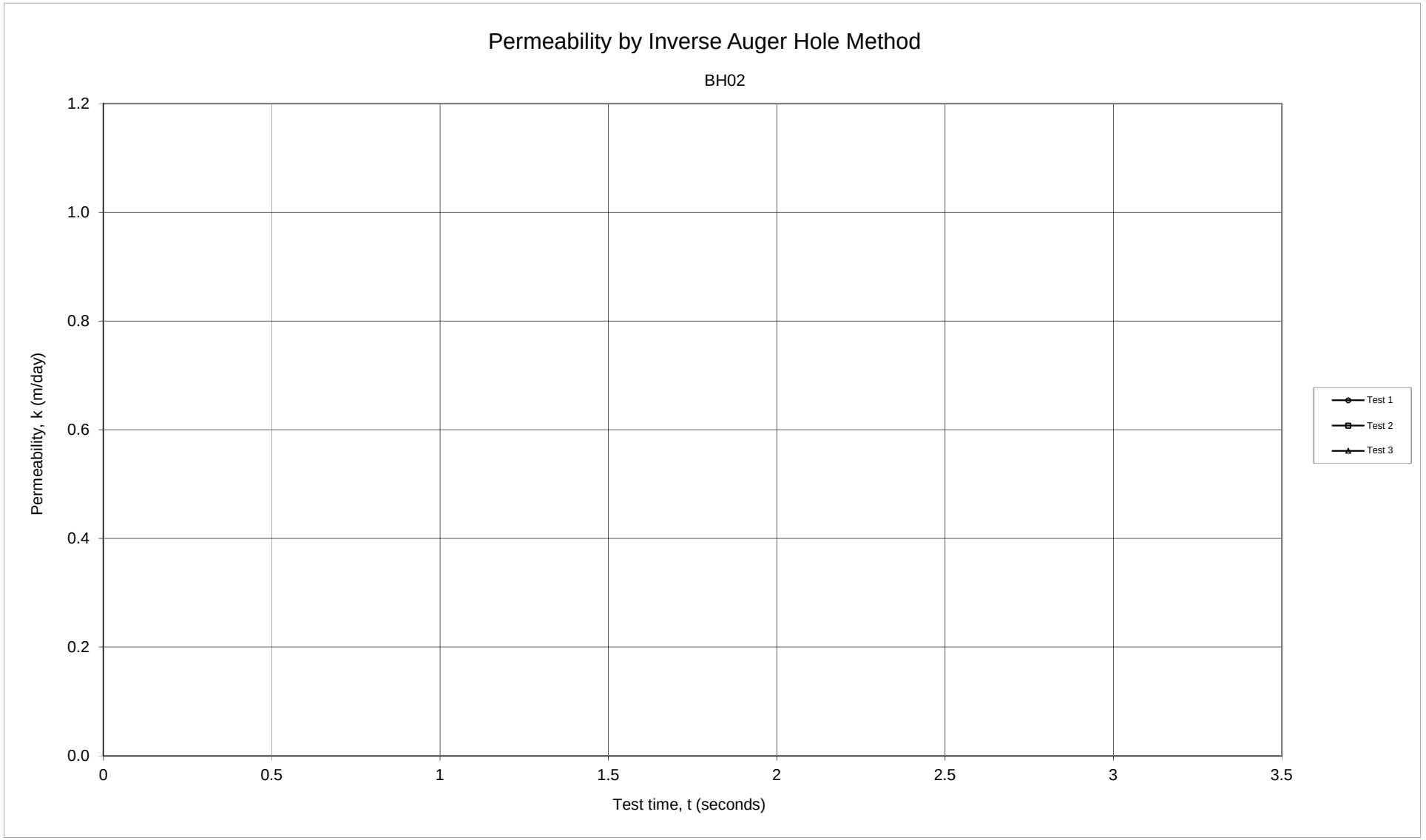
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
		AVERAGE	1.7E-04	>15


Permeability by Inverse Auger Hole Method
BH02
Permeability, k (m/day)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
0.5
1
1.5
2
2.5
3
3.5
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

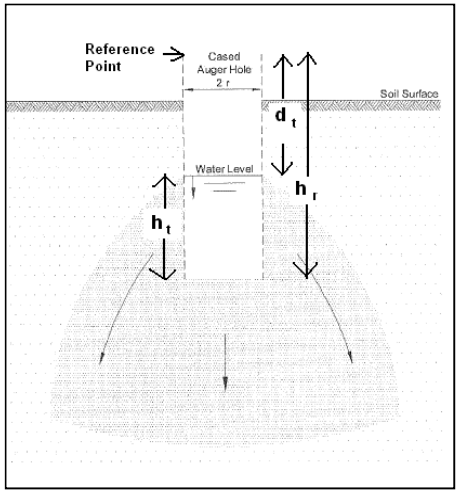
Galt Geotechnics

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH
BH Name:	BH03
Test Depth:	0.75 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.03	m
t	time since start of measurement		s
h_r	reference point height above base	1.05	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

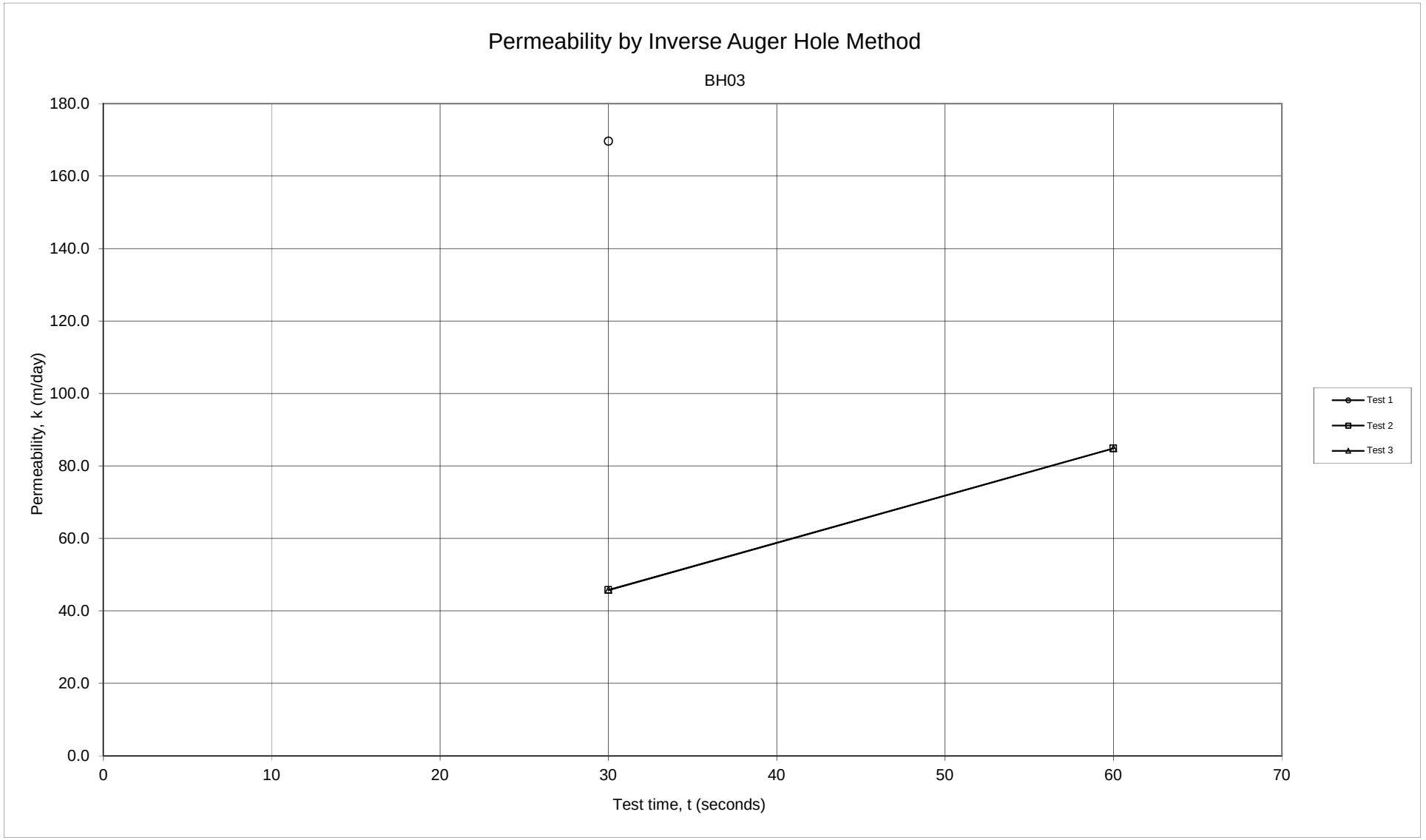
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.3	0.75		
30	1.05	0	2.0E-03	169.7
		AVERAGE	2.0E-03	169.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.3	0.75		
30	0.8	0.25	5.3E-04	45.7
60	1.05	0	9.8E-04	84.8
		AVERAGE	7.6E-04	65.3

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.3	0.75		
30	0.8	0.25	5.3E-04	45.7
60	1.05	0	9.8E-04	84.8
		AVERAGE	7.6E-04	65.3


Permeability by Inverse Auger Hole Method
BH03
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Permeability, k (m/day)
0
10
20
30
40
50
60
70
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential
Location:	Ingham Chicken Site,
Calc by:	KH
BH Name:	BH04
Test Depth:	0.80 m

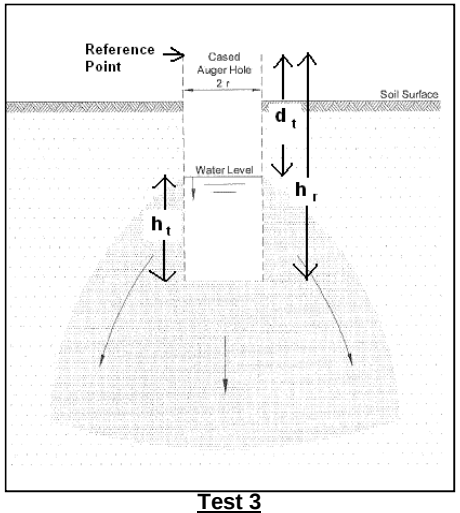
$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	1.05	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

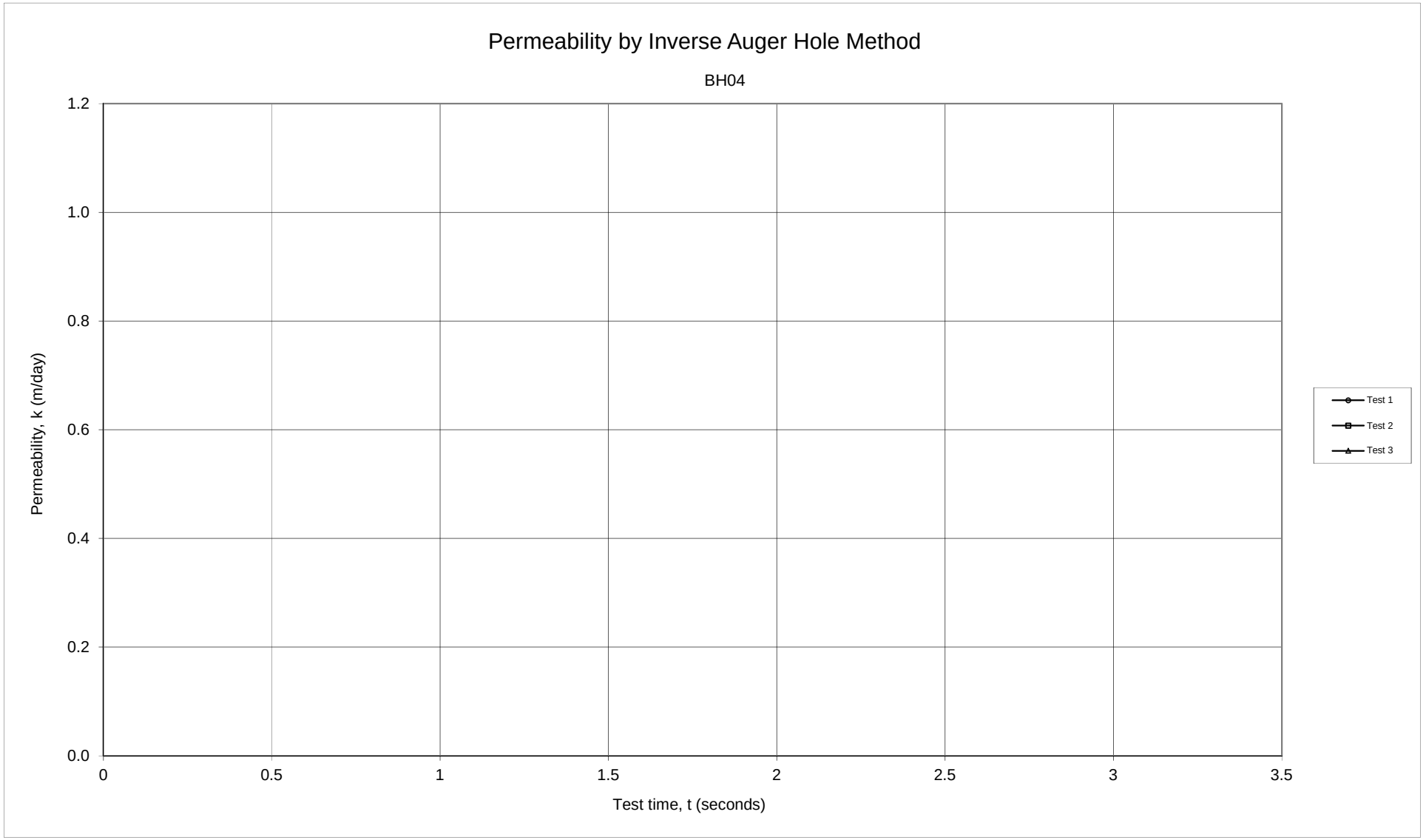
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
			AVERAGE	1.7E-04 >15

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
			AVERAGE	1.7E-04 >15

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
DID NOT FILL				
			AVERAGE	1.7E-04 >15


Permeability by Inverse Auger Hole Method
BH04
Permeability, k (m/day)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
0.5
1
1.5
2
2.5
3
3.5
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

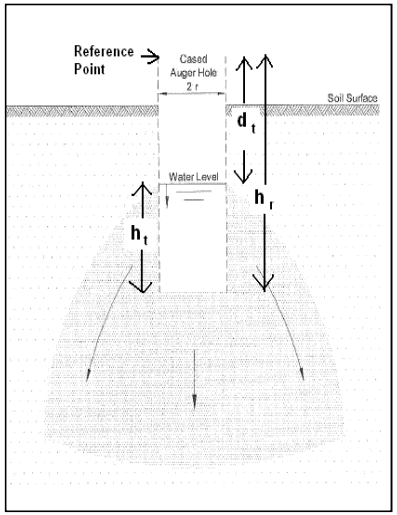
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



BH Name:	BH05	
Test Depth:	1.10	m

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
X	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	1.1	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

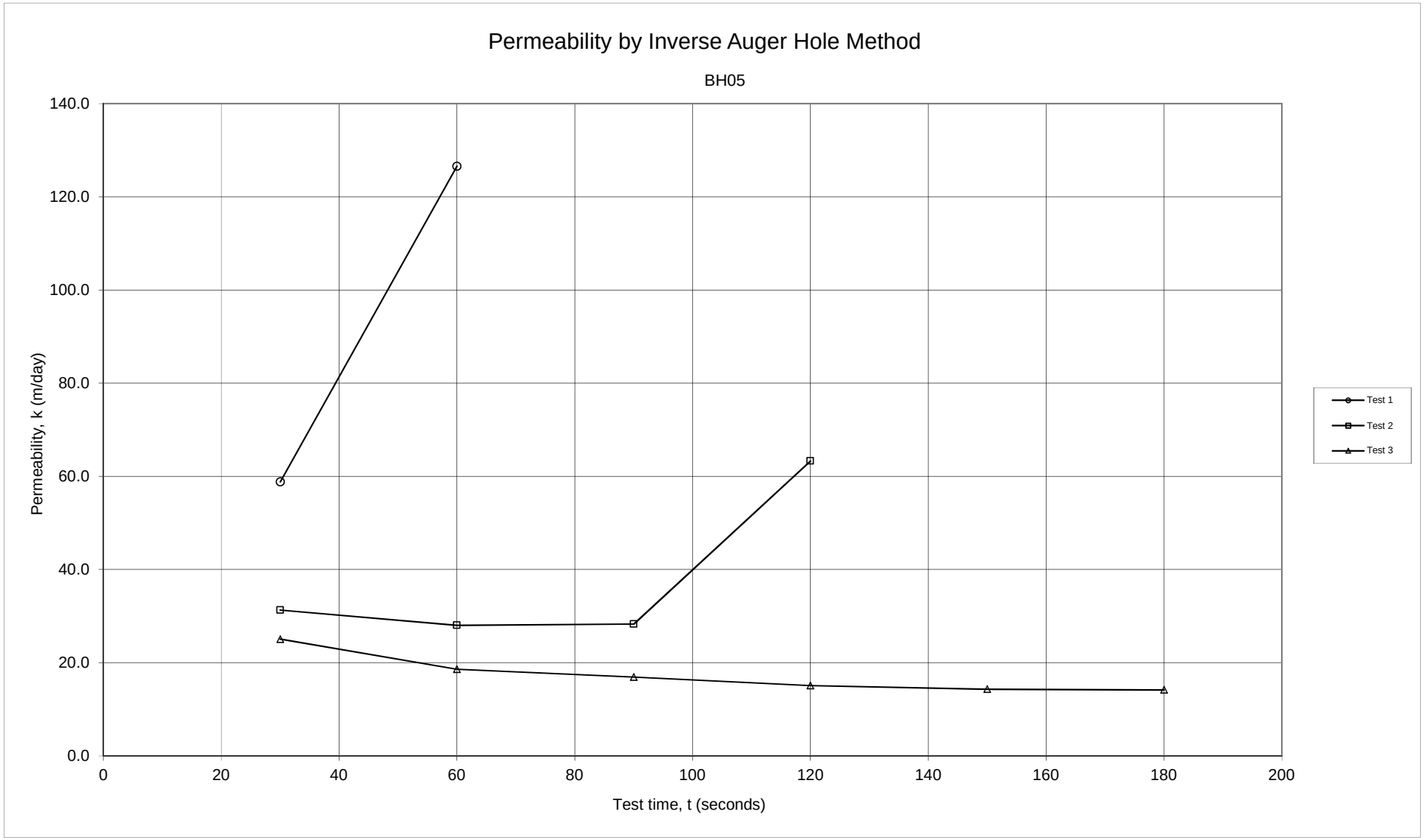
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0	1.1		
30	0.67	0.43	6.8E-04	58.8
60	1.1	0	1.5E-03	126.5
		AVERAGE	1.1E-03	92.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0	1.1		
30	0.43	0.67	3.6E-04	31.3
60	0.65	0.45	3.2E-04	28.0
90	0.82	0.28	3.3E-04	28.3
120	1.1	0	7.3E-04	63.3
		AVERAGE	4.4E-04	37.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0	1.1		
30	0.36	0.74	2.9E-04	25.0
60	0.49	0.61	2.1E-04	18.6
90	0.61	0.49	2.0E-04	16.9
120	0.68	0.42	1.7E-04	15.1
150	0.75	0.35	1.7E-04	14.3
180	0.82	0.28	1.6E-04	14.1
		AVERAGE	2.0E-04	17.3


Permeability by Inverse Auger Hole Method
BH05
Permeability, k (m/day)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

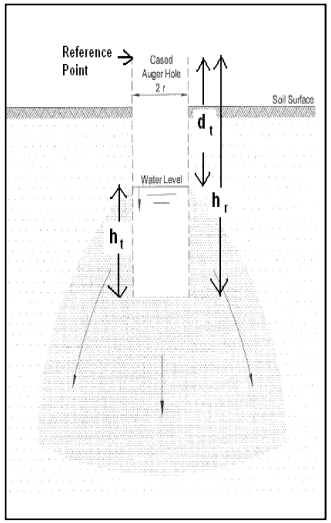
Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH

BH Name:	BH06	
Test Depth:	1.00	m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

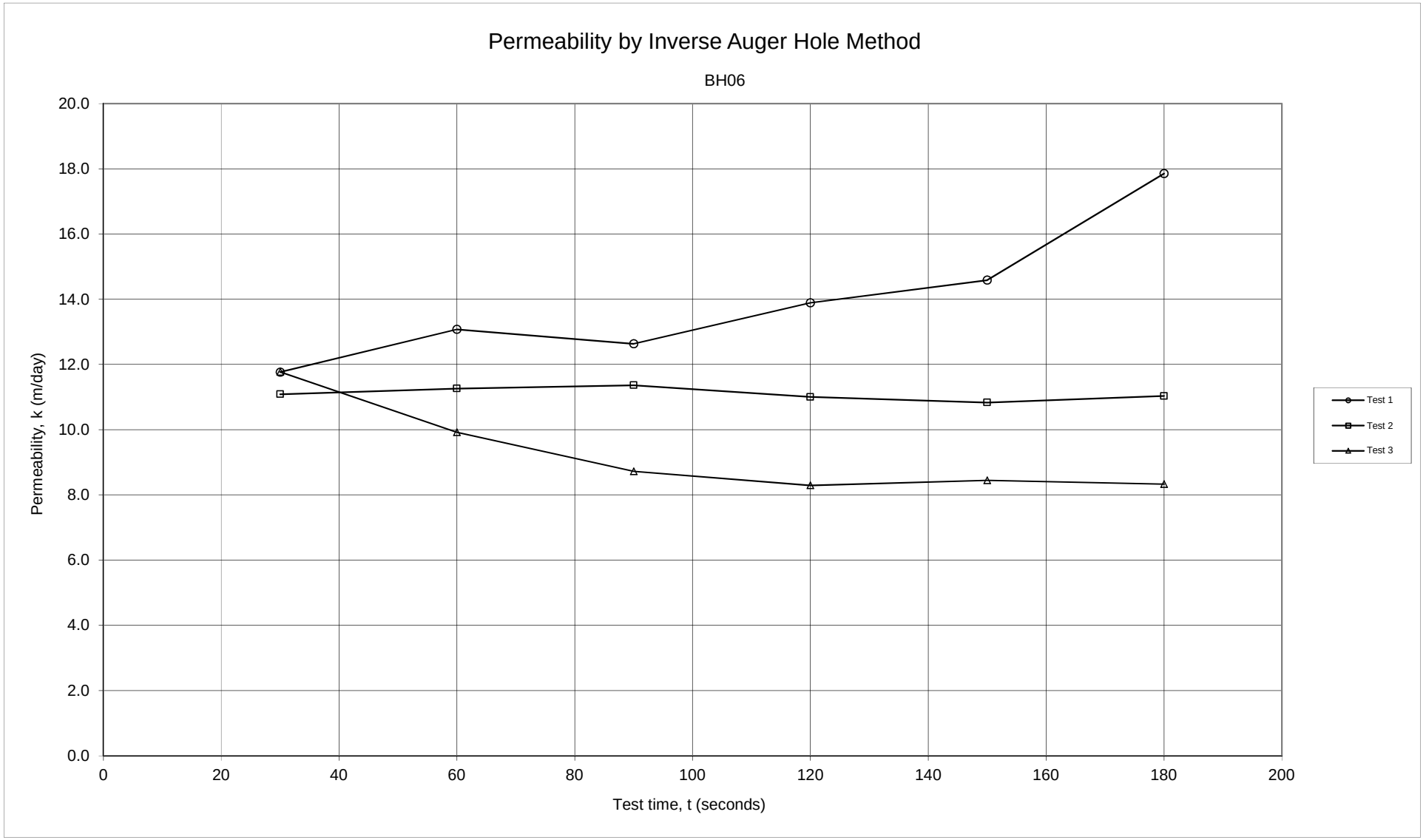
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.12	0.88		
30	0.27	0.73	1.4E-04	11.8
60	0.42	0.58	1.5E-04	13.1
90	0.52	0.48	1.5E-04	12.6
120	0.64	0.36	1.6E-04	13.9
150	0.73	0.27	1.7E-04	14.6
180	0.85	0.15	2.1E-04	17.9
		AVERAGE	1.6E-04	14.0

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.07	0.93		
30	0.22	0.78	1.3E-04	11.1
60	0.35	0.65	1.3E-04	11.3
90	0.46	0.54	1.3E-04	11.4
120	0.54	0.46	1.3E-04	11.0
150	0.61	0.39	1.3E-04	10.8
180	0.68	0.32	1.3E-04	11.0
		AVERAGE	1.3E-04	11.1

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0	1		
30	0.17	0.83	1.4E-04	11.8
60	0.27	0.73	1.1E-04	9.9
90	0.34	0.66	1.0E-04	8.7
120	0.41	0.59	9.6E-05	8.3
150	0.49	0.51	9.8E-05	8.4
180	0.55	0.45	9.6E-05	8.3
		AVERAGE	1.1E-04	9.2


Permeability by Inverse Auger Hole Method
BH06
Permeability, k (m/day)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

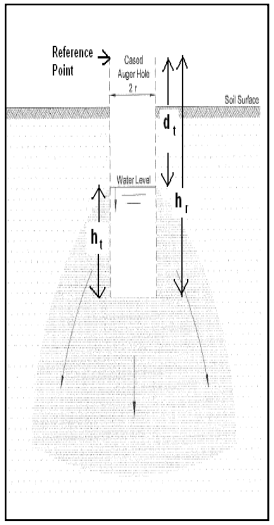
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



BH Name:	BH07	
Test Depth:	0.80	m

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
X	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.8	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

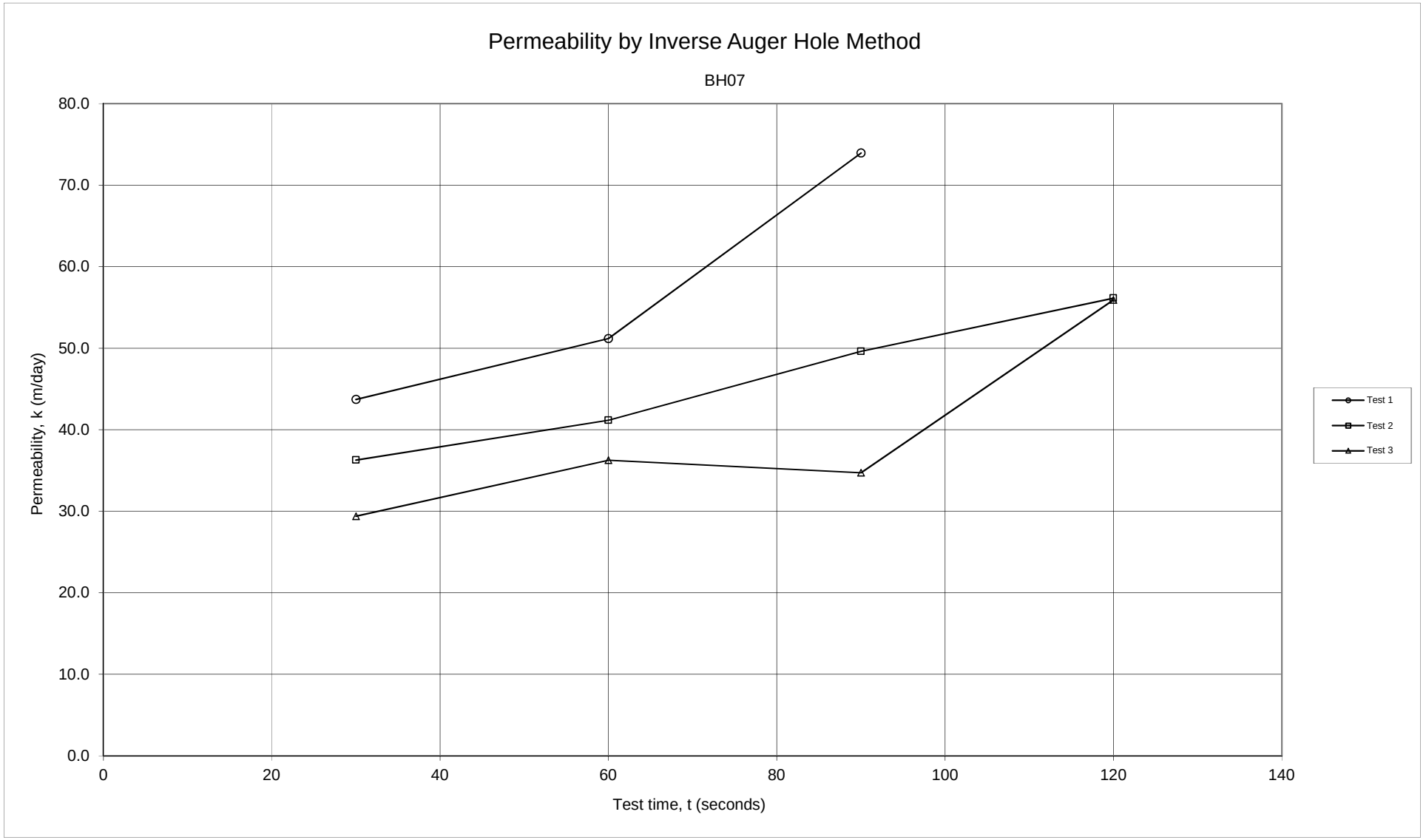
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.13	0.67		
30	0.47	0.33	5.1E-04	43.7
60	0.68	0.12	5.9E-04	51.2
90	0.8	0	8.6E-04	73.9
		AVERAGE	6.5E-04	56.3

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.1	0.7		
30	0.41	0.39	4.2E-04	36.3
60	0.62	0.18	4.8E-04	41.2
90	0.75	0.05	5.7E-04	49.6
120	0.8	0	6.5E-04	56.1
		AVERAGE	5.3E-04	45.8

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.11	0.69		
30	0.37	0.43	3.4E-04	29.4
60	0.59	0.21	4.2E-04	36.2
90	0.68	0.12	4.0E-04	34.7
120	0.8	0	6.5E-04	55.9
		AVERAGE	4.5E-04	39.1


Permeability by Inverse Auger Hole Method
BH07
Permeability, k (m/day)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

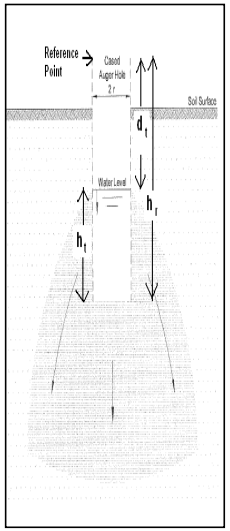
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	J1701214
Client:	Cossill and Webley
Project:	Proposed Resindential Subdivision
Location:	Ingham Chicken Site, Sinagra
Calc by:	KH
BH Name:	BH08
Test Depth:	1.00 m

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

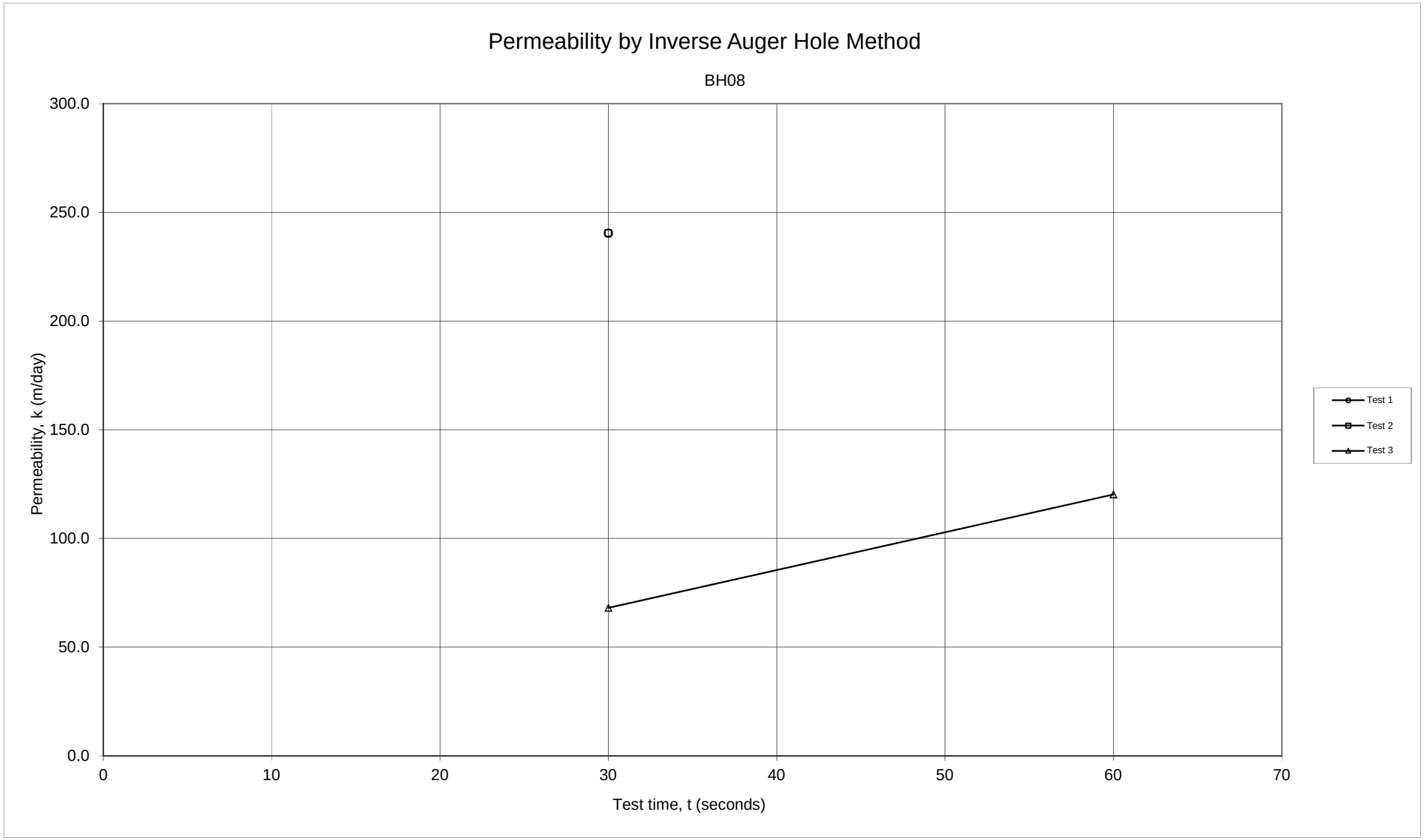
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.1	0.9		
30	1	0	2.8E-03	240.4
		AVERAGE	2.8E-03	240.4

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.1	0.9		
30	1	0	2.8E-03	240.4
		AVERAGE	2.8E-03	240.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.1	0.9		
30	0.7	0.3	7.9E-04	68.0
60	1	0	1.4E-03	120.2
		AVERAGE	1.1E-03	94.1


Permeability by Inverse Auger Hole Method
BH08
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Permeability, k (m/day)
0
10
20
30
40
50
60
70
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix H: Laboratory Test Results

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ABN: 64 625 054 729

LIQUIDLABSWA
CONSTRUCTION MATERIALS TESTING LABORATORY
UNIT 4, 96 BRIGG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

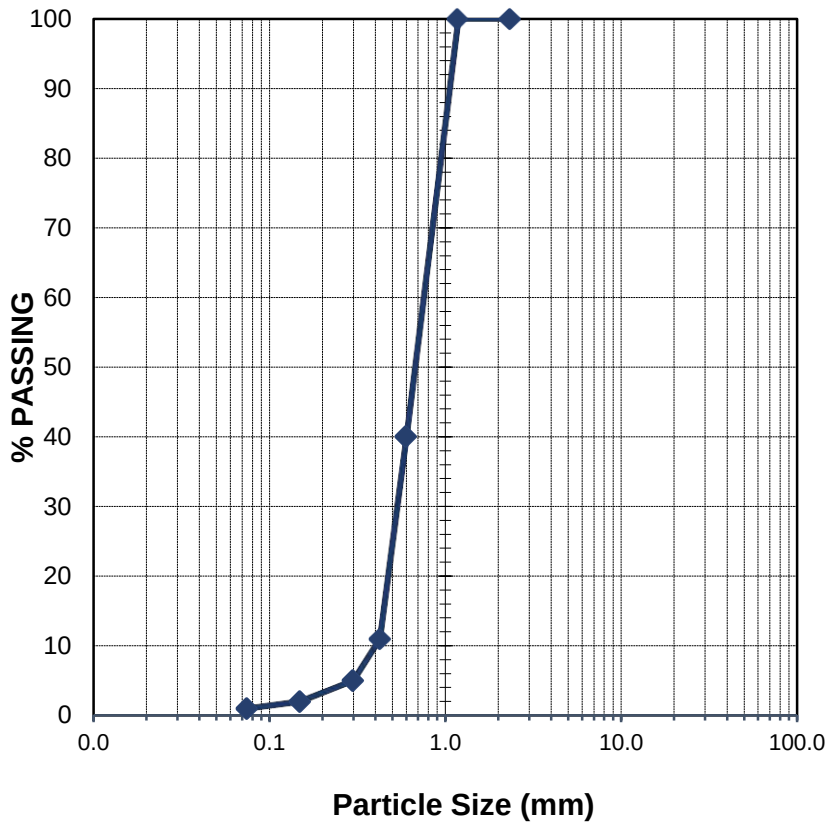
SOIL CLASSIFICATION - TEST REPORT

In accordance with **AS 1289.3.6.1**

Client	**Galt Geotechnics**	Ticket No.	**S858**
Client Address	**4/15 Walters Dr, Osborne Park, WA 6017**	Report No.	**LLS17/2326 _2**
Project	**1040 Wanneroo Road**	Sample No.	**LLS17/2326**
Sampling Location	**Sinagra**	Sampled By	**Client**
Sample Identification	**HA01 0.4-1.0m**		
Sampling Method	**Tested as Received**	Preparation Method	**AS 1289.1.1**
Sample History	**Air Dried**	Wet or Dry Sieved	**Dry Sieved**

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	40
0.425	11
0.300	5
0.150	2
0.075	1

Comments:

Approved Signatory

Name	M. van Herk
Function	Laboratory Manager
Issue Date	06-October-2017

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation No. 19872

LIQUIDLABSWA
CONSTRUCTION MATERIALS TESTING LABORATORY
UNIT 4, 96 BRIGG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

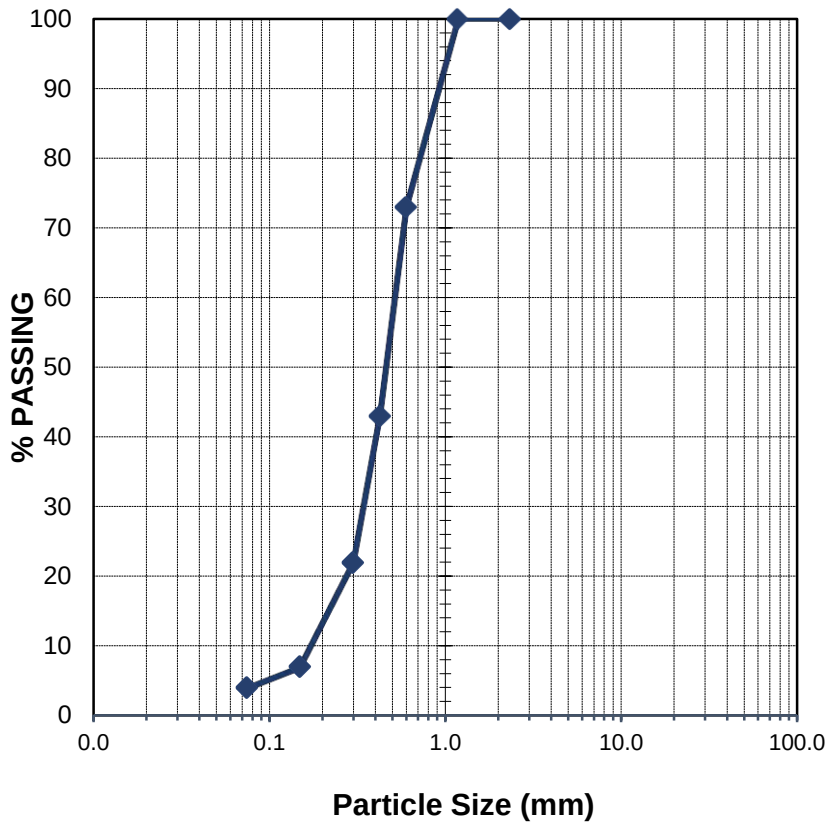
SOIL CLASSIFICATION - TEST REPORT

In accordance with **AS 1289.3.6.1**

Client	**Galt Geotechnics**	Ticket No.	**S858**
Client Address	**4/15 Walters Dr, Osborne Park, WA 6017**	Report No.	**LLS17/2327 _1**
Project	**1040 Wanneroo Road**	Sample No.	**LLS17/2327**
Sampling Location	**Sinagra**	Sampled By	**Client**
Sample Identification	**TP06 0.8-1.5m**		
Sampling Method	**Tested as Received**	Preparation Method	**AS 1289.1.1**
Sample History	**Air Dried**	Wet or Dry Sieved	**Dry Sieved**

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	73
0.425	43
0.300	22
0.150	7
0.075	4

Comments:

Approved Signatory

Name	M. van Herk
Function	Laboratory Manager
Issue Date	05-October-2017

NATA WORLD RECOGNISED ACCREDITATION

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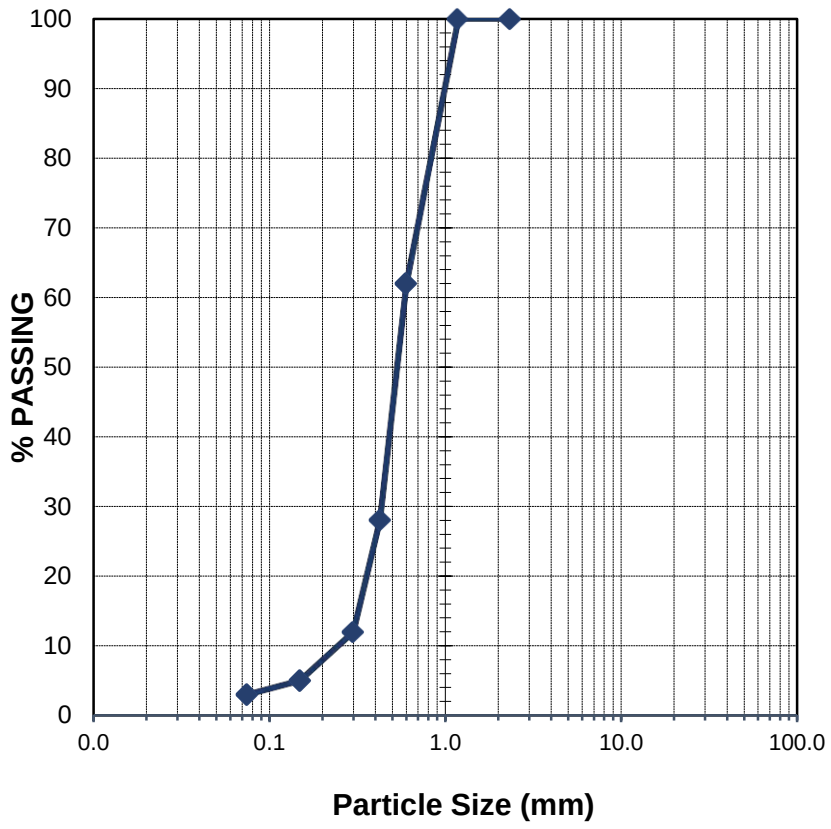
SOIL CLASSIFICATION - TEST REPORT

In accordance with **AS 1289.3.6.1**

Client	**Galt Geotechnics**	Ticket No.	**S858**
Client Address	**4/15 Walters Dr, Osborne Park, WA 6017**	Report No.	**LLS17/2328 _1**
Project	**1040 Wanneroo Road**	Sample No.	**LLS17/2328**
Sampling Location	**Sinagra**	Sampled By	**Client**
Sample Identification	**TP09 0.2-1.0m**		
Sampling Method	**Tested as Received**	Preparation Method	**AS 1289.1.1**
Sample History	**Air Dried**	Wet or Dry Sieved	**Dry Sieved**

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	62
0.425	28
0.300	12
0.150	5
0.075	3

Comments:

Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation No. 19872

Approved Signatory

Name	M. van Herk
Function	Laboratory Manager
Issue Date	05-October-2017

LIQUIDLABSWA
CONSTRUCTION MATERIALS TESTING LABORATORY
UNIT 4, 96 BRIGG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

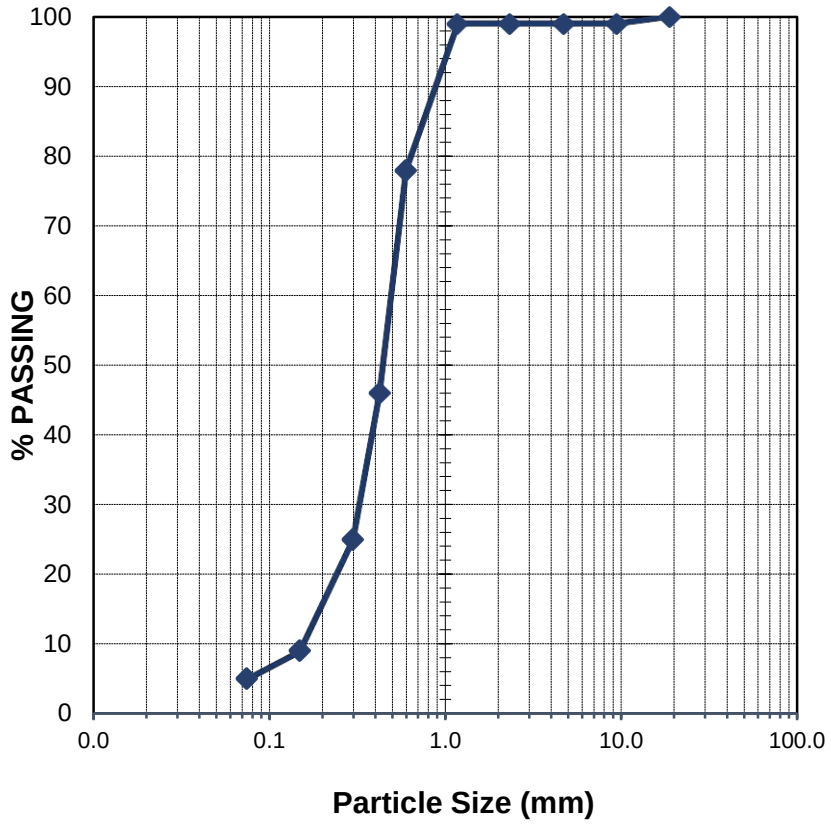
SOIL CLASSIFICATION - TEST REPORT

In accordance with **AS 1289.3.6.1**

Client	**Galt Geotechnics**	Ticket No.	**S858**
Client Address	**4/15 Walters Dr, Osborne Park, WA 6017**	Report No.	**LLS17/2329 _1**
Project	**1040 Wanneroo Road**	Sample No.	**LLS17/2329**
Sampling Location	**Sinagra**	Sampled By	**Client**
Sample Identification	**TP10 0.7-1.7m**		
Sampling Method	**Tested as Received**	Preparation Method	**AS 1289.1.1**
Sample History	**Air Dried**	Wet or Dry Sieved	**Dry Sieved**

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.0	
37.5	
19.0	100
9.5	99
4.75	99
2.36	99
1.18	99
0.600	78
0.425	46
0.300	25
0.150	9
0.075	5

Comments:

Approved Signatory

Name	M. van Herk
Function	Laboratory Manager
Issue Date	05-October-2017

NATA WORLD RECOGNISED ACCREDITATION

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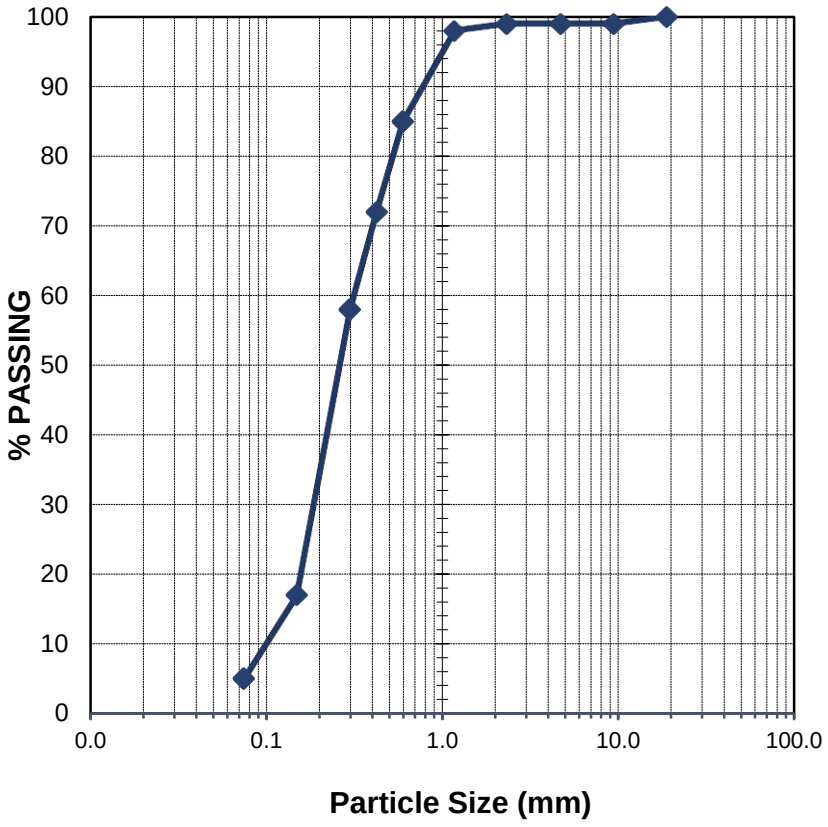
SOIL CLASSIFICATION - TEST REPORT

In accordance with **AS 1289.3.6.1**

Client	**Galt Geotechnics**	Ticket No.	**S858**
Client Address	**4/15 Walters Dr, Osborne Park, WA 6017**	Report No.	**LLS17/2330 _1**
Project	**1040 Wanneroo Road**	Sample No.	**LLS17/2330**
Sampling Location	**Sinagra**	Sampled By	**Client**
Sample Identification	**TP16 0.5-1.0m**		
Sampling Method	**Tested as Received**	Preparation Method	**AS 1289.1.1**
Sample History	**Air Dried**	Wet or Dry Sieved	**Dry Sieved**

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.0	
37.5	
19.0	100
9.5	99
4.75	99
2.36	99
1.18	98
0.600	85
0.425	72
0.300	58
0.150	17
0.075	5

Comments:

Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation No. 19872

Approved Signatory

Name	M. van Herk
Function	Laboratory Manager
Issue Date	05-October-2017

Appendix I: Understanding Your Report

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ABN: 64 625 054 729

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev2

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.