PART ONE
IMPLEMENTATION SECTION

LOT 345 WOOLLCOTT AVENUE, BRABHAM
LOCAL STRUCTURE PLAN 3B

October 2016

ALCOCK BROWN-NEAVES GROUP

CLE TOWN PLANNING + DESIGN

LOT 345 WOOLLCOTT AVENUE, BRABHAM LOCAL STRUCTURE PLAN 3B

PART ONE - IMPLEMENTATION SECTION

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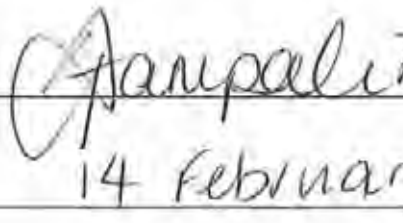
3403Rep13B
October 2016

This structure plan is prepared under the provisions of the City of Swan Local Planning Scheme No.17

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON: 10 FEBRUARY 2017

Signed for and on behalf of the Western Australian Planning Commission

an officer of the Commission duly authorised by the Commission pursuant to Section 16 of *the Planning and Development Act 2005* for that purpose, in the presence of:



Witness

14 February 2017

Date

Date of Expiry: 10 FEBRUARY 2027

TABLE OF AMENDMENTS

Amendment No.	Summary of the Amendment	Amendment Type	Date approved by WAPC

TABLE OF DENSITY PLANS

Density Plan No.	Area of density plan application	Date approved by WAPC

EXECUTIVE SUMMARY

The Brabham Local Structure Plan 3B (LSP3B) allows for the creation of a diverse and integrated urban community that responds to the surrounding land use context and natural environment, as well as the planning framework established by the Albion District Structure Plan.

The LSP3B area covers approximately 20.7 hectares over Lot 345 Woollcott Avenue, Brabham. The urbanisation and development of the subject land provides further opportunities to maximise the catchment to existing and planning infrastructure through consolidation of urban development, while satisfying State Government housing targets and recognising the natural setting of the land.

LSP3B area is a self contained residential cell in single ownership, and consolidates the planning already undertaken for land in the north and west. Through the inclusion of a permeable local road network, the LSP establishes a clean and interconnected interface for the future development of the Department of Housing land to the east, and supplements all future provision of services and infrastructure within it.

LSP3B responds to the current endorsed planning framework provided in the Albion District Structure Plan. It recognises and elaborates on the key principles of this overarching document to provide a mechanism for its implementation.

The Structure Plan allows for the creation of approximately 325-335 dwellings over the 20 hectares of urban zoned land. Consistent with the Albion District Structure Plan, LSP3B allows for 2.45 hectares of creditable Public Open Space, achieving an appropriate amount of usable passive open space, as well as recognising significant vegetation and drainage requirements within St Leonards Creek and other public open space reserves. In accordance with Liveable Neighbourhoods, once appropriate credits are applied, 12.3% open space is provided.

Consistent with the Albion District Structure Plan, the LSP area will provide a diverse range of housing choice. Medium density housing options will be located around areas of public open space, and within close proximity to a neighbourhood centre on the land to the east, balanced with more traditional medium densities that integrate with surrounding development.

LSP3B recognises the existing Parmelia Natural Gas Pipeline that traverses the western boundary of the LSP area from north to south, providing a landscaped public utilities reserve. Setback distances from this pipeline have been determined following a Qualitative Risk Assessment in accordance with the WAPC and Local Planning Scheme requirements.

Land Use Summary

Item	Data	Section number referenced within the Structure Plan Report
Total area covered by the structure plan	20.7 hectares	1.2.2
Area of each land use proposed: - Residential - Local Reserve - Public Utilities - Local Reserves - Recreation - St Leonards Creek (Lot 33)	 16.82 hectares 1.36 hectares 2.45 hectares 0.07 hectares	
Total estimated lot yield	320 – 330 lots	3.4
Estimated number of dwellings	325 – 335 dwellings	3.4
Estimated residential site density	29 dwellings per site hectare 16 – 17 dwellings per gross urban hectare	3.4
Estimated population	910 – 938 people @ 2.8 people per household	3.4
Estimated area and percentage of public open space given over to: - District open space Neighbourhood parks - Local parks	 0ha / 0% 1.7ha / 69% (POS 3 and 4) 0.81 – 31% (POS 1 and 2)	3.2

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TABLES

PLANS

1.0 STRUCTURE PLAN AREA

This Local Structure Plan, also referred to as Lot 345 Woollcott Avenue, Brabham Local Structure Plan 3B (LSP 3A), applies to that land contained within the inner edge of the broken line denoting the structure plan boundary as shown on Plan A: Local Structure Plan, being all of lot 345 Woollcott Avenue and part Lot 33, Henley Brook.

2.0 STRUCTURE PLAN CONTENT

This Local Structure Plan comprises:

- Part One – Implementation Section
- Part Two – Explanatory Report
- Appendices – Technical Reports

Part One of the Local Structure Plan comprises the structure plan map and statutory provisions and requirements necessary in order to implement the structure plan. Part Two of the Local Structure Plan justifies and clarifies the provisions contained in Part One, and is used as a reference guide to interpret Part One.

3.0 OPERATION

This Local Structure Plan comes into effect on the date that it is approved by the Western Australian Planning Commission.

4.0 INTERPRETATION AND RELATIONSHIP WITH STATUTORY PLANNING FRAMEWORK

The Lot 345 Woollcott Avenue Local Structure Plan 3B constitutes a Local Structure Plan required to be prepared prior to subdivision and development of the subject land pursuant to Schedule 4 of the City of Swan Local Planning Scheme 17 and the *Planning and Development (Local Planning Schemes) Regulations 2015 Schedule 2 – Deemed provisions for local planning schemes*.

The Structure Plan Map (Plan A) outlines future land use, zones and reserves applicable within the structure plan area.

Pursuant to the *Planning and Development (Local Planning Schemes) Regulations 2015 Schedule 2 – Deemed provisions for local planning schemes*, a decision maker of an application for development approval or subdivision approval is to have due regard to the provisions of this Local Structure Plan, including the Structure Plan Map, Implementation Report, Explanatory Report and Technical Appendices.

5.0 STAGING

Development staging will follow an orderly sequence and shall not exceed the extension of essential service infrastructure or constructed road access.

6.0 SUBDIVISION AND DEVELOPMENT REQUIREMENTS

6.1 Land Use and Zones

Land use permissibility within the Structure Plan area shall generally be in accordance with the corresponding zone or reserve under the Scheme, or as otherwise outlined in this Structure Plan.

6.2 Residential

6.2.1 Dwelling Target

In accordance with the requirements of the Albion District Structure Plan, subdivisions are to achieve an average residential density of 22 dwellings per site hectare across the Structure Plan area.

6.2.2 Density

a) Plan A defines the broad residential density ranges that apply to specific areas within the Structure Plan. Lot specific residential densities, within the defined residential ranges, are to be subsequently assigned in accordance within a Density Plan approved by the WAPC at subdivision stage.

b) A Density Plan is to be submitted at the time of subdivision to the WAPC and shall be consistent with the Structure Plan, and the Residential Density Ranges identified on Plan A and locational criteria contained in Clause 6.2.3.

c) The Density Plan is to include a summary of the proposed dwelling yield of the subdivision.

d) Approval of the Density Plan shall be undertaken at the time of determination of the subdivision application by the WAPC. The approved Residential Density Code Plan shall then form part of the Structure Plan and shall be used for the determination of future development applications.

e) Variations to the Density Plan will require further approval of the WAPC, with a revised Density Plan submitted generally consistent with the approved plan of subdivision issued by the WAPC. The revised Density Plan shall be consistent with Residential Density ranges identified on Plan A and the locational criteria contained in Clause 6.2.3.

f) A revised Density Plan, consistent with Clause 6.2.2 (e) will replace, wholly or partially, the previously approved Density Plan, and shall then form part of the Structure Plan as outlined in Clause 6.2.2 (d).

g) Density Plans are not required if the WAPC considers that the subdivision is for one or more of the following:

   i) The amalgamation of lots;

   ii) Consolidation of land for 'superlot' purposes to facilitate land assembly for future development;

   iii) The purposes of facilitating the provision of access, services or infrastructure; or

   iv) Land which by virtue of its zoning or reservation under the Structure Plan cannot be developed for residential purposes.

6.2.3 Locational Criteria

The allocation of residential densities shall be in accordance with the following locational criteria:

a) The R30 density code shall apply as the base code to all 'Residential' zoned lots, with the exception of those lots coded R40 and R60 as set out in (b) and (c) below.

b) The R40 density code may apply to all 'Residential' zoned lots where one or more of the following applies:

   i) The lot has a laneway abutting the rear boundary;

   ii) The lot is located within a 400m walkable catchment of a planned Local Centre.

c) The R60 density code may apply to 'Residential' zoned lots that meet one or more of the criteria set out in (b) above and where the lot is located immediately abutting or directly opposite public open space.

6.3 Public Open Space

The provision of a minimum of 10 per cent public open space (POS) being provided. The 10% POS provision includes a pro-rata contribution to the three Neighbourhood Parks and the Local Community Centre site identified in the Development Contributions Plan DCA1 - Brabham (Albion). The balance of the 10% POS contribution shall be provided in accordance with the WAPC's Liveable Neighbourhoods policy.

Public open space is to be provided generally in accordance with Plan A and Table 1 of Part 1 of this Structure Plan, with an updated public open space schedule to be provided at the time of subdivision for determination by the WAPC, upon advice of the City of Swan.

Table 1: Strategic Public Open Space

Strategic Public Open Space Site	Indicative Size (ha)
POS 1	0.71
POS 2	0.11
POS 3	1.14
POS 4	0.49
TOTAL	2.45

6.4 Utilities Planning

6.4.1 Gas Pipeline Corridor

The land comprising the existing Parmelia Gas Pipeline easement as shown on the structure plan map (Plan A) shall be ceded free of cost to the Crown as a reserve for 'Public Utilities' at the time of subdivision, unless otherwise determined by the Western Australian Planning Commission and agreed with the City of Swan. Prior to the land being ceded, it is a condition of the Department of Lands that the Parmelia Gas Pipeline easement must be surrendered and then re-granted following ceding. The landowner will bear any costs associated with the surrender and re-grant of such easements.

The WAPC, on advice of the City of Swan and/or relevant utilities service provider(s), may require as a condition of subdivision approval:

i) the implementation as part of subdivisional works, any endorsed AS2885 Safety Management Study (Qualitative Risk Assessment) to the specification of the WAPC and/or relevant utilities service provider(s) (DBP and/or APA Group).

ii) a notification pursuant to Section 70A of the Transfer of Land Act 1893 to be placed on the certificate(s) of title of lot(s) created within the setback distances outlined in Planning Bulletin 87. The notification is to advise that the lot is in close proximity to the pipeline corridor.

7.0 DEVELPOMENT

7.1 Local Development Plans

The preparation of a Local Development Plan may be required by the Western Australian Planning Commission (WAPC), on the advice of the City of Swan, as a condition of subdivision approval where deemed necessary for land comprising, but not limited to:

i) R60 coded density sites; and

ii) Lots less than 260m² (where required).

7.2 Bushfire Management

Land identified as bush fire prone under the Department of Fire and Emergency Services' Map of Bush Fire Prone Areas are to accord with State Planning Policy 3.7 Planning in Bushfire Prone Areas, Guidelines for Planning in Bushfire Prone Areas and the Building Code of Australia.

Notwithstanding any statement to the contrary within the Australian Standard- Construction of Buildings in Bushfire Prone Areas AS 3959-2009 (or equivalent), any Class 1, 2 or 3 building or Class 10a building or deck associated with a Class 1, 2, or 3 building to be erected on residential lots within bushfire prone areas as declared under the Department of Fire and Emergency Services' Map of Bush Fire Prone Areas shall comply with requirements of AS3959-2009 (or equivalent).

8.0 OTHER REQUIREMENTS

8.1 Provision of Community Infrastructure (Funding Arrangements)

Land within the Structure Plan area is within Development Contribution Area 1 (DCA 1) as identified in the Scheme Map and Schedule 13 of the Scheme (as amended), and the Development Contributions Plan DCA 1 - Brabham (Albion) (as amended) should be read in conjunction with this Structure Plan.

A landowner shall be liable to make a cost contribution at the time and in the circumstances contemplated in Part 5A.2 of the Scheme (as amended), and this will be imposed as a condition of subdivision or development approval, generally whichever is granted first.

8.2 Conditions of Subdivision Approval

The following technical reports / strategies are to be prepared and submitted or implemented as a condition of subdivision approval where applicable:

- Urban Water Management Plan
- Pipeline Risk Management and Protection Plan (Qualitative Risk Assessment)

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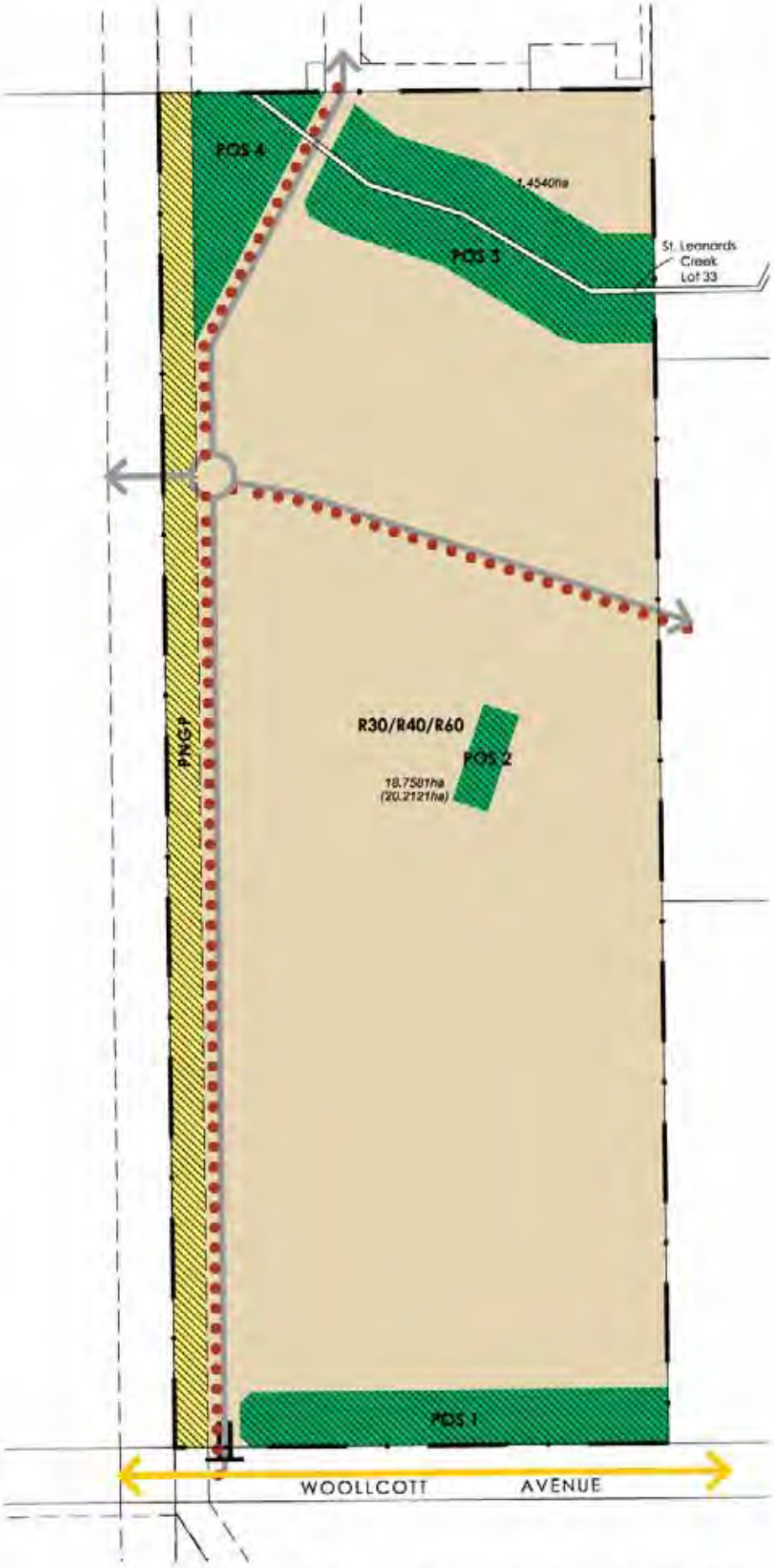

LEGEND

ZONES

Residential (R30/R40/R60)

The Density Plan forming part of this Structure Plan shall indicate the R-Code applicable to each lot in accordance with the following locational criteria:

1) The R30 density code shall apply as the base code to all 'Residential' zoned lots, with the exception of those lots coded R40 and R60 as set out in (2) and (3) below.
2) The R40 density code may apply to 'Residential' zoned lots where one or more of the following applies:
   i) the lot has a laneway abutting the rear boundary;
   ii) the lot is located within a 400m walkable catchment of a planned Local Centre.
3) The R60 density code may apply to 'Residential' zoned lots that meet one or more of the criteria set out in (2) above and where the lot is located immediately abutting or directly opposite public open space.

RESERVES

PNGP — Local Reserve - Public Utilities (Parmelia Natural Gas Pipeline Easement)

POS — Local Reserve - Recreation

OTHER

- Structure Plan Boundary
- Neighbourhood Connector A
- Access Street A
- 2.5m Shared Path to one side
- Single Lane Roundabout
- Full Movement Intersection

NOTES

1. Lots within 90m of the Parmelia Natural Gas Pipeline Easement are subject to a S70A Notification regarding the Pipeline location and that implementation of the Pipeline Risk Management and Protection Plan will be required as a condition of subdivision approval.

LOCAL STRUCTURE PLAN 3B - PLAN A: STRUCTURE PLAN MAP

3403-148-01 (21.10.2016). NTS

Lot 345 Woollcott Avenue, Brabham, City of Swan

PART TWO
EXPLANATORY REPORT

LOT 345 WOOLLCOTT AVENUE, BRABHAM
LOCAL STRUCTURE PLAN 3B

October 2016

ALCOCK BROWN-NEAVES GROUP

CLE TOWN PLANNING + DESIGN

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LOT 345 WOOLLCOTT AVENUE, BRABHAM LOCAL STRUCTURE PLAN 3B

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October 2016

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DEVELOPER

ABN Group

PROJECT TEAM

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Hydrology - 360 Environmental

Civil Engineering - Pritchard Francis

Landscape Design - LD Total

Bushfire - Natural Area Consulting

Traffic & Transport - KCTT

Pipeline Risk Assessment - Worley Parsons

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FIGURES

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APPENDICES

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LOCATION PLAN

Figure 1

1.0 PLANNING BACKGROUND

1.1 Introduction and Purpose

The Albion Local Structure Plan 3B (LSP3B) is prepared on behalf of the landowners, Brabham 2015 Pty Ltd, represented by ABN Group, pursuant to City of Swan Local Planning Scheme No. 17 (LPS 17). LSP3B covers the entire portion of lot 345 Woollcott Avenue, centrally located within the Albion District Structure Plan area.

The purpose of this LSP is to refine the level of planning detail provided in the Albion District Structure Plan (DSP). The LSP draws on the key elements of the DSP, while ensuring that all environmental, social, economic and infrastructure issues are comprehensively addressed.

A number of local structure plans have been prepared over the northern and western portions of the DSP area and are at various stages of approval and development. The LSP area is a logical local stand-alone structure planning area, and is consistent with the criteria established in the DSP for determining local structure plan boundaries.

The structure and format of this LSP provides a framework for future subdivision and development consistent with, and implementing the objectives and strategies of the DSP.

This Report comprises three sections, consistent with the WAPC's Structure Plan Framework (2015):

- Part 1 – Implementation Section
- Part 2 – Explanatory Report
- Part 3 – Technical Appendices

The Part 1 Implementation Section contains clear, measurable, defined provisions to implement the Explanatory Report outcomes at future stages. The framework for these provisions is derived from existing statutory documents, including the DSP, LPS 17 and Residential Design Codes. Part 1 contains the Structure Plan Map, and is consistent with the WAPC's Structure Plan Framework (2015).

The Part 2 Explanatory Report distils the key outcomes and planning implications of the background reports to deliver a succinct summary of the key land use and planning implications. The format of the Part 2 Explanatory Report is based on the WAPC's Structure Plan Framework, and responds to each of the key elements of the DSP.

Part 2 is based on a detailed site specific analysis of opportunities and constraints and the following technical reports and strategies:

- Environmental Assessment Report, including Vegetation Management Strategy and Fauna Management Strategy;
- Fire Management Plan;
- Transport & Access Strategy;
- Landscape Concept Plan and Descriptions;
- Local Water Management Strategy;
- Servicing and Infrastructure Strategy; and
- Pipeline Risk Management Plan and Pipeline Protection Plan (Qualitative Risk Assessment).

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SITE PLAN

Figure 2

Preparation of this LSP has involved extensive consultation with the City and relevant service authorities in accordance with the Framework. In addition, the proponent has been in regular consultation with Department of Lands as well as the gas pipeline operators APA and DBP in order to ensure that the LSP and subsequent development works can satisfy the statutory requirements relating to the protection of the pipeline and minimisation of risk.

LSP3B will facilitate growth of the existing Brabham community through the creation of approximately 335 dwellings, as well as contributing to the extensive public open space network, and expanding the existing local road network.

1.2 Land Description

The following sections provide a brief overview of the LSP area, and examine its context with respect to location, land use and ownership.

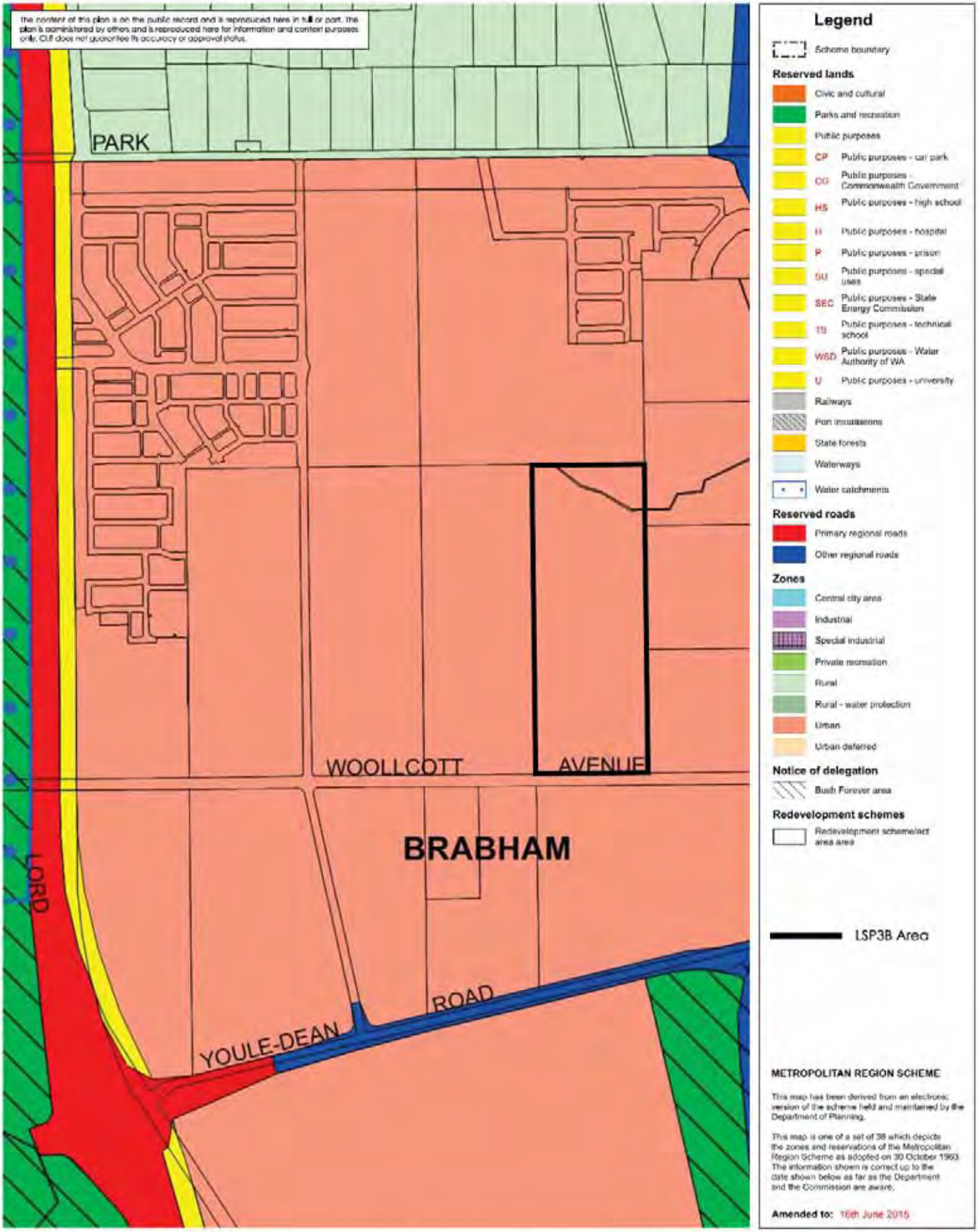
1.2.1 Location

The Albion DSP area, located in the suburb of Brabham, covers approximately 570 ha and is located within the City of Swan. The DSP area is approximately 17km north east of the Perth CBD, 5.5km south of the Ellenbrook Secondary Centre and 7.5km north of the Midland Strategic Metropolitan Centre, refer Figure 1 – Location Plan.

The LSP3B area covers all of lot 345 Woollcott Avenue, as well as a portion of lot 33, which comprises the St Leonards Creek and is owned by the City of Swan, refer Figure 2 – Site Plan.

The LSP area forms a logical eastern extension of the residential development of lots 347 and 346 to the west (referred to as LSP1B), which once fully developed will deliver approximately 480 residential lots, along with a 4.5ha primary school and 3ha of neighbourhood active open space adjoining the LSP boundary.

The LSP area is separated from the development to the west by the Parmelia Natural Gas Pipeline and the Dampier to Bunbury Natural Gas Pipeline. Both pipelines are located within their own easements, with the Parmelia Pipeline easement located within the LSP boundary, and the Dampier to Bunbury Pipeline located immediately to the west. This separation provides a clear demarcation between the two structure plan areas, as well as an opportunity for a landscaped interface between the two projects once developed.



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METROPOLITAN REGION SCHEME ZONING

Figure 3

1.2.2 Area and Land Use

LSP3B is approximately 20.7ha in size and is mostly cleared, having been previously used predominantly for agricultural land uses, and in more recent times for the extraction of sand. The site is generally flat, with a small ridge along the western edge adjacent to the Parmelia Gas Pipeline.

The majority of the site is grassland with generally sparse trees, comprising a mix of native and introduced species. Trees become more prominent around the St Leonards Creek to the north of the LSP area.

1.2.3 Legal Description and Ownership

LSP3B comprises all of lot 345 Woollcott Avenue, and a portion of lot 33, which encompasses the St Leonards Creek. Table 1 sets out the legal description of each individual land parcel within the LSP area.

Table 1: Legal Description

Lot No.	Land Owner	Volume	Folio	Plan	Area
Lot 345	Brabham 2015 Pty Ltd	1401	812	4560	20.21ha
Lot 33	City of Swan	1680	54	4560	0.07ha

Lot 345 is encumbered by an easement in favour of the Department of Lands for the purpose of accommodating the Parmelia Gas Pipeline.

1.3 Planning Framework

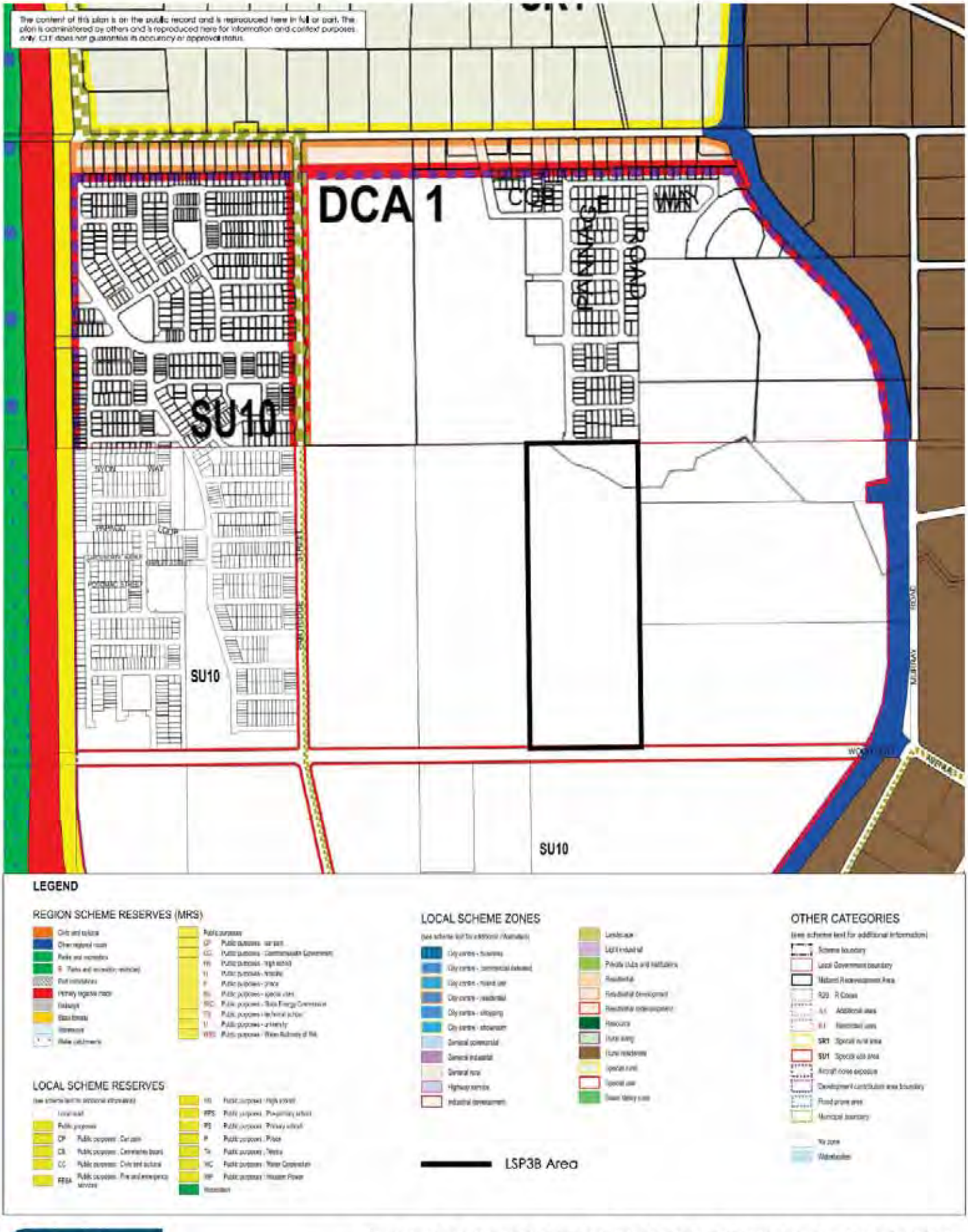
The following provides an overview of the planning framework as it relates to the LSP area.

1.3.1 Zoning and Reservations

Metropolitan Region Scheme (MRS)

LSP3B is entirely consistent with the zonings under the Metropolitan Region Scheme (MRS).

The LSP3B area is zoned 'Urban' under the MRS, refer Figure 3 – MRS Zoning Plan.



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CITY OF SWAN LOCAL PLANNING SCHEME No.17 ZONING

Figure 4

City of Swan Local Planning Scheme No. 17 (LPS 17)

The LSP3B area is zoned Special Use – Albion pursuant LPS 17, refer Figure 4 – LPS 17 Zoning Plan.

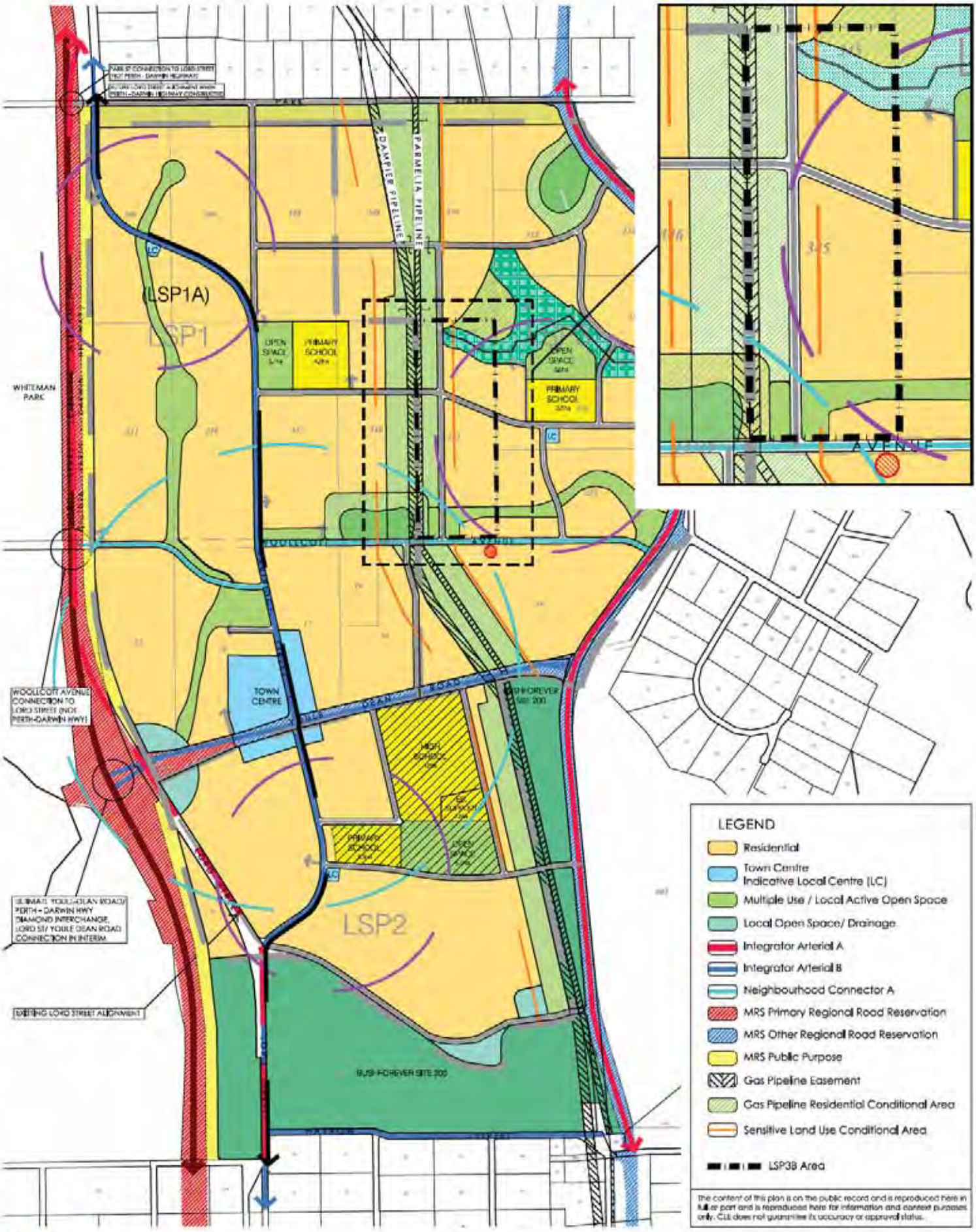
This Report comprises a Local Structure Plan for the purposes of Schedule 4 of LPS 17.

LPS 17 identifies that a key objective of the local structure planning is to coordinate subdivision and development to provide comprehensive planning. Pursuant to Clause 5A.1.5.2 of the Scheme a local structure plan can be prepared over all or part of a structure planning area.

Schedule 4 of LPS 17 sets out an environmental reporting hierarchy to be incorporated as a detail of the local structure plan. Table 2 sets out the requirements of Schedule 4 and where it is addressed in this report.

Table 2: Details submitted as part of a local structure plan pursuant to LPS 17 Schedule 4 Special Use Albion Zone

Requirement	Addressed within this report
Acid Sulphate Soils (ASS) Site Assessment Management Plan	Refer Appendix 1 – Environmental Assessment Report – 360 Environmental
Urban Water Management Plan *Note: Local Water Management Strategy required pursuant to SPP2.9 and Better Urban Water Management*	Refer Appendix 2 – Local Water Management Strategy – 360 Environmental
Wetland Management Plan	Not applicable
Cultural Heritage Management Plan	Refer Appendix 1 – Environmental Assessment Report – 360 Environmental
Fire Management Plan	Refer Appendix 3 – Fire Management Plan – Natural Area Consulting



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ALBION DISTRICT STRUCTURE PLAN CONTEXT

Figure 5

1.3.2 Albion District Structure Plan

The LSP area is located within the Albion District Structure Plan area, refer Figure 5 – DSP Context Plan.

The DSP was endorsed by the Western Australian Planning Commission in January 2011, and is intended to provide the statutory framework for more detailed land use planning at the local level. The LSP has been prepared within the framework specified by the DSP, and addresses each of the critical elements identified in the DSP in detail.

1.3.2.1 DSP - Local Structure Plan Areas

The DSP acknowledges that, to a large extent, local structure planning boundaries are impacted by land ownership, development intentions and staging. The DSP establishes criteria for the determination of local structure plan boundaries.

The LSP3B boundary has been determined based on servicing, land ownership and drainage considerations, consistent with the criteria established through the DSP.

The following demonstrates how the LSP3B boundary meets the criteria established under the DSP.

1. *Demonstrate that the local structure plan can address drainage and water management consistent with the approved District Structure Plan (Section 4.2 & Local Water Management Strategy), State Planning Policy 2.9 and Better Urban Water Management to the specification of the Department of Water.*

The LSP3B Local Water Management Strategy (LWMS), refer Appendix 2, demonstrates that drainage can be managed in accordance with the DSP, State Planning Policy 2.9 and Better Urban Water Management.

The LSP area forms part of the St Leonards Creek drainage catchment, with the natural flow path heading east towards the Swan River.

The LWMS includes detailed arterial drainage modelling to demonstrate how drainage will be managed across the LSP area in order to ensure that water quality and pre-development flow rates are maintained, and that development of the land will not have any downstream implications for other land in the DSP area.

2. *Demonstrate that the local structure plan allows for integrated and staged development with surrounding landowners (including consideration of future road connections and intersections and the coordinated provision of essential services and drainage.*

The LSP is bounded by the existing Woollcott Avenue to the south, "Avonlee" Estate to the north, and the Pamelia Gas Pipeline to the west. Whilst capable of being developed as a stand-alone project by virtue of its existing frontage to Woollcott Avenue, the LSP allows for integrated development with surrounding projects to the west and north through the provision of seamless road and open space connections. The LSP also provides a series of permeable road connections to the east where planning is less advanced, and enables maximum flexibility for future development of the land to the east by backing residential lots on to the boundary to minimise any interface considerations. The proponent is in regular contact with all adjoining landowners, ensuring that the LSP can provide the best possible interface to all surrounding projects.

Services are generally being delivered from the existing projects to the west and south, with the LSP3B area being a logical extension to the existing development front.

3. *Management plans and landscape strategies included in the Local Structure Plan are to cover the total area of identified wetlands and conservation areas and not dissect these environmental features (to ensure protection and management is considered holistically).*

The DSP does not identify any wetlands or significant environmental features within the LSP3B area, with the exception of the St Leonards Creek to the north of the LSP area, which has limited natural environmental value however is an important part of the district drainage system. The LWMS at Appendix 2 clearly demonstrates that the LSP area can be developed without having any downstream adverse impacts on the Creek with respect to water flow rates or quality.

4. *The local structure plan boundaries should generally correspond with features shown on the DSP (such as higher order roads) to coordinate logical integration and should not dissect major non-residential land uses (such as commercial centres and school sites). Local structure plans shall demonstrate the interface with any different land uses contemplated by the DSP which adjoin the proposed local structure plan boundary.*

The LSP boundaries are clearly defined by existing land uses and do not dissect major non residential land uses with all commercial centres and school sites being located to the west or east of the LSP area. Woollcott Avenue and the Parmelia Gas Pipeline form a 'hard edge' to the southern and western boundaries of the LSP area, providing an appropriate interface to future adjoining land uses. The northern boundary is already defined by the existing Avonlee Estate, which is nearing completion with the development front having been extended to the boundary of lot 345, where a local road interface is already constructed for the length of the boundary. The land to the east forms a small component of a much larger landholding of 130ha under the control of the Department of Housing. It is therefore a logical inclusion for a future structure plan encompassing all of the Department's landholdings along the eastern edge of the Albion DSP area.

5. *Will result in a POS distribution which is generally consistent with the DSP and with POS credits calculated in accordance with Liveable Neighbourhoods.*

The LSP recognises and refines the POS distribution as identified on the DSP, whilst also retaining the key elements including the 30m buffer to St Leonards Creek, and the multi-use open space along the southern boundary of the LSP area.

Refer Table 3 - Public Open Space Schedule, and Figure 9 for further demonstration of the POS distribution and consistency with Liveable Neighbourhoods requirements.

6. *The local structure plan boundary will not prejudice the preparation of a local structure plan over adjoining land to achieve the above.*

The LSP boundary will not prejudice the preparation of future local structure plans on adjoining land. Structure planning is already completed for land to the north, south and west of the LSP area. Lots 354 and 355 to the east form part of a much larger self contained 130ha land parcel under single ownership, and is a logical inclusion as part of a larger LSP over this area. As noted previously, the LSP boundary does not prejudice the ability for a structure plan to be prepared over the land to the east, and provides a permeable road network, as well as a suitable lot interface in order to ensure that future development is not compromised.

1.3.2.2 DSP - Environmental Management Plans

Pursuant to LPS 17, the DSP includes a number of endorsed environmental management plans:

- Strategic Acid Sulphate Soils Management Plan;
- Local Water Management Strategy;
- Noise Management Plan;
- Quantitative Risk Assessment Plan (Planning Bulletin 64), and
- Bushland Management Plans.

These management plans form the basis for the opportunities and constraints analysis as set out in section 2 of this structure plan.

1.3.2.3 DSP - Land Use Elements

The DSP includes the following land use elements over the LSP area, which are recognised and refined through the LSP.

Residential

The large majority of the LSP area is identified as 'Residential' in the DSP, with opportunities for a range of housing densities throughout the LSP area, commensurate with proximities to the planned local centre to the east, and other areas of high amenity.

Transport Network

The DSP does not identify any higher order roads within the LSP area. Woollcott Avenue is identified as a Neighbourhood Connector A, and although not located within the LSP area, the LSP recognises the significance of Woollcott Avenue through provision of a suitable interface and limited access from Woollcott Avenue to the LSP area.

The DSP identifies two key 'access streets' within the LSP area:

- An east – west access street that traverses the LSP area and provides a direct link to both of the planned primary schools; and
- A north-south access street located on the eastern boundary of the Parmelia Gas Pipeline corridor and connects to Woollcott Avenue, providing a managed interface to the corridor.

This road network is recognised and further refined by the LSP.

Open Space and Drainage

The DSP designates three key areas of open space / drainage within the LSP area.

- A multiple use corridor (MU5) of approximately 1.6ha located in the southern portion of the LSP, serving both a drainage and recreation function. There are no specific environmental values identified within MU5.
- A multi use corridor (StL) of approximately 1.32ha that encompasses the existing drainage line of St Leonards Creek, as well as a 30m buffer to either side of the Creek. This POS area will also provide opportunities for both drainage and passive recreation, and will ultimately form part of a broader POS network that follows the creekline to the east, and links up with the planned primary school and active open space within the Department of Housing's landholding to the east.

- A small portion of the conservation area to the north of the St Leonards Creek was identified in the DSP as possibly containing a Threatened Ecologicial Community (TEC). The DSP recommended further investigation be undertaken as part of subsequent local structure planning in order to determine whether the TEC is in fact likely to exist in this area given the degraded nature of the vegetation. It is understood that this investigation was carried out by Cardno as part of structure planning and subdivision of Avonlee Estate to the north, where it was determined that there is no TEC present in this area. The portion of the conservation area within the Avonlee Estate to the north has since been cleared and developed for residential purposes.

There are opportunities to refine the open space / drainage network through detailed planning and drainage modeling as part of the LSP.

Gas Pipeline Corridor

The Parmelia and Dampier – Bunbury gas pipelines run through the DSP area in a north south direction, with the pipeline corridor forming the western boundary of the LSP area. Consistent with the WAPC's Planning Bulletin No.87 (October 2007) for 'High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region', the DSP identifies a land use setback to the pipeline corridor of 75m, with a 'sensitive land use' setback (Conditional Area) of 110m.

The DSP notes that the setback distances can be varied as part of a LSP subject to the preparation and endorsement of a Qualitative Risk Assessment (QRA). There are opportunities to review and potentially reduce the setback distance to the pipeline corridor as part of this LSP, and a QRA has been prepared in this regard and is included as Appendix 4. Further discussion on the pipeline corridor and QRA is included as Section 3.9 of this report.

The DSP notes that land uses and developments within the pipeline corridor will be determined at local structure plan stage, in accordance with an approved QRA and in consultation with authorities.

1.3.2.5 DSP - Surrounding Land Uses

The DSP identifies a primary school and active open space approximately 100m-200m to the west of the LSP area within lots 346 and 347 Woollcott Avenue. A second primary school and local activity centre are planned approximately 400m to the east of the LSP area, providing context for increased housing densities and diversity.

A third primary school, along with a public high school and education support facility are located approximately 1km to the south of the LSP area within lot 800 Youle Dean Road. This education support precinct is co-located with 5ha of active open space, providing a district level community hub.

Further to the south west of the LSP area the DSP identifies a 'Large Neighbourhood Centre' comprising approximately 10,000m² - 20,000m² of retail floor space, along with a number of non-retail commercial and community uses. This Large Neighbourhood Centre will provide local retail convenience, potentially including two supermarkets, along with access to essential commercial and community services and facilities.

1.3.3 Planning Strategies

The LSP area and broader DSP are located within the Swan Urban Growth Corridor Sub Regional Structure Plan (SRSP). The SRSP is a non-statutory structure plan which informs the broad land use principles over the entire Swan growth corridor, including the development cells of Albion, West Swan, Dayton and Caversham.

The land use principles depicted on the SRSP within the LSP3B area are consistent with the Albion DSP.

1.3.4 Policies

The following State and Local Planning Policies are directly relevant and applicable to LSP1C:

- Planning for Bush Fire Protection Guidelines
- Liveable Neighbourhoods Operational Policy
- Structure Plan Preparation Framework
- Planning Bulletin No.87 (October 2007) 'High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region'

The LSP has been prepared to be consistent with the principles and requirements of the WAPC's operational policies and guidelines outlined above. Compliance with operational policy requirements is further demonstrated throughout Part 3 of this report.

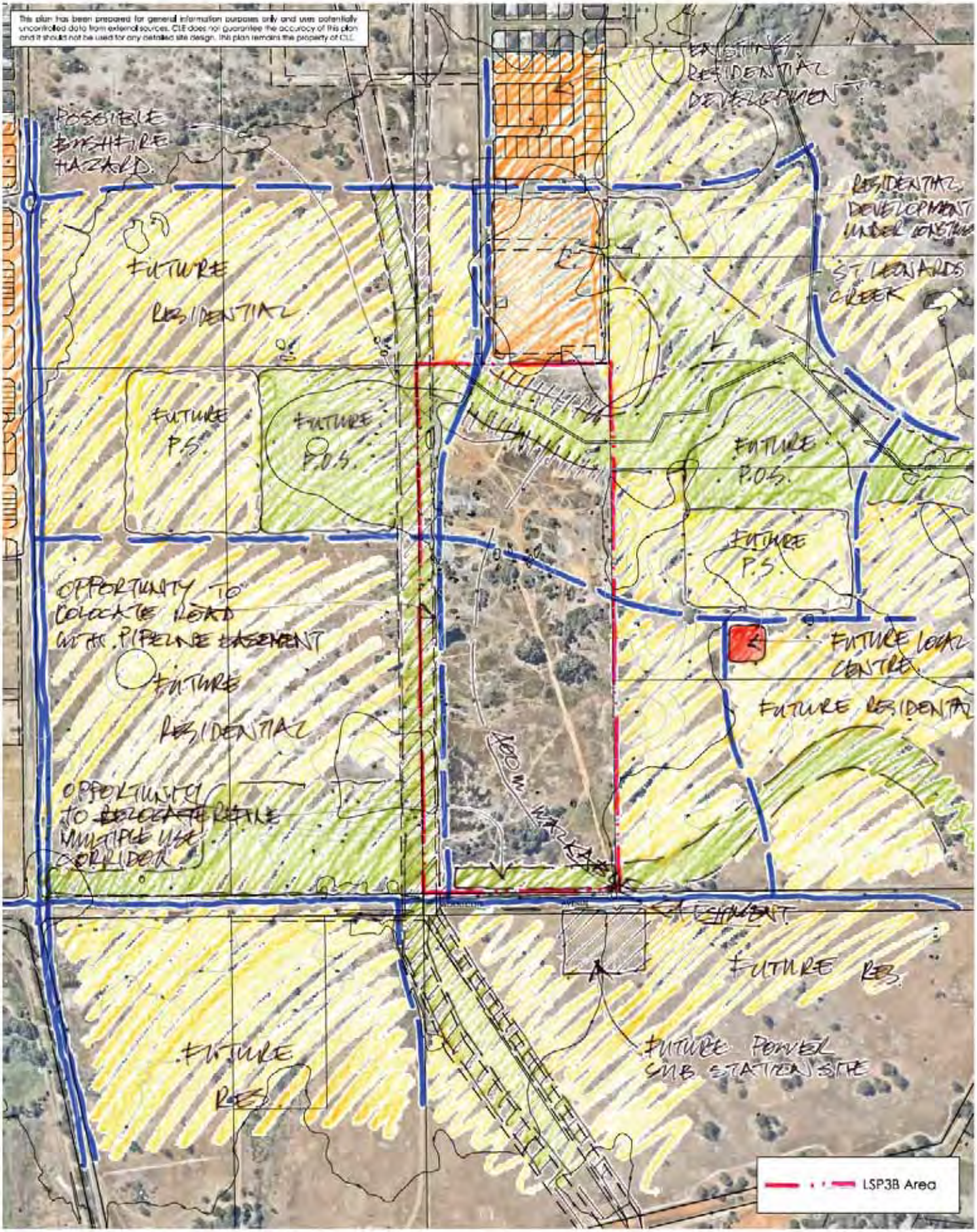
1.3.5 Other Approvals and Decisions

The Albion District Structure Plan area was zoned 'Rural' under the City of Swan Town Planning Scheme No.9. Council initiated Amendment 364 to Town Planning Scheme No. 9 to rezone the site from 'Rural' to 'Special Use - Albion' in 1999. The City forwarded the Amendment to the Environmental Protection Authority (EPA), who issued final instructions for the preparation of an Environmental Review in October 1999. An Environmental Review was prepared by the proponent (Department for Housing & Works) in conjunction with the Department for Environment and Conservation (DEC) and the City of Swan, which was to be advertised concurrently with Amendment 364 to Town Planning Scheme No.9.

Importantly this document was completed in May 2006 to the satisfaction of the City of Swan and DEC, addressing the environmental issues as identified by the EPA and establishing a comprehensive environmental management plan framework to be set out in the 'Special Use Zone - Albion' provisions under Town Planning Scheme No.9.

During the preparation of the Environmental Review documents, the City of Swan progressed Local Planning Scheme No.17 to final approval, superseding Town Planning Scheme No.9.

Amendment 364 and the associated Environmental Review document, while in a form satisfactory to the City of Swan and DEC, was not advertised for public comment due to the progress and adoption of Local Planning Scheme No.17 into which the Amendment No. 364 provisions were included. The Environmental Protection Authority considers the Schedule 4 provisions of Local Planning Scheme No.17 adequately address the environmental issues.



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OPPORTUNITIES AND CONSTRAINTS MAP

Figure 6

2.0 SITE CONDITIONS AND CONSTRAINTS

The LSP area is free of any significant environmental constraints, and is ideally suited for urban development in this regard.

Based on the background and planning context described above, the following section describes key site opportunities and constraints that have informed and impacted on the LSP urban form and structure. This analysis has been further summarised in Figure 6 – Opportunities and Constraints Map.

Environmental consultant 360 Environmental has undertaken a detailed investigation of the site in order to determine the environmental features and attributes of the site. This included but was not restricted to a review of investigations previously conducted for the historical planning process over the site including:

- the proposed rezoning of the site (City of Swan Town Planning Scheme No. 9, Amendment 364);
- the Albion District Structure Plan; and
- the assessment of the potential TEC undertaken by Cardno in 2006 as part of the Avonlee Estate Structure Plan to the north.

The following summarises the key findings of this analysis, while a more comprehensive analysis is included in Appendix 1 – Environmental Assessment Report.

2.1 Biodiversity and Natural Area Assets

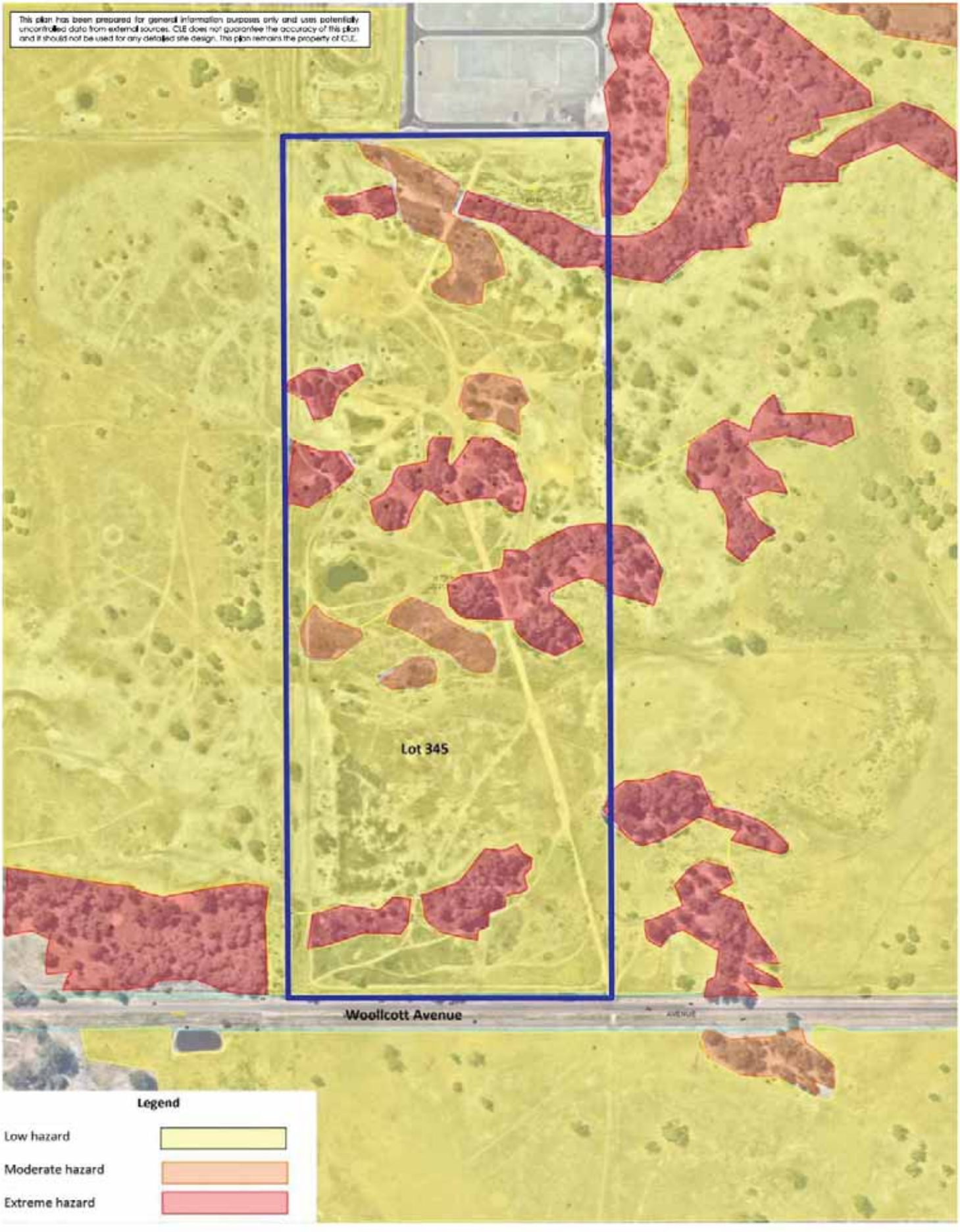
2.1.1 Flora and Vegetation

Aerial imagery shows that the LSP area is highly disturbed and native vegetation is limited to small pockets of degraded vegetation and scattered trees with limited understorey. The vast majority of the site consists of weedy grasses that have no ecological value.

It was previously determined via the DSP process that a possible Threatened Ecological Community (TEC) occurred within the north-western corner of the LSP area associated with the Eucalyptus Banksia woodland. In 2006 Cardno, on behalf of Terranovis, conducted an analysis of the portion of this community occurring within lot 350 (to the north) and determined that this community was not a TEC based on the vegetation classification. This area has since been cleared and developed for residential purposes with the approval of the WAPC and environmental agencies. Given that the portion of the possible TEC located within the LSP area consists of the same vegetation community, it is reasonable to conclude that there is no TEC present within the LSP area.

2.1.2 Fauna

There is no conservation significant fauna or suitable fauna habitat within the LSP area due to the highly degraded nature of any potential foraging habitat. There are opportunities to recognise riparian vegetation within the St Leonards Creek open space to the north of the site, and through planting and landscaping, enhance potential for suitable fauna habitat within the LSP area.



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Source: Natural Area Consulting
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PRE-DEVELOPMENT BUSHFIRE HAZARD MAP
Figure 7

2.2 Landform and Soils

The LSP area is generally level and is therefore well suited to urban development. The topography of the site falls from west to east, gently grading from approximately 34 meters Australian Height Datum (mAHD) to 22 m AHD. Soil types are predominantly free draining Bassendean sands. These soil types are typical of the Swan urban growth corridor and the Brabham area, and are not a constraint to development.

2.3 Ground and Surface Water

2.3.1 Groundwater

The Perth Groundwater Atlas (DoW 2013) indicates that minimum groundwater levels (May 2003) beneath the LSP area range between 0m and 1.5m. These conditions are indicative of the broader area and can be managed through importation of clean fill and / or use of subsoil drainage, consistent with other endorsed strategies within the DSP area.

2.3.2 Surface Water

There are no EPP Lakes, Conservation Category or Resource Enhancement wetlands mapped within the LSP area.

The DSP proposed to retain a Multiple Use drainage corridor which is mapped in the DSP as running along the southern boundary of the LSP area from the Resource Enhancement wetland to the west of the LSP area, and beyond the eastern LSP boundary. There are opportunities to refine this multi-use corridor as part of the LSP, and to integrate it into useable public open space consistent with the DSP.

The St Leonards Creek branches into the north-eastern corner of the LSP area. St Leonards Creek is a naturally occurring perennial watercourse that has been heavily modified in recent times to a more channelised creek. The St Leonards Creek system has been augmented with constructed drainage channels to aid drainage of the seasonally waterlogged land within the catchment. Previous planning has identified the need for a 30m buffer to St Leonards Creek (measured from either side of the high water line). There are opportunities to retain St Leonards Creek, buffers and associated riparian vegetation within a broader area of multi-purpose open space.

2.4 Bushfire Hazard

A bushfire hazard assessment has been prepared based upon the existing vegetation type and structure, topography and relationship to surrounding development, refer Figure 7 – Pre-development Bushfire Hazard Map. Bushfire hazard ratings within the LSP (and the surrounding 100m from bushland areas) range from 'moderate' to 'high'. Following development, the bushfire hazard rating within the LSP area will be reduced to 'low' as the majority of the vegetation will be cleared. Dwellings to be constructed within 100m of classified vegetation will have a Bushfire Attack Level (BAL) rating assigned that nominates higher building construction requirements as defined by Australian Standard AS 3959 *Construction of Buildings in Fire Prone Areas*. All other areas considered "low risk" are not considered as a bushfire risk and do not require further consideration.

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A Fire Management Plan prepared by Natural Area Consulting, refer Appendix 3, indicates that bushfire management measures can meet the performance criteria of the Planning for Bushfire Protection Guidelines, and that the potential bushfire risk can be managed within the LSP design through dwelling setbacks, roads and construction standards of BAL 12.5 - BAL 29. Section 3.3 outlines the LSP fire management response in more detail.

2.5 Heritage

2.5.1 Indigenous Heritage

The LSP does not contain any sites of cultural heritage significance.

An Aboriginal Cultural Heritage Survey was completed for the DSP area in 1996 and 1997 (W.G. Martinick and Associates Pty Ltd 1998). This survey included an archaeological investigation and Aboriginal consultation. The archaeological investigation found an archaeological site within the DSP area associated with Park Street (outside of the LSP area). The archaeological investigation also located two isolated finds (stone artefacts) over Lots 17 and Lot 18.

While no Aboriginal heritage sites have been identified within the LSP area, it is acknowledged that there is the potential that Aboriginal heritage sites may be found during civil and construction works. It is recognised that if during construction Aboriginal artefacts or sites are uncovered, that these are protected under the Aboriginal Heritage Act 1972 and that works will need to cease and suitably qualified experts will be brought in to survey the potential site. If required, permission under the Aboriginal Heritage Act 1972 to manage and disturb sites will be sought.

2.5.2 Non-Indigenous Heritage

A desktop survey undertaken by 360 Environmental indicated that there are no European heritage sites present within the LSP area.

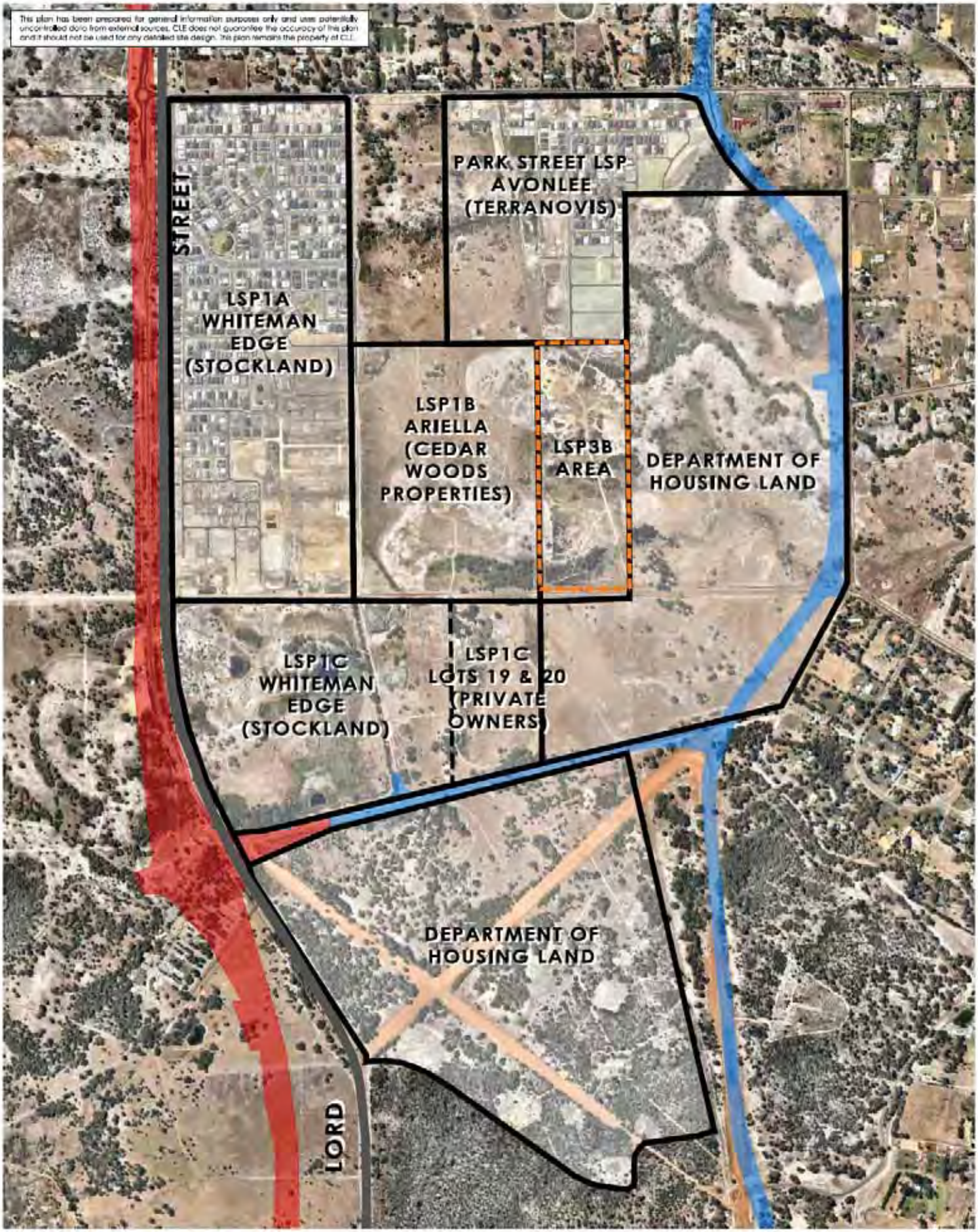
2.6 Other Land Use Opportunities and Constraints

In addition to the key environmental considerations outlined above, the following sections summarise other key land use considerations and opportunities for the LSP.

2.6.1 Existing and Future Road Network

The LSP area has excellent access to the existing road network to both the north and south:

- The existing Woollcott Avenue is located immediately to the south of the LSP area, and provides an east-west link between Partridge Street and Henley Brook Avenue. Woollcott Avenue is designated as a Neighbourhood Connector A, and is planned to be upgraded to a boulevard standard adjacent to the LSP area. There are opportunities to provide a primary access to the LSP area from Woollcott Avenue, most likely via a priority T intersection.
- Park Street is located approximately 1km to the north of the LSP area, and provides an east-west link between Henley Brook Avenue and Lord Street. The LSP can access Park Street via the existing north-south route of Arpent Link and Mormaer Street, via the Avonlee Estate.



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DISTRICT CONTEXT MAP

Figure 8

2.6.2 Adjoining Developments

The LSP is surrounded on all four sides by urban development projects, each of which is either under construction, or progressing through the planning process at present. refer Figure 8 District Context Map. The advanced nature of planning and development of the surrounding areas ensures the timely delivery of a range of essential services and infrastructure, consistent with the vision of the Albion DSP.

- Immediately to the west of the LSP area is the Ariella Private Estate (Local Structure Plan 1B), a residential estate of approximately 480 dwellings, as well as a public primary school and 3ha of neighbourhood playing fields / active open space. Stage 1 of Ariella is currently under construction. The LSP area falls within the catchment for both the primary school and associated neighbourhood park, providing excellent access to community facilities in the short – medium term.
- Further to the west of Ariella Private Estate is the established project of Whiteman Edge. Whiteman Edge is a master planned community of more than 2,000 dwellings, and also includes a large neighbourhood activity centre with a planned retail floor space allocation of 10,000-20,000m². There are approximately 1,000 lots currently developed within Whiteman Edge, providing a critical mass of population to support early delivery of district level infrastructure and facilities such as retail and community services.
- On the south side of Woollcott Avenue adjacent to the Ariella Private Estate is lot 20 Woollcott Avenue. Lot 20 is subject to an approved structure plan (Whiteman Edge Local Structure Plan 1C), and it is anticipated that development will commence within the next 2-3 years. Lot 20 is a residential enclave of approximately 200 dwellings, with opportunities for it to be integrated into the broader Whiteman Edge project area in the future.
- Immediately to the north of the LSP area is the Avonlee Estate. Avonlee is an established residential project with a variety of lot / housing types. Avonlee provides direct access between the LSP area and Park Street to the north.
- To the east of the LSP area is a substantial future urban landholding of 106ha under the sole ownership of the Department of Housing. At full development the Department's landholding is expected to deliver approximately 1,600 dwellings, a primary school, a neighbourhood park, and a local commercial centre. The primary school and local centre are located less than 400m to the east of the LSP area, and provide a context for increased densities in the central and eastern portions of the LSP area. Preliminary planning is currently progressing over this landholding by the Department, with formal structure planning likely to commence within the next two years.

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2.6.3 Infrastructure and Utilities

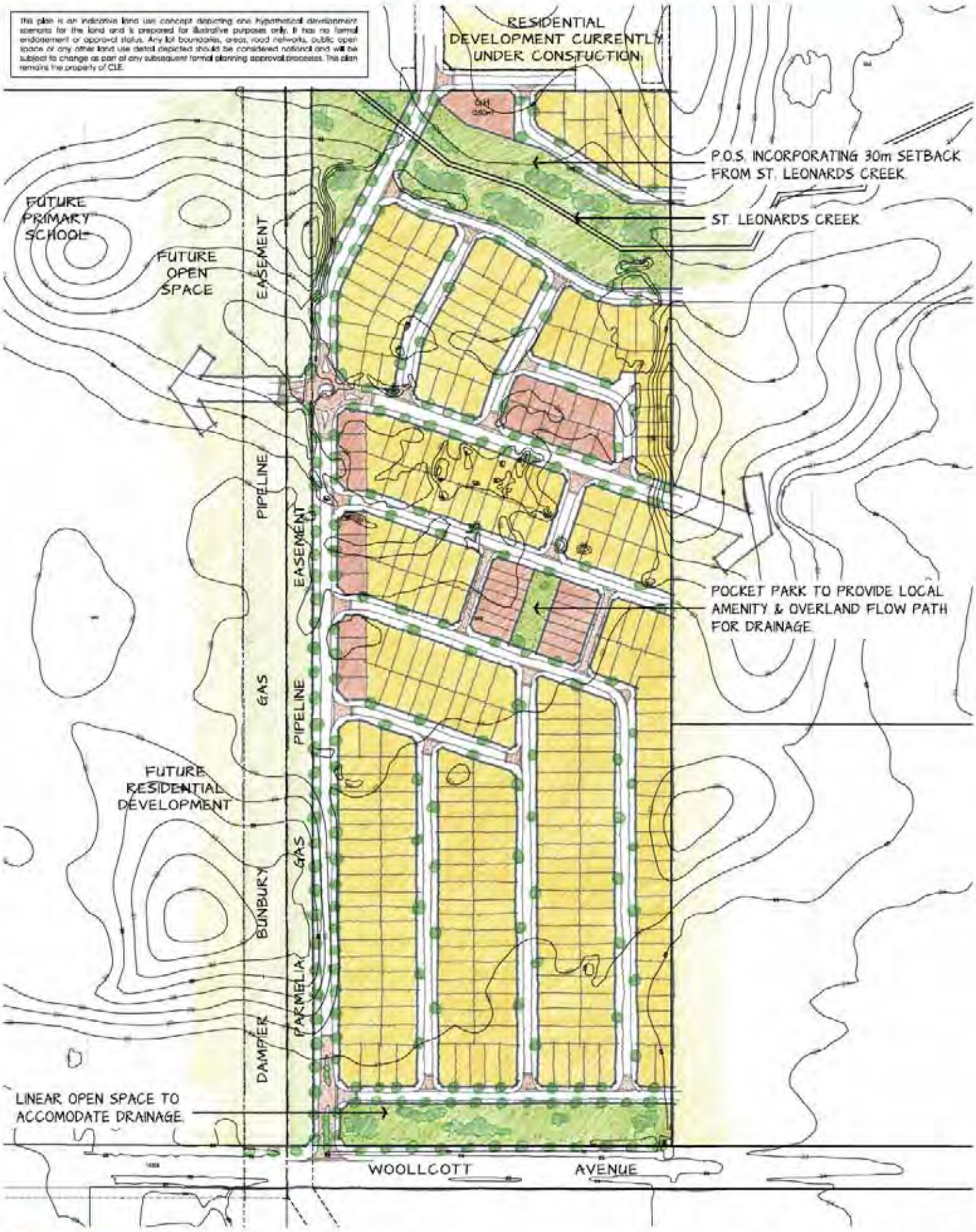
Pritchard Francis consulting engineers have undertaken a review of existing and planned infrastructure for the LSP area. A comprehensive servicing report is provided as Appendix 5 and is summarised in section 3.10.

Pritchard Francis concludes that the LSP area has excellent access to all essential service infrastructure, and that existing services from adjoining developments to the west and north can be extended to service the LSP area without requiring substantial upgrades.

2.6.4 Gas Pipeline Corridor

The Gas Pipeline Corridor containing both the Parmelia Gas Pipeline and the Dampier to Bunbury Gas Pipeline runs north-south along the western boundary of the LSP area. Consistent with the DSP and recent structure plan approvals to the north and west of the LSP area, there are opportunities to set aside the easement within a public utilities reserve or similar, with residential land uses adjoining. This is discussed further in section 3.9.

The DSP establishes setbacks to the pipeline corridor in accordance with Planning Bulletin 87. As noted by the DSP, there are opportunities to review these setbacks and improve land efficiency through this area as part of a Qualitative Risk Assessment at local structure plan stage. Further discussion in relation to the pipeline corridor and interface treatment is provided at section 3.9, and a Qualitative Risk Assessment is included as part of the Pipeline Risk Management Plan and Protection Plan at Appendix 4.



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LSP CONCEPT PLAN

Figure 9

3.0 LAND USE AND SUBDIVISION REQUIREMENTS

3.1 Land Use

LSP3B provides the framework for a robust, stand-alone urban development within the broader context of the Brabham suburb. The Plan provides a level of detail that builds upon and refines the principles of the Albion DSP, whilst also remaining flexible in recognition of more detailed stages of planning still to come.

The LSP Concept Plan indicatively demonstrates how development could occur on the site consistent with the LSP requirements, refer Figure 9. The following outlines the fundamental design components of the LSP, consistent with the guiding principles of the Albion District Structure Plan:

- Allow for the creation of a diverse range of medium density housing choices, meeting affordable living objectives.
- Provide robust urban form and land use response adjoining transport corridors and key areas of open space.
- Deliver a permeable, interconnected road and path network encouraging and facilitating multi-modal transport outcomes.
- Deliver a connected network of public open space meeting local active and passive, conservation and drainage needs allowing for planned and unplanned community activity.
- Recognise existing natural features within public open space throughout the LSP area and balance these features with competing demands.

Based on these key principles, the LSP provides a framework for the creation of:

- A total of approximately 320-330 lots. Higher residential densities are focused around key areas of open space, while the balance of the LSP area will comprise of more traditional medium density housing, consistent with LSP1B to the west.
- A clear hierarchy of higher order access streets consistent with the DSP, ensuring a robust framework for internal trips, as well as walking and cycling. The road network is fully integrated with the planned and approved road network as determined in LSP1B to the west, and the Avonlee subdivision to the north.
- Vehicle access to the broader road network via Woollcott Avenue, and the central access street to the west, consistent with the DSP.
- A managed road interface to the Pipeline Corridor on the western periphery of the LSP area. The interface is supported by a detailed Qualitative Risk Assessment that has been negotiated and confirmed with the pipeline operators, consistent with Planning Bulletin 87.
- Approximately 2.45 hectares of public open space ensuring opportunities for passive recreation, delivering key drainage objectives, as well as meeting the minimum 10% public open space requirement of Liveable Neighbourhoods.
- Recognition of the St Leonards Creek and associated buffers as established through the DSP, with this area being retained in multiple use open space.

The following sections provide a more detailed analysis of the LSP and its response to the opportunities and constraints identified in section 2, as well as the key land use elements described above.

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Source: LD Total

3403-23-01 (31.08.2015), NTS

PUBLIC OPEN SPACE

Figure 10

3.2 Open Space

3.2.1 DSP Open Space Context

Section 7.0 of the approved DSP describes the open space strategy for the Albion cell. In brief, there are seven different categories of open space described:

- Multiple Use (MU)
- Local Active and Passive Open Space (LA/LP)
- Local Open Space – Drainage (D)
- Wetlands (W/WB)
- Conservation (C)
- St Leonards Multiple Use (StL)
- Bush Forever and Parks and Recreation
- Neighbourhood Parks

The public open space areas shown on the DSP are indicative and subject to detailed design, modelling and confirmation at LSP stage. The DSP establishes the broad principles for public open space distribution at a district level and recognises that the LSP will refine public open space provision, and additional local parks may be shown at the local planning level.

Within LSP3B the DSP shows three separate areas of open space:

1. An east-west linear multiple use corridor (MU5) of approximately 1.65ha located in the southern portion of the LSP, serving both a drainage conveyance and recreation function;

2. A multi use corridor (StL) of approximately 1.32ha that encompasses the existing drainage line of St Leonards Creek, as well as a 30m buffer to either side of the creek. This POS area will ultimately form part of a broader POS network that follows the creek line to the east, and links up with the planned primary school and active open space within the Department of Housing's landholding to the east; and

3. A small portion of a much larger conservation area to the north of the St Leonards Creek that was identified in the DSP as possibly containing a Threatened Ecological Community (TEC). The DSP recommended further investigation be undertaken as part of subsequent local structure planning in order to determine whether the TEC is in fact likely to exist in this area given the degraded nature of the vegetation. It is understood that this investigation was carried out as part of structure planning and subdivision of Avonlee Estate to the north, where it was determined that there is no TEC present. The portion of the conservation area within the Avonlee Estate to the north has since been cleared and developed for residential purposes.

   The total open space area shown on the DSP within LSP3B, excluding the conservation area, which has deemed through more detailed investigation to be not worthy of retention, is approximately 3.0ha, or approximately 16% of the gross subdivisible area of the LSP.

   The DSP states that the calculation of public open space credits will be calculated in accordance with Liveable Neighbourhoods principles, which recognises the detailed water modelling undertaken at LSP stage as part of the Local Water Management Strategy. The approved DSP does not set out public open space credits.

Table 3: Public Open Space Schedule (all areas are in hectares)

Based on LSP Concept Plan 3403-09A-01

Site Area		20.36
Deductions		
Gas Pipeline Easement	1.34	
St Leonards Creek	0.07	
Restricted Use (above 2%)	0.04	
Net Site Area		18.91
Other Deductions		
1:1 Drainage within POS	0.08	
Gross Subdivisible Area		18.83
POS @ 10%		1.88
Public Open Space Requirement		
May Comprise:		
Min 8% unrestricted POS	1.51	
Max 2% restricted POS	0.38	
TOTAL POS REQUIRED		1.88
Public Open Space Provided	Unrestricted POS Area	Restricted POS Area
POS 1	0.53	0.15
POS 2	0.04	0.05
POS 3	0.89	0.22
POS 4	0.49	0.00
TOTAL (ha)	1.95	0.42
Additional Deductions		
Restricted Open Space Surplus		0.04
Revised Public Open Space Contribution		
Min 8% unrestricted POS	1.95	10.3%
Max 2% restricted POS	0.38	2.0%
Total Creditable POS Provided	2.3	12.3%

1. *Site Area is the total area of the LSP boundary, including all lots and road reserves within the boundary*
2. *In accordance with Liveable Neighbourhoods: the area subject to indunation more frequently than a one year average recurrance interval rainfall event is not included as restricted or unrestricted open space and is a deduction from the net site area (LN R33); areas for the detention of stormwater for a greater than one year average recurrance interval up to the five year recurrance interval is restricted open space up to 20%, the area greater than 20% is a deduction (LN R26 & Table 11); areas for the dentention of stormwater for a greater than five year average recurrance interval is within unrestricted open space (LN R25).*
3. *Drainage areas are based on the LWMS - 360 Environmental (AUG 2015).*
4. *All POS areas are indicative only and are subject to refinement and detailed design at subdivision stage.*
5. *The POS provision includes a pro rata contribution to the three neighbourhood parks and the local community centre site identified in the Development Contribution Plan. The balance of the POS shall be provided in accordance with the WAPC's Liveable Neighbourhoods method of calculation.*

3.2.2 LSP3B Open Space Provision

Based on a gross subdivisible area of 18.83ha (site area minus the pipeline corridor), the 10% open space requirement is for LSP3B is 1.88ha. The LSP concept plan allows for the provision of approximately 2.45ha of gross public open space, including the St Leonards Creek open space in the north, and multiple use open space to the south.

Once Liveable Neighbourhoods credits are applied the open space provision is 12.3% consistent with the requirements of WAPC policy and Liveable Neighbourhoods to provide 10% creditable public open space, refer Table 3, Liveable Neighbourhoods POS Schedule and Figure 10 – Public Open Space Plan.

The following outlines the key aspects of public open space provision based on Liveable Neighbourhoods requirements, with the detailed description of each open space type outlined in Section 3.2.3 below.

- The LSP provides 2.45 ha of gross open space, with the majority of open space areas serving a shared drainage function, while not compromising the informal active and passive recreational uses.
- Approximately 0.08ha of open space will receive drainage for events occurring more frequently than the 1 in 1 year (1 hour) event, and as such is a deduction from the Gross Subdivisible Area in accordance with Liveable Neighbourhoods.
- Liveable Neighbourhoods allows up to 2% of the 10% open space requirement to comprise of restricted use open space. The balance of restricted use open space becomes a deduction.
- Based on the requirements of Liveable Neighbourhoods, a maximum of 0.38ha can be creditable restricted use open space and a minimum of 1.51ha unrestricted open space.
- Approximately 0.42ha of open space will receive drainage from the 1 in 1 year to 1 in 5 year drainage event in landscaped infiltration basins and swales in accordance with water sensitive urban design principles. The 1 in 1 to 1 in 5 year drainage event is treated as restricted use open space in accordance with Liveable Neighbourhoods.
- All other POS areas are unrestricted open space, providing a range of passive and active functions, as well as local amenity for future residents. The total unrestricted use open space area is 1.95ha, while total creditable open space is 2.3ha (12.3%).

POS 1 PLAN N.T.S

LEGEND

1. Drainage Basin revegetation Winter planting only (low fuel zone)
2. 10.0M wide swale landscape area
3. Cluster of small tree planting on drainage basin
4. Tubestock planting on bund
5. Proposed Concrete Footpath
6. Exercise station with equipment
7. Proposed Street tree planting
8. Parmelia Gas Pipeline Easement with tubestock planting (Winter)
9. Entry Signage
10. Woollcott Avenue 12.0M wide drainage reserve

KEY PLAN

TYPICAL SECTION - C - C

3.2.3 Public Open Space Description

The LSP identifies four distinct areas of public open space. A detailed Landscape Strategy prepared by LD Total is Appendix 6. The following provides a brief overview of each open space parcel within the LSP area.

POS 1 - Multiple Use Open Space

Consistent with the DSP, the LSP includes a multiple use open space area adjacent to the southern boundary of the LSP area. This open space area is approximately 0.71ha, and allows for a high amenity open space immediately adjacent to Woollcott Avenue. This open space will enable both a formal and informal meeting space for the community in a high quality landscaped space, as well as detaining and conveying surface water in a landscaped 'living stream'. There are opportunities to further enhance the amenity of this open space through the inclusion of a path network and exercise stations, as well as seating / shade areas. An indicative concept plan for POS 1 is Figure 11. Details of the landscaping treatment for POS 1 will be confirmed at detailed design stage in consultation with the City.

POS 2 – Pocket Park

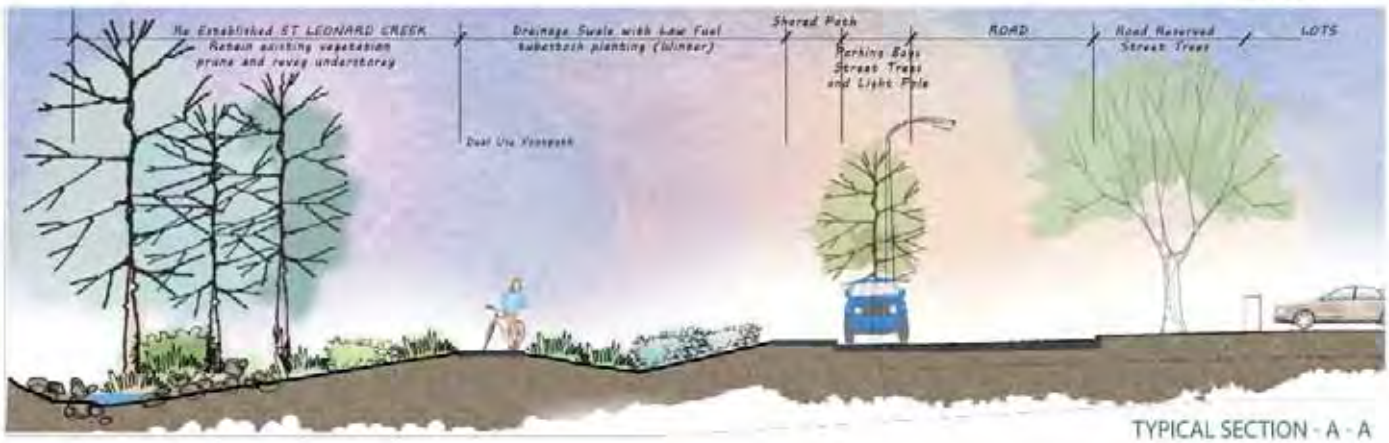
POS 2 is a small neighbourhood / pocket park of approximately 0.1ha, located centrally within the LSP area. POS 2 forms an important part of the overall drainage network for the LSP area through the detention and treatment of high frequency rainfall events, as well as providing an intimate landscaped space for passive recreation, and local amenity. POS 2 is 20m wide, and is framed on both the eastern and western sides by laneway lots, ensuring a high level of surveillance and amenity of this pocket park, and providing a unique opportunity for a custom build-out of this area – most likely comprising 2 storey homes that overlook the park.

POS 3 PLAN N.T.S

LEGEND

1. Existing St.Leonard Creek
2. Buffer and protection revegetation Winter planting (low fuel zone)
3. Verge turfing (street)
4. Retained existing vegetation
5. Tubestock planting on swale
6. Crossover bridge in Recycle Plastic
7. Proposed Concrete Footpath
8. Children's Play area and Picnic
9. Feature Node with seating
10. Exercise station with equipment
11. Proposed Street tree planting
12. Parmelia Gas Pipeline Easement with tubestock planting (Winter)
13. Entry Signage
14. Street Parking bays

KEY PLAN



TYPICAL SECTION - A - A

CLE TOWN PLANNING + DESIGN

Source: LD Total

3403-25-01 (31.08.2015), NTS

POS 3 & 4 CONCEPT

Figure 12

POS 3 and POS 4 – St Leonards Creek

Consistent with the DSP, the LSP recognises and retains the St Leonards Creek and 30m buffer in the north of the LSP area. The St Leonards Creek is traversed by a north – south access street linking to the Avonlee estate to the north, which separates and defines the two areas of open space.

POS 3 is approximately 1.2ha (including the actual creek line) and forms the central and eastern portion of the St Leonards Creek open space. The key feature of POS 3 will be the retention of the riparian vegetation along the creek line, as well as opportunities for vegetation retention and rehabilitation within the buffer – recognising the need to provide sufficient low fuel areas in order to reduce bushfire risk. As well as depicting an integrated path network with pedestrian crossings across the creek, the landscape concept for POS 3 also identifies opportunities for a 'nature play' recreation area with associated seating and shade. It is envisaged that this open space area will be the main community meeting place / focal point for the future population of the LSP area, and potentially Avonlee residents to the north.

POS 4 is approximately 0.49ha, and forms the western portion of the St Leonards Creek area. POS 4 recognises and retains existing topography, as well as providing a managed interface to the Parmelia Gas Pipeline to the west. Once the adjoining area to the west is developed, POS 4 will form an eastern extension of the larger active open space area adjacent to the primary school to the west.

An indicative landscape concept of both POS 3 and POS 4 is Figure 12.

Pipeline Corridor

Whilst not 'creditable' open space, the Parmelia Gas Pipeline easement provides a landscaped interface along the western boundary of the LSP area, ensuring a high amenity entry to the south of the LSP area, whilst also recognising and protecting the gas pipeline. The easement will be landscaped with a combination of low level shrub planting and appropriate surface treatment which will be discussed and confirmed with the pipeline operators as part of the detailed design process.

3.2.4 Active Open Space

The Structure Plan area is surrounded by existing and planned areas of neighbourhood and district open space for formal and organised sporting activities. As such, the Structure Plan does not provide any formal active POS due the sufficient provision of these types of POS within the locality and the competing demands within the Structure Plan area. Opportunities for formal recreation and organised sporting activities for residents of the Structure Plan are provided via the following:

- The future neighbourhood sporting oval that will be co-located with the planned primary school to the west of the LSP area (within LSP1B);
- The future neighbourhood sporting oval that will be co-located with the planned primary school to the east of the LSP area as identified on the DSP; and
- The planned area of district open space to the south of the LSP area, which will form the primary recreation area for the suburb of Brabham.

As demonstrated above, there are ample planned and existing large areas of open space within, and in immediate proximity to, the LSP area that can accommodate the formal and organised recreational needs of residents.

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3.2.5 Streetscapes

While not usually acknowledged as traditional public open space pursuant to Liveable Neighbourhoods and recognised under Table 2, streetscapes make up an important component of the public realm, and the quality of landscaping within key streets assists to deliver a true sense of place within new urban areas.

The LSP enables opportunities for a higher standard of landscaping along two key streets:

- The main entry from Woollcott Avenue, where a combination of a wider boulevard style access street with landscaped verges, and the landscaped pipeline corridor will promote a sense of place upon arrival, as well as forming a key view corridor from the entry road to the St Leonards Creek open space to the north. Driveways will be designed such that they form a key part of the verge landscaping and promote an attractive, low speed environment.
- The east-west neighbourhood connector road that traverses the centre of the structure plan area and links the two primary schools to the east and west of the LSP area. There are opportunities to include a boulevard treatment as well as additional verge landscaping / planting to highlight the importance of the road, whilst also promoting a low speed environment.

The detailed engineering design and landscaping schedule of these key streets will be determined in consultation with the City at subdivision stage.

3.3 Bushfire Protection

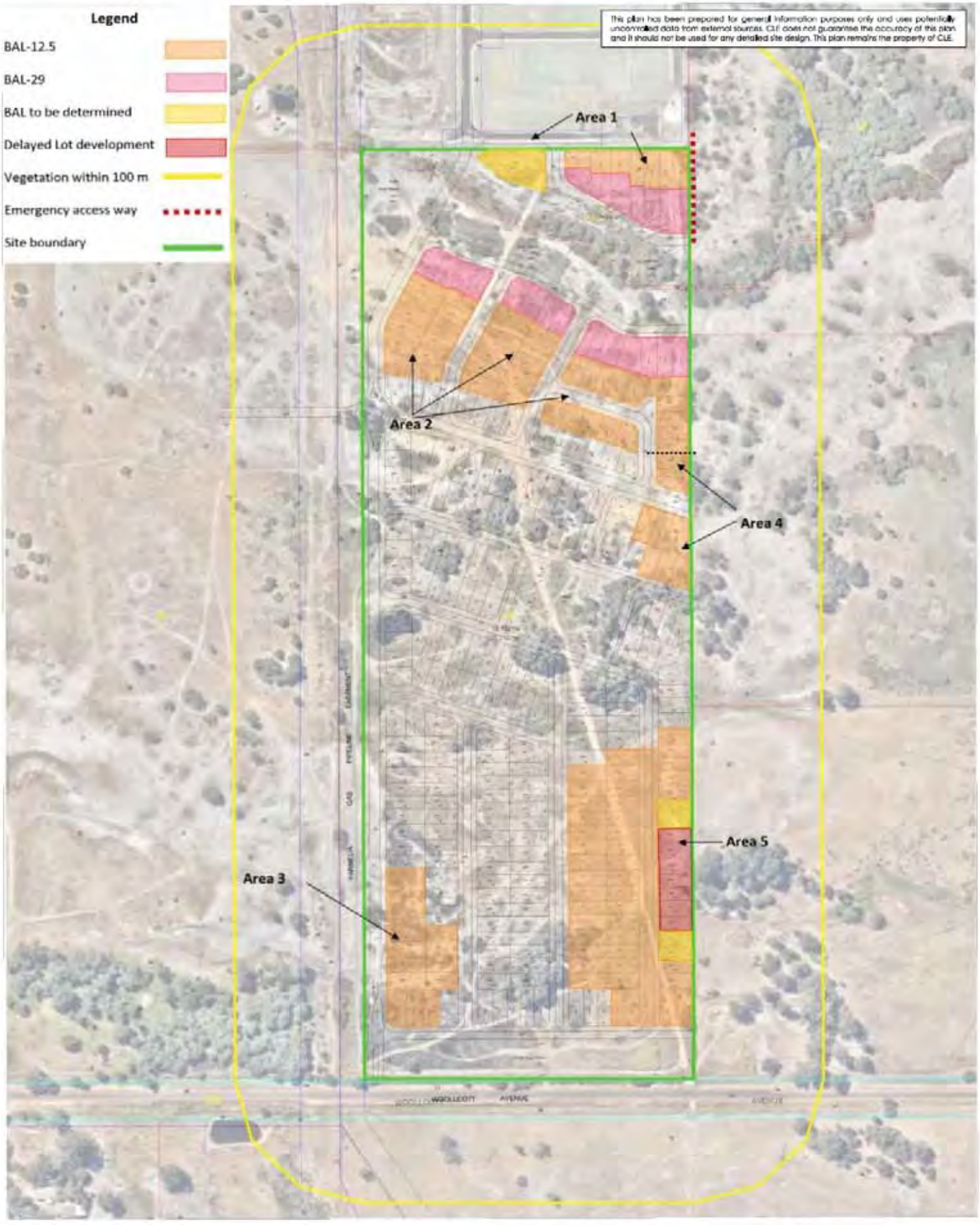
The LSP provides a comprehensive statutory and design response to address potential bush fire hazard and demonstrates that bushfire risk over the site can be managed through a combination of dwelling setbacks and construction standards.

A Fire Management Plan (FMP) has been prepared by Natural Area Consulting to support the LSP refer Appendix 3. This FMP has been prepared in accordance with the WAPC's State Planning Policy 3.7 Planning in Bushfire Prone Areas and Guidelines for Planning in Bushfire Prone Areas, and includes a detailed Bushfire Hazard Assessment. This Hazard Assessment demonstrates that the post development bushfire threat and hazard will be restricted to the following areas:

- The riparian vegetation within the St Leonards Creek POS and the continuation of the creek to the east of the LSP area;
- The wetland vegetation contained within the Resource Enhancement Wetland within the south eastern corner of the adjoining property to the west; and
- Intermittent scattered vegetation within the Department of Housing's landholding to the east.

All lots located within 100m of these hazards are deemed to be bushfire prone, and as such, are subject to the provisions of AS3959.

The Fire Management Plan provides an indication of the setback distances required between dwellings and bushfire hazards (Bushfire Protection Zone) to achieve Bushfire Attack Level (BAL) rating of 29 or lower.



CLE TOWN PLANNING + DESIGN

Source: Natural Area Consulting
3403-27-01 (24.10.2016), NTS

INDICATIVE BAL RATINGS & BUILDING PROTECTION ZONES

Figure 13

A plan depicting likely BAL ratings and Building Protection Zones (BPZ) is Figure 13. BALs and BPZs are assigned to all lots within 100m of any classified vegetation (i.e. lots that are deemed to be Bushfire Prone) on the following basis:

- **Lots to the north of St Leonards Creek** - Area 1 includes approximately 14 single dwelling Lots, with those fronting the vegetated area within the St Leonards Creek requiring a BAL-29 rating and a minimum setback of 4m from the front lot boundary in addition to the road reserve to provide adequate separation from the vegetation. The seven lots to the north will require a BAL-12.5 rating.

  The LSP identifies a grouped housing site in the north eastern corner, adjacent to the St Leonards Creek POS. A BAL rating will be determined for this site once further design work is carried out post subdivision approval. A minimum separation distance of 14m will be required between the vegetation and buildings for a BAL-29 rating, and which may be achieved through ensuring car park and hardstand areas are concentrated towards the south of the lot. Landscaping and some clearing within St Leonards Creek may also contribute to separation distances between buildings and vegetation.

- **Lots to the south of St Leonards Creek** - Fourteen lots that front the vegetated buffer associated with St Leonards Creek will be provided with a 4m setback from the lot boundary in addition to the road reserve to achieve a minimum separation distance from the vegetation for a BAL-29 rating. All other lots within 100 m of that vegetation will require a BAL-12.5 rating.

- **Lots in south western corner of the LSP area** - A larger stand of woodland vegetation is to be retained within the Resource Enhancement Wetland to the west of the LSP area adjacent to Woollcott Avenue. The presence of the Parmelia gas pipeline easement and the main north-south road into the LSP enables a minimum separation distance of 43m between the vegetated areas and lots, thus a BAL-12.5 rating will apply to lots within 100m.

- **Vegetation to the east in Department of Housing landholdings** - The Department of Housing landholdings will be developed at some future point in time, which will result in the clearing of the majority of the scattered vegetation to the east of the LSP area. If development within the LSP area proceeds ahead of that in the land to the east, vegetation in that land will need to be considered from a fire management perspective. This is likely to result in the majority of affected lots requiring a BAL rating of BAL 12.5, with approximately seven lots that cannot achieve adequate separation distance unless this vegetation is cleared. Other lots within 100m of this vegetation are developable if a BAL rating is assigned as a fire protection mechanism, with the majority being a BAL-12.5.

  It is the proponent's intent that those lots immediately adjacent to the vegetation in the Department of Housing land will not be developed until such time as that vegetation is cleared and the fire risk in that area reduced accordingly.

With the exception of the St Leonards Creek, all areas of POS will be designed and landscaped to a 'low threat' standard under the Australian Standards and will not pose a bushfire hazard to development within the site.

In accordance with LPS 17 Amendment no.99, the LSP has provided a map of Bushfire Prone Areas (refer figure 13) to demonstrate those areas which require a detailed BAL Assessment prior to dwelling construction. The bushfire mapping detailed in the fire management plan supersedes the City of Swan bushfire mapping, in accordance with the scheme provisions outlined in LPS 17 Amendment 99.

Bushfire construction standards, including any increased front setback areas will be implemented at development application / building licence stage in accordance with the City's standard practice.

Table 4 – Typical Lot / Dwelling Types

	Contemporary Front Loaded Lots	Compact Front Loaded Lots	Rear Loaded Cottage Lots
Typical Lot Width	10.5m - 15m	12.5m – 15m	6.5m – 10m
Typical Lot Depth	30m	20m - 25m	25m - 30m
Lot Area	300m² - 450m²	250m² – 375m²	250m² – 375m²
Vehicle Access	Street	Street	Rear lane
Typical Location	Mid block, end of block Typically where no specific density drivers Lot frontages are normally 'salt and peppered' along the street block to ensure streetscape amenity and housing diversity	End of street blocks, adjacent to POS, primary schools and other areas of high amenity Where more traditional module depths are not achievable	Adjacent to neighbourhood connectors and boulevards where street access is constrained. Adjacent to schools and public open space to avoid driveway conflicts Directly abutting, high amenity POS.
Residential Density Code	Residential R30	Residential R30 - R40	Residential R40
Built Form Control	RMD Codes Design Guidelines (by developer)	RMD Codes Design Guidelines (by developer)	RMD Codes Design Guidelines (by developer)
Built Form Character and Delivery	Single dwellings Typically sold as land only	Single dwellings Land only or pre-built house and land Appearance of traditional front loaded dwelling from the street	Single and grouped dwellings Typically built out and sold as a house and land package

3.4 Residential

The LSP provides a framework for the delivery of a diverse range of housing, including a number of innovative and affordable housing types, and achieving residential density targets specified under State policy.

As both a home builder and land developer, the delivery of quality housing is a key objective for the ABN Group. Key to this is the delivery of housing that addresses and surveys public spaces, incorporation of solar passive design principles for private outdoor living areas and ensuring garages / carports are appropriately located. This will be implemented through the RMD provisions, as set out in Planning Bulletin 112/2015, which are recognised in the LSP Part 1 statutory section.

3.4.1 Dwelling Yields and Density Targets

The LSP provides the framework to deliver a range of housing types and tenures to facilitate residential yields commensurate with the strategic and statutory planning framework, as well as the site's location within the broader district context.

The LSP has the potential to realise approximately 325 – 335 residential dwellings accommodating approximately 910 – 938 people. Densities range from R30 to R60, based on the following principles:

- The majority of the Structure Plan area has a density code of R30, providing opportunities to deliver a range of front loaded lots, ranging in size from approximately 260 m^2 – 450 m^2.
- Medium density R40 and R60 coded lots are typically located adjacent to areas of public open space and within the 400m walkable catchment to the planned local centre, where a higher standard of amenity is expected. This coding provides opportunities to deliver contemporary single and two storey cottage style housing with front or rear lane access, as well as grouped / multiple housing options in appropriate locations. Single house lot sizes will generally range from 150m^2 up to 360m^2.

Directions 2031 and Beyond recommends a housing density target of 15 dwellings per gross urban zoned hectare. The Structure Plan establishes a framework to exceed this target, and has the potential to deliver more than 16 dwellings per gross urban hectare, or 17 dwellings per hectare if the gas pipeline easement is deducted from the site area. This density is commensurate with the broader context in which the site is located.

3.4.2 Lot / Dwelling Types

A diverse mix of lot and housing typologies will be achieved. There may be opportunities for the proponent to build out pockets of medium density housing to deliver a range of housing types and amenity. Table 4 provides a brief description of the housing typologies that could be delivered within the Structure Plan area.

3.4.3 Residential Design Code Variations

In order to effectively and efficiently deliver the housing types envisaged in Table 4 above, it is necessary to apply the RMD standards identified in the WAPC's Planning Bulletin 112/2015. The LSP includes the applicable RMD30 and RMD40 provisions within the Part 1 Statutory Report, and it is anticipated that the City will be preparing a local planning policy to adopt the RMD provisions in the near future.

CLE TOWN PLANNING + DESIGN

Source: KCTT

3403-28A-01 (21.10.2016), NTS

STREET TYPES PLAN

Figure 14

3.5 Movement Networks

The Albion DSP provides the key transport elements, and identifies the regional and district road hierarchy for the DSP area. A Transport Assessment for the LSP3B area has been prepared by KCTT traffic consultants, refer Appendix 7. This report draws on the key elements of the earlier traffic assessment prepared as part of the DSP and provides updated traffic modelling specific to the LSP area.

The following section outlines the key elements of the Transport Assessment including details of the existing and the proposed road networks, the road hierarchy classification and road cross-sections. The section also provides an overview of cyclist and pedestrian network provision within LSP3B.

3.5.1 Road Network, Capacity and Arterial Road Access

The DSP provides an indicative grid of Integrator and Neighbourhood Connectors as well as key local access streets that link the key land use nodes within the DSP. This road network has been further refined by local structure planning and subsequent subdivision approvals within the DSP area, which provides a road network generally consistent with the principles of the DSP.

Arterial access to the LSP area is provided predominantly by Woollcott Avenue – a Neighbourhood Connector A road, linking the Partridge Street activity corridor in the west with Henley Brook Avenue to the east. Access to the LSP area from Park Street is afforded by the existing north south Neighbourhood Connector B road that passes through the Avonlee estate to the north, while a planned east-west Access Street A connects the LSP area to Partridge Street via the planned primary school to the west of the LSP area within LSP1B. The analysis undertaken by KCTT confirms the DSP analysis that there is sufficient existing capacity within the arterial road network to accommodate the traffic generated from the LSP area.

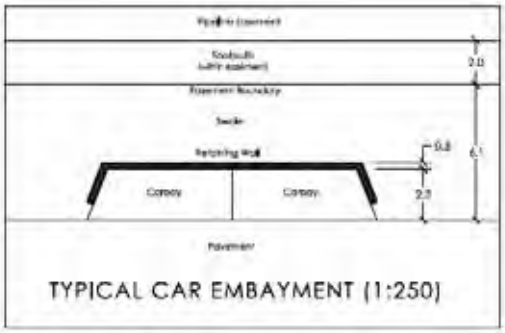
LSP3B refines and builds upon the existing road network as well as the network established via the DSP and adjoining structure plans. KCTT's analysis confirms that traffic volumes within the LSP area, including external traffic, are relatively low and road classifications and cross sections are allocated accordingly.

The Street Types Plan at Figure 14 identifies the proposed LSP road network, including the identification of a hierarchy of local access streets within the LSP area.

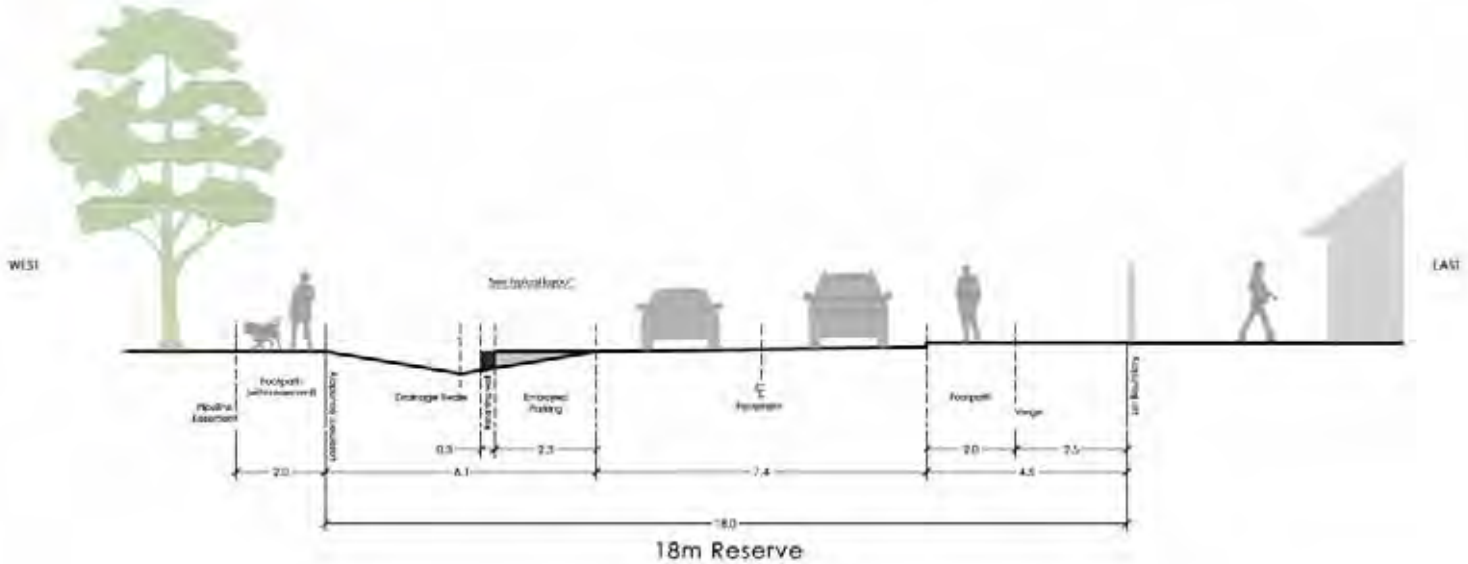
The traffic volumes forecast for the LSP road network are comfortably within the acceptable limits as prescribed in the DSP and Liveable Neighbourhoods - refer Appendix 7 for detailed traffic forecasts.

3.5.2 Street Cross Sections

The following provides a summary of the indicative cross sections and reserve widths for the key streets within the LSP area. The cross sections and reserve widths are indicative only, and will be confirmed at subdivision stage in the usual manner. The cross sections described in this report are included in Appendix 7.



TYPICAL CAR EMBAYMENT (1:250)



18m Reserve

Woollcott Avenue

Whilst not within the actual LSP area, Woollcott Avenue provides the primary access to the arterial network. Consistent with the DSP, the LSP identifies Woollcott Avenue as a Neighbourhood Connector A road, carrying approximately 1,200 vehicles per day (vpd).

The existing Woollcott Avenue road reserve is 30m wide, and can easily accommodate a Neighbourhood Connector A standard road as per Liveable Neighbourhoods standards, with the surplus road reserve allowing for wider landscaped verges / median and arterial drainage conveyance. The precise design and cross section of Woollcott Avenue has already been determined by the City of Swan as part of previous structure planning to the west of the LSP area, and it is anticipated that the same cross section will apply in this instance.

Local Access Streets

By virtue of the residential land uses and the absence of any major non residential land uses, the LSP road network comprises entirely of local access streets. The LSP classifies two roads as Access Street A based on the Liveable Neighbourhoods functional road hierarchy as follows:

i. The north – south road abutting the Parmelia Gas Pipeline Easement and providing access to Woollcott Avenue – carrying approximately 500 vehicles per day (vpd); and

ii. The east – west road that traverses the easement and links to the primary school to the west of the LSP area. Provision is made in the LSP for an eastern extension of this Access Street A to connect to the planned primary school to the east of the LSP area as part of future planning for the eastern landholdings. This road is forecast to carry approximately 1250 vpd at ultimate development.

The cross section for the Access Street A – refer Figure 15, is generally consistent with figure 19 of Liveable Neighbourhoods, and will include 2 x 3.5m carriageways with a dividing median in the order of 2m-3m. Due to the need for direct lot access, the opportunities to include formal embayed verge parking are limited, with informal visitor parking to instead be provided within the private property driveways. This has resulted in a reduced reserve width from that depicted in Liveable Neighbourhoods, however the functional intent of the Access Street A remains consistent with the core principles of Liveable Neighbourhoods.

All other streets within the LSP area are classified as Access Street C by virtue of the low forecast traffic volumes and the local access function provided. Consistent with the WAPC's Structure Planning Guidelines, access streets are not shown on the LSP Plan and will be determined at subdivision stage once planning is further progressed. The LSP Concept Plan at Figure 9 and Street Types Plan at Figure 14 show one possible manner in which local access streets can be located and aligned within the broader network.

Source: KCTT
3403-30-01 (01.09.2015), NTS

CYCLE / PEDESTRIAN NETWORK PLAN
Figure 16

3.5.3 Pedestrian and Cyclist Network

The LSP facilitates safe and convenient pedestrian and cycle movement through a combination of permeable road networks with short street lengths, linear open space, and provision of a detailed network of footpaths and shared paths. As demonstrated in the cycle / pedestrian network plan at Figure 16, the LSP provides multiple route options to the land use elements within the DSP such as schools, the neighbourhood centre, and public transport routes.

The key principles for determining the hierarchy of pedestrian and cycling facilities is as follows:

- Neighbourhood Connector roads will allow for on-road cycling (either in designated lanes or shared spaces) as well as footpaths on either side.
- A 2.5m wide dual use path will be provided on all designated Access Street A roads, with a standard footpath on the opposite side of the street.
- A standard 2m footpath will be provided on one side of all Access Street C roads, consistent with Liveable Neighbourhoods.
- Key areas of public open space will provide recreational footpaths / shared paths to facilitate safe pedestrian and cycle movement away from key transport corridors.

These principles will be confirmed and refined as part of further detailed planning at the detailed design stages.

3.5.4 Public Transport

The key principles for public transport provision in the Brabham area are established via the DSP, and are premised on regular passenger bus services using Lord Street, Partridge Street, and Youle Dean Road, with opportunities for a future rapid bus transit service or similar adjacent to Lord Street that links Ellenbrook to the Midland rail line.

Partridge Street is the closest planned public transport route to the LSP area, and is located within an easy walking distance of approximately 600m – 800m from the majority of dwellings within the LSP area. Access to Partridge Street can be easily achieved via Woollcott Avenue, or via the road / POS network established by LSP1B to the west.

3.6 Water Management

Schedule 4 of LPS 17 sets out a framework for environmental and water management reporting for the Albion cell at DSP, LSP and subdivision stages. A Local Water Management Strategy (LWMS) was prepared and adopted as a detail of the Albion DSP, pursuant to LPS 17. The Albion DSP LWMS was prepared in the context of existing and concurrent regional and district ground water studies including; Drainage Management Strategy for the North East Corridor (GB Hill 1995) and the Swan Urban Growth Corridor Drainage Water Management Plan (DWMP) (GHD 2009).

LPS 17 Schedule 4 requires the preparation of an Urban Water Management Plan (UWMP) to support a Local Structure Plan. This is inconsistent with the hierarchy of water strategy documents outlined in the WAPC Better Urban Water Management 2008 (BUWM), which requires a LWMS to be prepared at the local structure planning level and not at the district level.

The endorsed Albion DSP sets out an agreed water management reporting framework at LSP and subdivision stages. It has previously been agreed with the City of Swan and the Department of Water (DoW) that the appropriate level and content of investigation and reporting for a LSP is a Local Water Management Strategy as described in BUWM. Urban Water Management Plans will be prepared for all subsequent subdivision application areas as a condition of subdivision approval. This is consistent with the endorsed approach that has been successfully implemented elsewhere within the DSP area.

Consistent with the agreed framework, hydrologists 360 Environmental have prepared a LWMS in support of LSP3B – refer Appendix 2. The LWMS provides a localised urban water management strategy for the site consistent with the requirements of the Albion DSP LWMS, the framework and requirements outlined in BUWM and LPS 17.

The following summarises the key outcomes and implications of the LWMS.

3.6.1 Water Conservation

At the development scale, the LWMS recommends the use of a non-potable source for establishment of open space. As discussed further below, the aquifers underlying the LSP area are fully allocated. A temporary licence application been submitted for supply of water for construction and to establish the vegetation within the POS. The vegetation species will be selected to be drought tolerant and not require any ongoing irrigation, thereby ensuring that ongoing water consumption for the project is limited to individual consumption of scheme water.

The LWMS identifies a range of best practice water conservation measures at a local (individual lot) scale, including:

- Showerheads installed with a rating better than the minimum WELS 3 Star.
- Taps installed with a rating better than minimum WELS 4 Star.
- Dual flush toilets with a rating better than minimum WELS 4 Star.

- Water using appliances, such as washing machines and dishwashers installed with a rating of WELS 4 Star or better.
- Baths and Spas are low volume and small surface area.
- Hot water systems located less than 20m from the point of use and / or a recirculation or heat pump is installed.

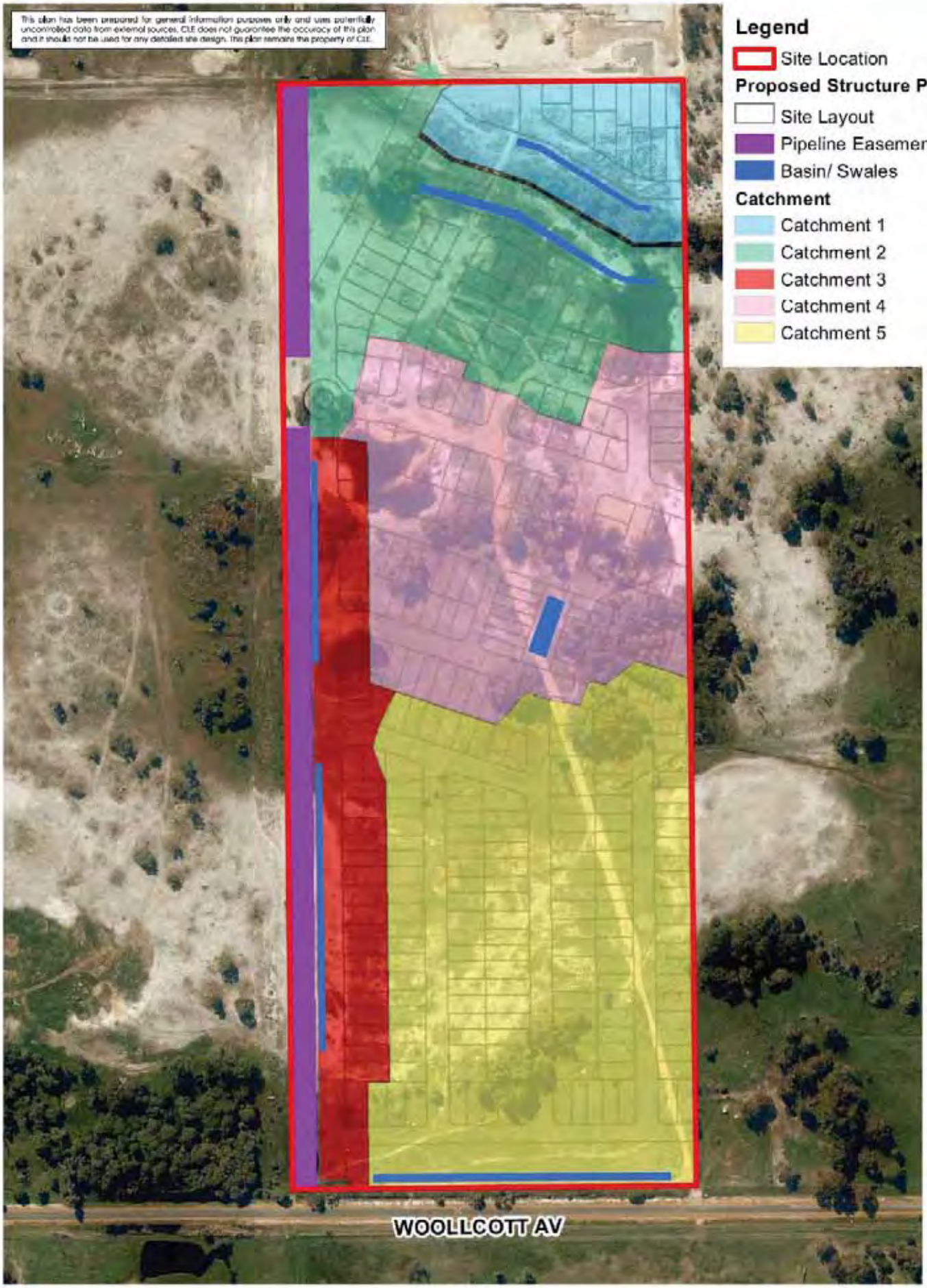
Conservation measures for external household use include:

- Garden designs will incorporate waterwise or endemic plant species.
- Garden beds will be mulched to a minimum of 5cm with Smart Approved WaterMark mulch.

3.6.2 Surface Water Management

The LWMS identifies the following key strategies for the management of surface water / storm water:

- Maintain the existing catchments and flow paths across the north and south of the LSP area through earthworks and alignment of road networks;
- Adopt a 'treatment train' approach to water quality management and protection of receiving environments, including infiltration of frequent events close to source and bio-retention areas to strip nutrients;
- Frequent events (≤1yr ARI Event) infiltrated within the majority of lots through the use of soakwells, with runoff from roads infiltrated via a bio-retention system within either public open space or roadside swales;
- Smaller lots (<300m²) will have lot connections to the street drainage network, removing the need for soakwells within the lot, and ensuring that the water will be treated and infiltrated in bio-retention areas within open space and / or roadside swales;
- Major events will be discharged offsite at near pre-development peak flow rates;
- Attenuation of discharge offsite to reflect pre-development hydrology will be achieved with the use of a drainage infrastructure (swales and basins);
- Modification of St Leonards Creek to formalise the channel morphology, provide the community with amenity and provide similar hydraulic performance; and
- Modification of the Woollcott Avenue drain with general road upgrades to convey arterial runoff downstream (final form, either drain or pipe, to be determined in detailed engineering design).



CLE TOWN PLANNING + DESIGN

Source: 360 Environmental
3403-31-01 (01.09.2015), NTS

CONCEPTUAL STORMWATER MANAGEMENT PLAN

Figure 17

A major and minor approach to the design of stormwater management systems has been adopted for the LSP area. The minor system consists of underground pipes, kerbs and gutters deigned to convey runoff up to the 5yr ARI event and ensure serviceability of the road network. The major system consists of roads, swales, open space, St Leonards Creek and the Woollcott Avenue Drain, and provides protection to the community from extreme flooding events (up to the 100yr ARI event) that exceed the capacity of the minor system. Figure 17 – Conceptual Stormwater Management Plan demonstrates the integrated nature of the minor stormwater management system.

As demonstrated in Figure 17, the LSP responds to these key principles through the location of public open space at the low point in each drainage catchment, and ensuring that each area of open space that serves a drainage function is appropriately sized and dimensioned in order to improve efficiency and maximise functionality of the open space. Further discussion on the stormwater management system is provided in the LWMS at Appendix 2.

3.6.3 Groundwater Management

The LSP provides adequate clearance to maximum ground water level (MGL) through the importation of sufficient fill to ensure at least 1.5m of clearance. This removes the requirement for sub-soil drainage and ensures a low maintenance, low risk solution to the management of groundwater.

Quality of groundwater will be maintained or improved through the use of bio-retention areas which will treat storm water and remove nutrients before discharging into the broader system.

3.6.4 Groundwater Abstraction Licences / Irrigation Supply

The LSP has been designed specifically to minimise the need for an ongoing irrigation water supply. As noted above, the underlying aquifers are fully allocated at present, creating opportunities for a range of waterwise landscape treatments throughout the open space areas. These waterwise open space areas are complementary to the 3.12ha of active open space located immediately to the west of the LSP area, which will cater for active recreation uses that require irrigated turf areas.

3.7 Education Facilities

The LSP area is well serviced by planned educational facilities, as established via the DSP. This distribution has been confirmed in consultation with the Department of Education, with the school sites being centrally located within the surrounding catchment, consistent with Liveable Neighbourhoods.

There are no planned educational facilities within the LSP area, however the following sections demonstrate the availability of public education facilities within close proximity.

3.7.1 High Schools

The DSP identifies a 12ha public high school site within Lot 800, approximately 800m to the south of the LSP area. Accompanying the high school is an additional 1.5ha site that is set aside specifically for "Education Support". It is intended that this high school will service the LSP area at ultimate development.

3.7.2 Primary Schools

The DSP identifies three public primary schools evenly distributed throughout the DSP area. Two of these three primary schools are within an 800m catchment of the LSP area, ensuring convenient and safe access for future residents.

3.8 Activity Centres and Employment

LSP3B has excellent access to nearby activity centres and employment opportunities, as recognised by the DSP.

The LSP is located approximately 1km from the planned Large Neighbourhood Centre located on the corner of Partridge Street and Youle Dean Road. The Centre is identified as a 'Large Neighbourhood Centre' in the DSP, and an 'Emerging District Centre' in State Planning Policy 4.2 – Activity Centres for Perth and Peel. At ultimate development, the Centre is likely to support between 10,000 and 20,000 square metres of retail floor space along with associated non-retail commercial uses, providing for the day to day retail and community needs of future residents of the LSP area as well as providing employment opportunities for a proportion of the population.

The DSP also identifies a Local Centre immediately to the east of the LSP area. The Local Centre is forecast to accommodate between 300m² and 500m² of retail floor space (NLA), and will meet the local convenience needs of the surrounding community. The LSP responds to the planned centre through allocating appropriate housing densities within the walkable catchment, and ensuring direct vehicle and pedestrian access to the centre via the east-west access street. The increased density and direct access will improve the retail catchment, and therefore the viability of the local centre, increasing the likelihood of early delivery of the centre as the area to the east develops.

3.9 Pipeline Corridor

As noted previously, an easement containing the Parmelia Gas Pipeline is located along the western periphery of the LSP area, while the Dampier-Bunbury Gas Pipeline is located within an adjacent easement to the west within lot 346.

The DSP and Planning Bulletin 87 (PB87) establish a 'default' setback to the pipeline corridor, which is deemed to ensure an acceptable level of risk to future residents without requiring any additional works or improvements to the pipeline itself. Both the DSP and PB87 acknowledge that the default setbacks can be reduced where it can be demonstrated via a Qualitative Risk Assessment that the risk arising from the pipeline is within acceptable risk levels pursuant to PB87 and AS 2885. Consulting engineers Worley Parsons have prepared a Pipeline Risk Management Plan and Protection Plan, which constitutes a QRA for the purpose of the DSP and PB87. The Pipeline Risk Management Plan and Protection Plan is informed by a risk assessment undertaken by Worley Parsons, APA Group (Parmelia Pipeline operators), and DBP (Dampier to Bunbury Pipeline operators).

A full copy of the Worley Parsons report is included as Appendix 4, with the key findings / recommendations summarised below.

The LSP reduces the default setbacks such that residential development is proposed to be separated from the pipeline corridor by an 18m wide access street. In order to maintain an acceptable level of risk whilst allowing reduced setbacks, the QRA recommends the following physical works to be undertaken:

- Increased safety signage;
- Bollards to prevent vehicle access into the corridor;
- Road crossing to comply with AS2885 (concrete slab and minimum separation of services from pipeline);
- Installation of temporary fencing to restrict access to the pipeline during construction; and
- Ground cover to comply with APA requirements.

In addition, the QRA identifies a series of practical actions to be undertaken during construction in order to ensure that safety standards are satisfied.

The QRA concludes that provided the abovementioned actions are undertaken, the reduced setback proposed by the LSP will achieve an acceptable level of risk.

The LSP reserves the Pipeline Corridor as 'Public Utilities' with the intention that this land will be ceded and vested with the Department of Lands free of cost at subdivision stage. Prior to the land being ceded, the gas pipeline easement must be surrendered and then re-granted following ceding. This apporach is consistent with previous structure plans in the area, including the recently endorsed LSP1B and LSP1C structure plans.

CLE TOWN PLANNING + DESIGN

Source: Pritchard Francis

3403-32A-01 (10.09.2015), NTS

PRELIMINARY EARTHWORKS PLAN

Figure 18

3.10 Infrastructure Coordination, Servicing and Staging

Civil engineering consultant Pritchard Francis has prepared an infrastructure servicing report in support of the LSP, refer Appendix 5. The report includes a detailed earthworks and servicing strategy, and demonstrates that coordination of, and access to essential service infrastructure is not a constraint to development. The strategy is summarised below, and is included in full as Appendix 5.

3.10.1 Earthworks

As part of subdivisional works, the LSP area will be re-contoured through a cut to fill operation and the importation of clean sand fill to maintain 1.2m clearance from the maximum groundwater level (MGL). This additional clearance removes the need for subsoil drainage, ensures that adequate flood protection is provided, and minimises the risk of exposure to acid sulphate soils.

The site preparation and earthworks will take into consideration the retention of significant trees within open space areas wherever possible, and will not include any substantial earthworks within the pipeline corridor.

A preliminary earthworks plan is Figure 18.

3.10.2 Waste Water

The LSP area has access to the existing reticulated waste water scheme via the planned type 90 waste water pumping station at Youle-Dean Road. Access to the pumping station will be provided via the extension of an external sewer main from the south, with the alignment of the extension to be confirmed in consultation with the Water Corporation as planning progresses. The extension of the sewer main to the LSP area will also allow the temporary Type 10 pump currently in use on lot 9203 to the north to be decommissioned.

Pritchard Francis will continue to work with the Water Corporation as planning progresses in order to refine the sewer design and to confirm timing and availability.

3.10.3 Water Supply

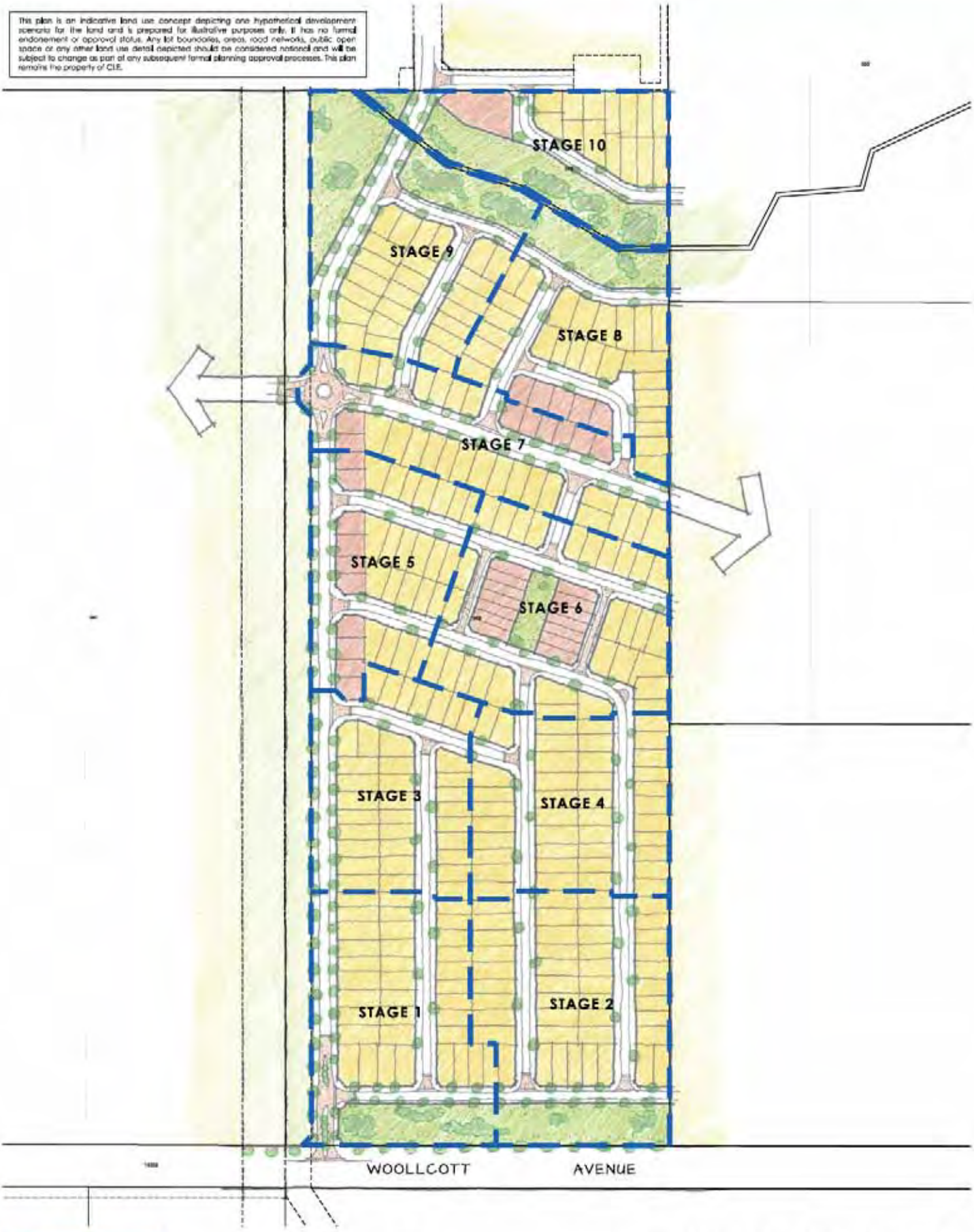
The Water Corporation has confirmed that the LSP area can be serviced by the extension of an existing 250mm water reticulation main located at the northern boundary within the Avonlee estate. A 200mm water main is proposed to extend through the LSP area, with 100mm mains to service lots.

3.10.4 Electrical Supply

The LSP has excellent access to existing Western Power transmission assets in the vicinity, including:

- Beechboro Zone Substation - approximately 10km south west of the site; and
- Ellenbrook Zone Substation on Gnangara Road - approximately 2.5km north of the site.

Western Power has indicated that approximately 5MVA of capacity remains between the two substations however both have the opportunity for future expansion to increase future capacity if warranted. As such, development of the LSP area will not require construction of any new substations, as all demand can be met from the existing substations.



CLE TOWN PLANNING + DESIGN

3403-33-01 (31.08.2015), NTS

PRELIMINARY STAGING PLAN

Figure 19

Access to the regional HV system is provided via the 132kV transmission lines located on the southern verge of Woollcott Avenue. It is understood that the transmission line will remain in Woollcott Avenue for the time being, however given it is located on the southern side of Woollcott Avenue there are no implications for the LSP area.

3.10.5 Telecommunications

It is understood that the LSP area falls within NBN Co's servicing region and there would be an opportunity for the landowners to enter into an agreement with NBN Co for the provision of NBN Co's 'Fibre to the Home' (FTH) in the LSP area.

Alternatively, Telstra is another provider of communications infrastructure in the Brabham area. Either NBN or Telstra pit and pipe infrastructure will be installed as part of the subdivision works, with the preferred provider to be determined as planning progresses.

3.10.6 Gas

A proposed 160E gas main is planned for lot 9203 which will terminate at the northern boundary of LSP area. Gas reticulation will be installed as part of the common trench, following the water main from the north to the south of the LSP area.

3.10.7 Development Staging

It is anticipated that the structure plan area will be developed in stages over a period of 12-24 months. Initial stages will include key infrastructure items including access and intersections to Woollcott Avenue. A preliminary staging plan is included as Figure 19.

The provision of civil infrastructure will be staged to suit development demand and precise timing and staging of development will be confirmed at detailed design stage.

3.11 Developer Contribution Arrangements

The LSP area is located within Development Contribution Area 1 (DCA 1) under Schedule 13 of LPS17 and thus is subject to the relevant Development Contribution Plan (DCP) for DCA 1. The DCP encompasses all of the DSP area, and puts in place a shared funding scheme for a range of road and community infrastructure across the DSP area.

The DCP applicable to DCA 1 identifies infrastructure items that are outside of the LSP area, which are required to be ceded, resumed or constructed as part of the urban development of the area. There are no DCP infrastructure items located within the LSP area.

The 'Infrastructure Demand' is apportioned across the development in order to derive Infrastructure Contribution Rates for each network of Infrastructure. Each subdivider will be required to make a cost contribution payment based on the area that they develop against the applicable contribution rate for DCA 1.

TECHNICAL APPENDICES

LOT 345 WOOLLCOTT AVENUE, BRABHAM
LOCAL STRUCTURE PLAN 3B

October 2016

ALCOCK BROWN-NEAVES GROUP

CLE TOWN PLANNING + DESIGN

LOT 345 WOOLLCOTT AVENUE, BRABHAM LOCAL STRUCTURE PLAN 3B

TECHNICAL APPENDICES

Prepared by:

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3403Rep7B_Appendices
October 2016

APPENDICES

Appendix 1: Environmental Assessment Report - 360 Environmental

Appendix 2: Local Water Management Strategy - 360 Environmental

Appendix 3: Fire Management Plan - Natural Area Consulting

Appendix 4: Pipeline Risk Management Plan and Protection Plan (Qualitative Risk Assessment) - Worley Parsons

Appendix 5: Service Infrastructure and Earthworks Strategy - Pritchard Francis

Appendix 6: Landscape Strategy - LD Total

Appendix 7: Transport and Movement Network Assessment - KCTT

APPENDIX 1

Environmental Assessment Report - 360 Environmental

Our Ref: 1044AB

26 August 2015

Jeremy Cordina
Land Development Manager
ABN Group
131 Hasler Road
OSBORNE PARK WA 6017

Dear Jeremy,

Lot 345 Woollcott Ave, Brabham, Environmental Assessment

1. Background

360 Environmental Pty Ltd (360 Environmental) have been commissioned by ABN Group to prepare an environmental report detailing the environmental features and associated development constraints, and the proposed management of these constraints, to support a Local Structure Plan (LSP) for Lot 345 Woollcott Avenue, Brabham (the Site, Figure 1).

The Site is located within Special Use Area 10 as defined in the City of Swan's *Town Planning Scheme No. 17* for which a District Structure Plan (DSP) was prepared in August 2008 (Chappell Lambert Everett). Various environmental studies have been undertaken across the DSP area as part of the preparation of the submission, some of which include the site. As a result, the 360 Environmental has undertaken a literature review of available environmental information for the Site as well as a desktop assessment to provide an overview of environmental features specific for the site to support the LSP. Consideration of management measures in accordance with the City of Swan and state agency expectations for an LSP application is also provided. The LSP is provided as Figure 2.

Please note that only the environmental characteristics which could potentially be impacted through the implementation of the LSP, or present a constraint to development if not managed appropriately, have been included in this report.

2. Environmental Assessment

2.1. Soils and Topography

Regional soil mapping indicates that the Site is situated upon the 212Bs soil unit of the Bassendean Sands which is described as sand dunes and sandplains with pale deep sand, semi wet and wet soil (DAFWA 2012). The topography of the site has been described as typically falling from west to east, gently grading from approximately 34 meters Australian Height Datum (mAHD) to 22 m AHD (JDA 2008).

2.1.1. Impacts and Management

The wet nature of the soils of the Site as indicated by the regional mapping, suggest potential drainage implications. An Urban Water management Plan (UWMP) will be prepared by 360 Environmental detailing how drainage will be managed across the Site in accordance with the *Better Urban Water Management Guidelines* (WAPC, 2008). The UWMP will be submitted to the City and the Department of Water for consideration and approval.

2.2. Acid Sulfate Soils

Acid Sulfate Soil (ASS) risk mapping by the Department of Environment Regulation has identified the majority of the Site as having a 'moderate to low risk of ASS within 3m from the ground surface' (Figure 3). The southern portion of the Site contains areas which are mapped as 'high to moderate risk of ASS within 3m from the ground surface'.

2.2.1. Acid Sulfate Soil Management Plan

ASS are naturally occurring soils containing iron sulphides that are widespread in low-lying coastal areas of Western Australia. Without appropriate management, these soils when disturbed can cause the production of sulfuric acid, which can result in significant environmental impacts. For this reason, appropriate management and monitoring strategies are required to minimise the impact of disturbing these soils through ground intrusive works.

Schedule 4 of the *City of Swan's Local Planning Scheme* (LPS) *No. 17* outlines the requirement for an *Acid Sulfate Soils (ASS) Site Assessment Management Plan* (SAMP). The ASS SAMP is required to include:

- *A detailed field assessment of ASS in proposed disturbance areas;*
- *The preparation of ASS management plans in accordance with the DEC's (now DER) current guidelines;*

- *The preparation of a monitoring program for groundwater discharge areas as part of the Urban Water Management Plan.*

The proponent is aware of the above requirements. Given the potential presence of ASS, a preliminary ASS risk assessment in accordance with the requirements of the DER will be undertaken prior to subdivision, in the event that any excavation or dewatering is proposed. If potential ASS are identified, the relevant management plans will be prepared prior to the commencement of subdivision works to the expectations of the DER.

2.3. Groundwater

Groundwater levels across the Site have been reported on in the Local Water Management Strategy prepared by JDA (2008) for the DSP. Groundwater Levels were reported as ranging from 'ponding' to >1.5 metres below ground level. Groundwater levels across the majority of the Site are expected to be less than one meter below ground level (JDA 2008). The north-western portion of the Site occurs within a Priority 3 Public Drinking Water Source Area (PDWSA) (DoW 2012). This area is the Gnangara Underground Water Pollution Control Area.

2.3.1. Impacts and Management

As stated in the DoW's *Better Urban Water Management Guideline* 2008 'Where the level is at or less than 1.2 m of the surface, the importation of clean fill and/or the provision of sub-surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. Management of any implications of the potentially shallow water table will be outlined in the (UWMP) prepared by 360 Environmental.

As stated by Department of the Environment (DotE 2004), Priority 3 PDWSAs 'are declared over land where water supply sources coexist with other land uses such as residential, commercial and light industrial development. Land uses considered to have significant pollution potential are nonetheless opposed or constrained'. Although residential land uses are considered compatible with the presence of P3 PDWSAs, this protection area will be given consideration in the UWMP.

2.4. Surface Water

There are no EPP Lakes, Conservation Category or Resource Enhancement wetlands mapped within the Site (EPA 2010, DPAW 2014). A Multiple Use Wetland is mapped across the southern portion of the Site, however development is generally permissible

upon this wetlands of this management category (Figure 4). A Resource Enhancement Wetland (REW) is located approximately 30m to the West of the Site (Figure 4).

The DSP proposed to retain a Multiple Use drainage corridor which is mapped as running from the REW to the west of the Site and beyond the eastern Site boundary. The LSP design proposes to retain a drainage corridor (POS area) along the southern boundary of the Site adjacent to the aforementioned REW. This area is depicted in Figure 2.

A watercourse known as St Leonards Creek, branches into the north-eastern corner of the Site (Figure 4). St Leonards Creek is a perennial watercourse which is both natural and manmade. The St Leonards Creek system has been augmented with constructed drainage channels to aid drainage of the seasonally waterlogged land within the catchment (Ecoscape, 2006).

2.4.1. Impacts and Management

A Wetland Management Plan has been prepared by ATA Environmental (2006) at the DSP level which has been used to guide the management of St Leonards Creek. Measures which will be employed by the proponent to ensure the protection of the watercourse include:

- A 30 meter buffer either side of the high water line;
- Passive Landuses;
- Treatment of runoff prior to any discharge into the creek (as detailed in the UWMP);
- Retention of riparian vegetation to assist in secondary nutrient stripping, erosion prevention and maintenance of habitats;
- Selective planting of native vegetation within degraded areas of the creek buffer for environmental and amenity purposes.

Incompatible land uses surrounding St Leonards Creek or the nearby REW have the potential to result in erosion, nutrient enrichment and habitat degradation of these waterbodies and their associated vegetation. As depicted in the Concept Plan (Figure 2) the proponent has committed to retaining a 30 meter buffer either side of St Leonards Creek as well as a minimum of 30 meters setback between the REW and the development.

Passive landuses within the 30 meter buffer area may include basic facilities such as a meandering footpath to prevent trampling of riparian vegetation. Any proposed landuses within the buffer area will be confirmed at the subdivision stage.

The development is setback from the REW approximately 30 meters, however in some areas as little as 20 meters separation is provided. It is considered that the presence of the pipeline easement and the hard edge of the access road will provide sufficient protection from the REW given that the areas outside of the wetland mapping (within the site) are degraded.

Stormwater management will generally be in line with the commitments outlined in the DSP documentation and will be detailed in the UWMP.

2.5. Vegetation

2.5.1. Vegetation Units

Aerial imagery shows that the Site is highly disturbed and native vegetation is restricted across the Site to pockets and scattered trees. A flora survey was conducted across the broader area by Ecologia in 2001 which mapped the following three vegetation communities within the Site boundary (Figure 5):

- *Corymbia calophylla* (Marri) woodland;
- *Eucalyptus/Banksia* woodland; and,
- *Melaleuca rhaphiophylla* woodland.

This survey was undertaken 14 years ago and therefore may not accurately represent the current vegetation on site. A site visit undertaken in January 2015 by 360 Environmental identified that remnant vegetation was still in degraded condition with some scattered patches of young trees and scattered established trees with little or no understorey. The vast majority of the site consisted of weedy grasses.

2.5.2. Threatened and Priority Ecological Communities

It was previously considered that a possible Threatened Ecological Community (TEC) occurred within the north-western corner of the Site associated with the Eucalyptus Banksia woodland. However in 2006 Cardno conducted an analysis of the portion of this community occurring within Lot 350 (to the north) and determined that this community was consistent with Floristic Community Type 23a and therefore not a TEC. It is therefore considered reasonable to conclude that the portion of this community within the Site is not a TEC, given it was mapped as the same vegetation complex in the 2001 report.

Banksia dominated woodlands of the Swan Coastal Plain IBRA region have been listed by DPaW as a Priority 3 community. The *Eucalyptus/Banksia* woodland vegetation community may potentially have been representative of this community prior to historical

clearing and agriculture on the site, however given the currently degraded state of the vegetation, it is considered to hold little environmental value.

2.5.3. Conservation Significant Flora

A two kilometre search was undertaken using the federal DotE PMST to identify any potential threatened flora within the Site. The search returned several species with the potential to occur, or have suitable habitat within the area. The species list is provided in the PMST report in Appendix B. A search of the Department of Parks and Wildlife *NatureMap* database (DPaW 2015) returned no known occurrences of conservation significant flora species within one kilometre of the centre-point of the Site. The *NatureMap* search results are based on actual recorded occurrences of individual plants and therefore are considered more site specific and more accurate then the PMST.

2.5.4. Impacts and Management

The proponent has committed to the retention of riparian vegetation associated with the 30 meter buffer to St Leonard's Creek in the northern portion of the Site. In addition, where possible the proponent will retain native vegetation in POS areas and road verges. Any amenity planting in street-scapes and POS will be undertaken with species native to the Brabham area.

2.6. Fauna Habitat

A search of NatureMap (DPaW 2015) returned no records of conservation significant fauna within one kilometre of the centre-point of the Site (Appendix A).

The DotE Protected Matters Search Tool (PMST) identified the potential for several conservation significant fauna species or their habitat to occur within the broader area of the Site (DotE 2015, Appendix B). The threatened fauna species which were returned in the PMST search include the:

- Forest Red tailed Black Cockatoo
- Carnaby's Black Cockatoo
- Baudin's Black Cockatoo; and,
- Chuditch/ Western Quoll.

Based on the findings of the flora and vegetation survey conducted by Ecologia in 2001, potential Black Cockatoo foraging and breeding habitat may occur within the Site including Banksia and Marri vegetation.

The most up to date information available on the federal Species Profile and Threats Database (DotE 2015b) states that the 'Chuditch currently inhabit most kinds of wooded habitat within its current range including eucalypt forest (especially Jarrah, *Eucalyptus marginata*), dry woodland and mallee shrublands (Serena & Soderquist 1995)'. Eucalypt vegetation was recorded during the 2001 vegetation survey conducted by Ecologia.

Given that the Site currently appears to be in a highly degraded condition, the potential for suitable habitat to occur for conservation significant species is limited.

2.6.1. Impacts and Management

Based on the extent and quality of remnant vegetation within the site, significant impacts to potential Black Cockatoo habitat is unlikely. However to ensure all impacts are properly considered, a Black Cockatoo habitat survey will be undertaken to determine the suitability of the Site for the Black Cockatoos. The proponent understands and will consider the requirement to refer the project to the DotE for potential significant impacts to the threatened species, under the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999* should this be deemed necessary following the habitat survey. It should be noted that this process is separate to the LSP assessment process.

It is considered unlikely that the Chuditch would utilise the site given the lack of understorey habitat available.

As mentioned previously, the proponent has committed to the retention of riparian vegetation associated with the 30 meter buffer to St Leonard's Creek. Any landscaping and amenity planting will be undertaken with native flora species which provide suitable foraging and/or breeding habitat to Black Cockatoos.

2.7. Cultural Heritage

A search of the Department of Aboriginal Affairs (DAA 2015) and the State Heritage Office (SHO 2015) cultural heritage databases did not return any registered heritage sites within the LSP area.

Although not listed as a registered heritage site, it has been noted that St Leonard's Brook may be considered to contain cultural heritage values (based on previous consultation undertaken with indigenous representatives). Disturbance of St Leonard's Brook will not occur and a 30 meter buffer will be retained either side of the brook. Additional protection/ enhancement measures are outlined in Section 2.4.1.

2.8. Cultural Heritage Management Plan

Impacts to any cultural heritage sites are not expected, however Schedule 4 of the City of Swan's *Local Planning Scheme* (LPS) *No. 17* outlines the requirement for a Cultural Heritage Management Plan (CHMP) under the Albion Special Use area. The purpose of the CHMP is to ensure:

- *The requirements of the Aboriginal Heritage Act 1972 are met so that the development of each cell does not affect cultural heritage and associations with the area;*
- *An application under the Aboriginal Heritage Act 1972 will be made if disturbance to the archaeological site located at Lot 351 Park Street is to occur as part of urban residential development;*
- *Commitments made during consultation with Aboriginal groups are maintained during all stages of planning;*
- *Appropriate recommendations are incorporated into development and subdivision plans which seek to maintain the cultural values of wetlands and creeks; and*
- *Prior to the commencement of site works, contractors shall undergo a briefing on Aboriginal Heritage issues to enable them to recognise materials that may constitute an Aboriginal site. During earthworks, all contractors shall be supervised by a Site Manager, who shall seek advice from the Aboriginal Affairs Department to confirm the identification of any suspected site.*

Given that no registered heritage sites have been identified within the LSP area, a stand-alone CHMP has not been prepared. The proponent commits to complying with any legal requirements, including those under the *Aboriginal Heritage Act 1972*. The proponent also commits to complying with the above requirements of the City's LPS where applicable.

In the event that any potential heritage artefacts or sites are uncovered during the construction phase, a stop works will be issued until the area has been determined to hold no heritage value. All construction staff will be inducted on these procedures to ensure the protection of any cultural heritage.

Conclusion

Based on the review of available information for the Site, there does not appear to be any significant environmental features or constraints that would prevent consideration of the LSP. In addition, management measures outlined in this report have been proposed to mitigate any environmental impacts that may result through implementation of the development.

Should you have any questions or require further action please do not hesitate to contact Carli Turner or the undersigned on (08) 9388 8360. We look forward to hearing from you.

For and on behalf of

360 Environmental Pty Ltd

Luke Rogers – Senior Environmental Scientist

Enc:
Figure 1 – Location Plan
Figure 2 – Local Structure Plan
Figure 3 – Acid Sulfate Soils
Figure 4 – Surface Water Features
Figure 5 – Vegetation Mapping Units

Attachment A – NatureMap Search Results
Attachment B – Protected Matters Search Results

References

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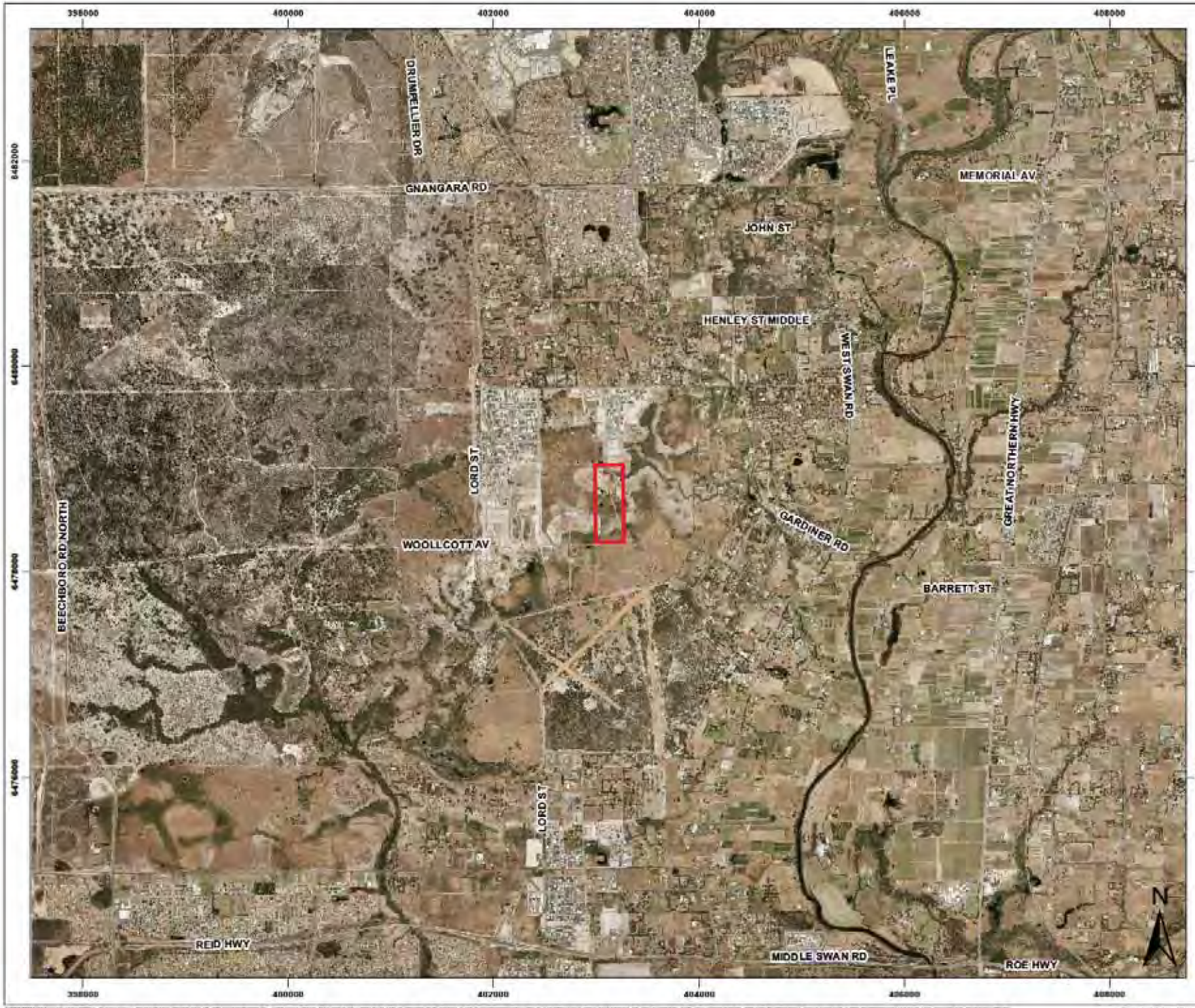
FIGURES



Legend

Site Location (20.3 ha)

Roads

NOTE THAT POSITION ERRORS CAN BE +5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- AERIAL PHOTOGRAPHY SOURCED LANDGATE NOV 2014
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LOCALITY MAP

PROJECT ID	DATE
1062	14/05/2015

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
CS	AN	RP	0

ABN Group
Lot 345, Woolcott Ave, Brabham

Environmental Assessment Report

Figure 1 - Site Location

Legend

- Site Location
- Cadastre

Local Structure Plan

- Creek Drainage
- Lots
- Parmelia Gas Easement
- Public Open Space
- Road Elements
- Roads
- St. Leonards Creek
- Verge

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- LSP SOURCED FROM CLE 2011 (3483-09A [SUB CONCEPT].DWG)
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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Meters
1:5,000 @ A4

LOCALITY MAP

PROJECT ID	DATE
1044	18-Jun-15

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
JJ	CT/LR	RP	0

ABN Group
Lot 345, Woolcott Ave, Brabham

Environmental Assessment Report

Figure 2 - Local Structure Plan

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Legend

Site Location

Acid Sulfate Soils Disturbance Risk

High to moderate risk

Moderate to low risk

- NOTE THAT POSITION ERRORS CAN BE +5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- AERIAL PHOTOGRAPHY SOURCED LANDGATE NOV 2014

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Meters

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LOCALITY MAP

PROJECT ID	DATE
1062	15/05/2015

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
CS	AN	RP	0

ABN Group
Lot 345, Woolcott Ave, Brabham

Environmental Assessment Report

Figure 3 -
Acid Sulfate Soils Risk Mapping

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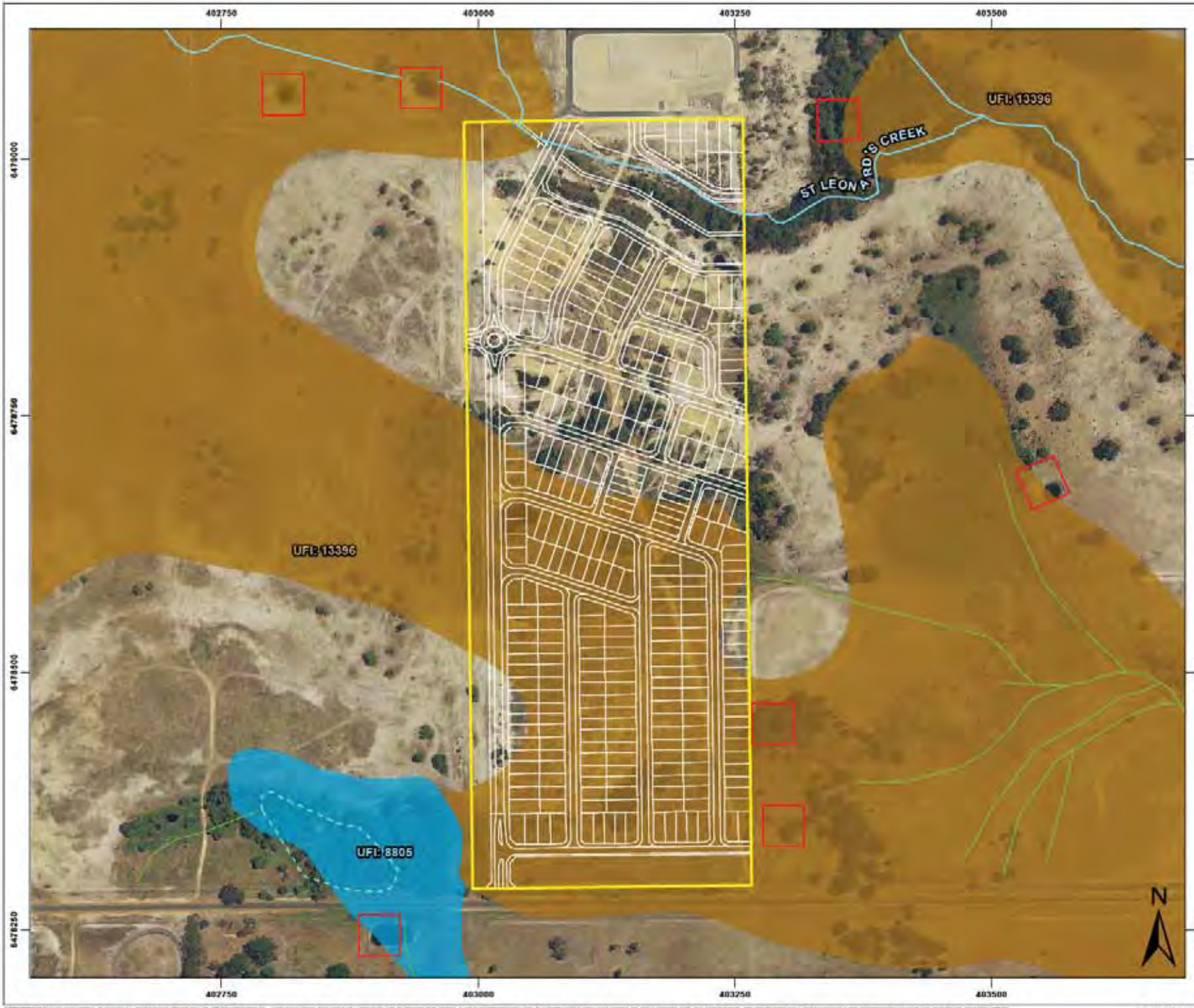

Legend

- Site Location
- Local Structure Plan

Geomorphic Wetlands

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

Surface Water Features

- Area Subject to Inundation
- Drain - minor
- Earth Dam
- Minor watercourse

- NOTE THAT POSITION ERRORS CAN BE +-5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- SURFACE WATER FEATURES SOURCED FROM DOW 2012
- GEOMORPHIC WET LANDS SOURCED FROM DPAW 2015
- LSP SOURCED FROM GIE 2015 (3403-99A [SUB CONCEPT] LDWG)
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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Meters
1:5,000 @ A4

LOCALITY MAP

PROJECT ID	DATE
1044	16-Jun-15

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
JJ	CT/LR	RP	0

ABN Group
Lot 345, Woolcott Ave, Brabham

Environmental Assessment Report

Figure 4 - Surface Water Features

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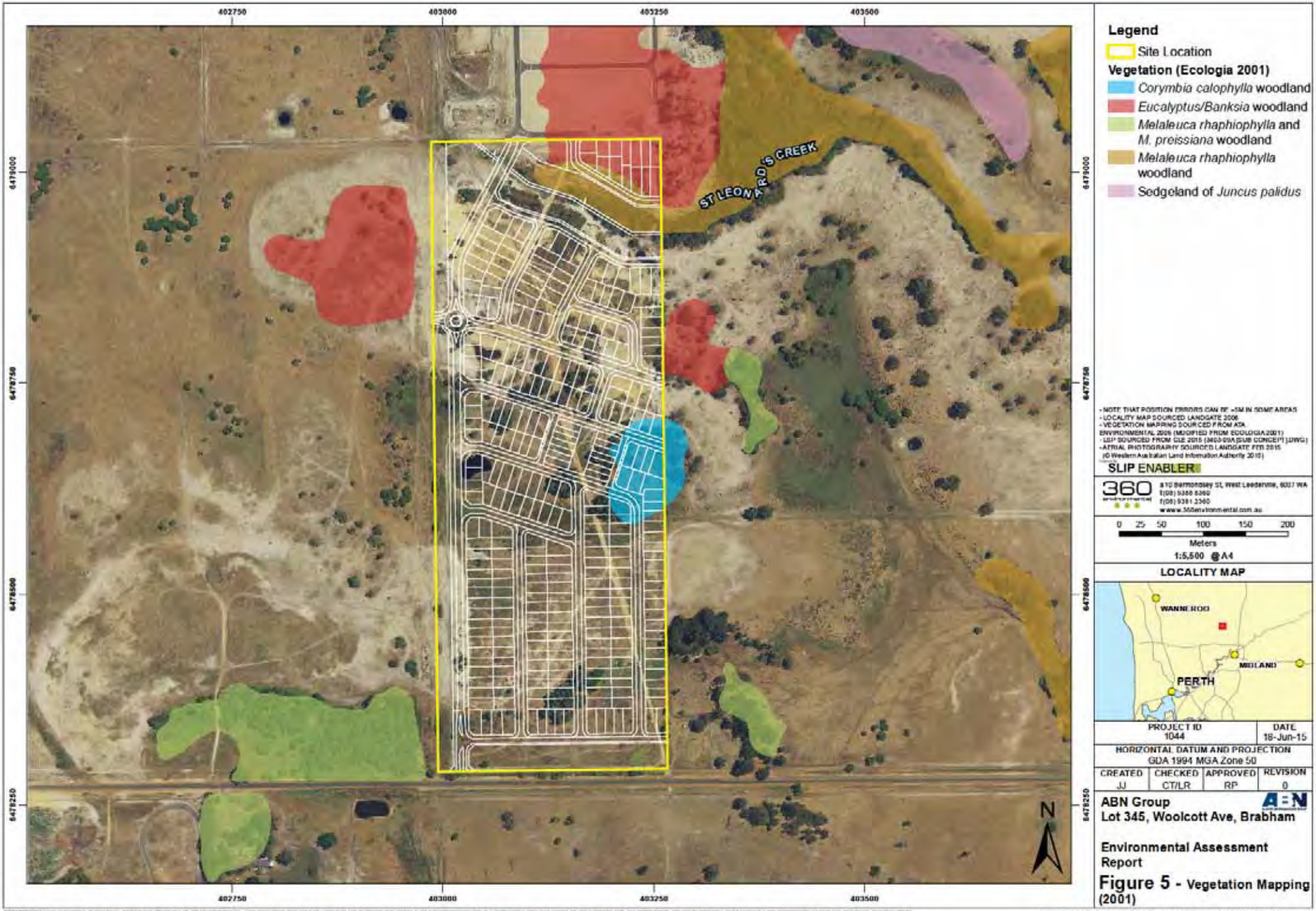
402750
403000
403250
403500
6479000
6478750
6478500
6478250
ST LEONARD'S CREEK
N
Legend
Site Location
Vegetation (Ecologia 2001)
Corymbia calophylla woodland
Eucalyptus/Banksia woodland
Melaleuca rhaphiophylla and M. preissiana woodland
Melaleuca rhaphiophylla woodland
Sedgeland of Juncus palidus
- NOTE THAT POSITION ERRORS CAN BE +5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- VEGETATION MAPPING SOURCED FROM ATA ENVIRONMENTAL 2005 (MODIFIED FROM ECOLOGIA 2001)
- LOT SOURCED FROM GIS 2015 (3403-99A [SUB CONCEPT] LDWG)
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
(© Western Australian Land Information Authority 2015)
SLIP ENABLER
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0 25 50 100 150 200
Meters
1:5,500 @A4
LOCALITY MAP
WANNEROO
MIDLAND
PERTH
PROJECT ID
1044
DATE
16-Jun-15
HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50
CREATED
JJ
CHECKED
CT/LR
APPROVED
RP
REVISION
0
ABN Group
Lot 345, Woolcott Ave, Brabham
Environmental Assessment Report
Figure 5 - Vegetation Mapping (2001)

APPENDIX A

DPaW NatureMap Search Results

NatureMap

NatureMap Species Report

Created By Guest user on 23/06/2015

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115°56' 35" E,31°49' 23" S
Buffer 1km
Group By Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	4	4
TOTAL	**4**	**4**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Non-conservation taxon					
1	1117	*Aphelia cyperoides*			
2	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
3	1190	*Juncus planifolius (Broadleaf Rush)*			
4		*Notiaspermus glaumfi*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX B

DotE Protected Matters Search Results

Australian Government
Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

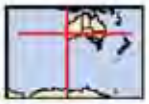
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 23/04/15 13:57:37

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 2.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	20
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	8
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	44
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Anigozanthos viridis subsp. terraspectans Dwarf Green Kangaroo Paw [3435]	Vulnerable	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Chamelaucium sp. Gingin (N.G.Marchant 6) Gingin Wax [64649]	Endangered	Species or species habitat may occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Epiblema grandiflorum var. cyaneum Baby Blue Orchid, Blue Babe-in-the-cradle Orchid, Blue Babe-in-a-cradle [67182]	Endangered	Species or species habitat may occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Thelymitra manginii K.Dixon & Batty ms [67443]	Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area
Trithuria occidentalis Swan Hydatella [42224]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Pandion cristatus Eastern Osprey [82411]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Defence - RAAF CAVERSHAM

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Protasparagus plumosus Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
RAAF Caversham	WA

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-31.82313 115.97543

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 2

Local Water Management Strategy - 360 Environmental

360 environmental

Lot 345 Woollcott Avenue,
Brabham

Local Water Management Strategy

Prepared for:
Alcock Brown Neaves Group

May, 2016

people planet professional

Document Reference	Revision	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
1062BA	Internal Draft	AN	RP	1 Electronic	31/08/2015
1062BB	Client Draft / Submission to CoS/DoW	AN	RP	1 Electronic	21/09/2015
1062BC	Revision for CoS and DoW	AN	RP	1 Electronic	19/12/2015
1062BD	Revision for DoW	KC	RP	1 Electronic	01/03/2016
1062BE	Revision for CoS	AN	RP	1 Electronic	09/05/2016

Executive Summary

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management)

Integration of water and land use planning, integrate Stormwater Treatment into the landscape
Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity
Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse
Define stormwater quality management objectives in relation to the sustainability of the receiving environment
Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions add value while minimising development costs

Category	Objectives	Site Considerations	Key Management Features
Water Sustainability To maximise the reuse of stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Apply for a groundwater licence for irrigation of POS. Use local, native waterwise plants in POS and streetscape landscaping. Remove wastewater from the site via mains sewerage system.	The Site currently has no groundwater licence. The superficial aquifer (Perth-Mirrabooka Management Area, Whiteman Park Subarea) is fully allocated. The Leederville and Yarragadee Aquifers in this area are fully allocated.	A temporary licence application to establish vegetation has been approved. Households will adhere to WC waterwise home guidelines. Local, native waterwise plants used in landscaping (no turf installed).
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤1yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (>1yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Attenuate runoff (≤100yr ARI) to pre-development peak flows.	St Leonards Creek flows through the northern part of the Site, flowing east towards the Swan River. The southern portion of the Site flows in a south easterly direction towards the roadside drain along Woolloott Avenue. Geotechnical information indicates the sandy soils across the Site promote infiltration, with a design rate of 5m/day recommended (Galt, 2015).	Existing flow paths and catchments will be maintained. Frequent events (≤1yr ARI) will be infiltrated within larger lots through the use of soakwells. Runoff from roads and smaller lots will drain to bio-retention areas and infiltrate in pits. Major events (up to 100yr ARI) will be attenuated in the POS before discharging to St Leonards Creek and Woolloott Avenue Drain at near pre-development rates.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure 1.2m of separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment. Convey excess groundwater to the nearest watercourse.	Groundwater data measured onsite (May - Nov 2015) indicates there is <1.2m of clearance to groundwater across parts of the Site. A comparison with long term monitoring records (DoW Bore MM71B) supports the groundwater monitoring results. Two bore identified Maximum Groundwater Level above the surface (Bore PB03 and PB06).	Where required by local conditions or engineering design, fill will be imported to provide 1.5m of clearance to MGL. The use of subsoils is not anticipated. Any fill will be free draining, cohesionless, well graded sand. The groundwater management strategy will be reviewed in the UWMP with additional monitoring data.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Adopt a treatment train approach to stormwater management, including bio-retention areas for treatment of frequent (≤1yr ARI). Retain and restore riparian vegetation to promote bio-filtration. Exclude polluting commercial activities within the Site in accordance with SPP 2.2 'Gnangara Groundwater Protection"	Groundwater quality was tested at two bores nearby to the Site with results typical for the Swan Coastal Plain. Total Nitrogen and Total Phosphorus exceed ANZECC guidelines and pH acidic.	A treatment train approach to water quality improvement is adopted. Higher density lots (compact and cottage lots) reduce the garden areas and nutrient application. Bio-retention systems will provide treatment to frequent events.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.	The Site is within the catchment of the St Leonards Creek that flows towards the Swan River. No Conservation Category Wetlands or Bush Forever areas are located within the Site.	The treatment train approach (above) will provide water quality improvement measures for water discharged to the downstream Swan River System.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.5m clearance from 100yr ARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.	No water logging was identified during a visit to the Site in May 2015. ASS investigations indicate that the risk for the Site is moderate to high. No contaminated sites exist on or within 2km of the Site.	Detailed ASS investigations will be required for excavation works. The habitable floor level will be 0.5m above the 100yr ARI flood level.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation, where possible. Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas.	The remnant vegetation may offer social aesthetic and cultural value, though it has been identified as generally degraded. St Leonards Creek is a significant feature, though it is partly degraded. There are no areas of Aboriginal Heritage on this Site.	St Leonards Creek will be rehabilitated and restored to provide ecological and hydraulic functions. Vegetation will be retained for the Creek where possible.
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.	The guiding water management document for the Site is the Albion Local Water Management Strategy (JDA, 2008) which provides a summary of key water investigations (Similar to a District Water Management Strategy.	The UWMP will document the final stormwater management strategy incorporating any additional monitoring data or engineering, planning and landscaping requirements.
Implementation / Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.	The UWMP will need to incorporate further data and adjust strategies/plans accordingly. Clearance to groundwater may require dewatering for construction activities, such as sewer installation.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements of proposed stormwater systems. Following completion of construction, monitor groundwater and surface water near sensitive environments.	Post-Development groundwater targets are based on Albion Groundwater Monitoring Data (JDA, 2008).	A post-development monitoring program will be implemented to demonstrate that the management strategies are capable of the intended purpose.

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1 Introduction

360 Environmental Pty Ltd (360 Environmental) were commissioned by Alcock-Brown Neaves (ABN) Group (the Client) to prepare this Local Water Management Strategy (LWMS) in support of the Local Structure Plan (LSP) for Lot 345 Woollcott Avenue, Brabham (the Site). The Site is approximately 20.3 hectares ha in size and is located in the City of Swan. It is approximately 24km north east of the Perth CBD (Figure 1).

The proposed development will influence the total water cycle as a result of an increase in impervious areas, the clearing of native vegetation, cut and fill. The LWMS has been prepared to provide strategies and plans for total water cycle management across the Site in accordance with the principles of Water Sensitive Urban Design (WSUD) and the guiding documents in Section 1.2. It provides a summary of local and regional environmental data that informs management strategies for stormwater, groundwater, protection of receiving environments and water conservation. A strategy for implementing the total water cycle management during construction and post-development is also provided.

A checklist for the LWMS requirements is included in Appendix A and outlines the compliance of this document with the Better Urban Water Management (BUWM) (WAPC, 2008) framework.

1.1 Planning Background

The BUWM framework (WAPC, 2008) integrates water management into the land use planning process to ensure planning strategies include total water cycle management and WSUD.

The Site is located within the City of Swan's local government area and is currently zoned as 'Special Use' under the Councils most recent Local Planning Scheme (LPS No. 17) (DoP, 2013). The Site is listed as 'Urban' under the Western Australian Planning Commission (WAPC, 2014) Metropolitan Region Scheme (MRS). The LSP has been developed to coordinate the provision and planning for land use development at the Site (Appendix B). The LWMS is prepared in support of the LSP.

1.2 Guiding Documents

Development and associated water management strategies for the Site are guided by the Albion Local Water Management Strategy (JDA, 2008). This document provides guidance for developers and stakeholders and was prepared with reference to City of Swan's Local Planning Scheme No.17.

The LWMS has also been prepared with consideration for the following guidelines and policy documents:

- Swan Urban Growth Corridor Drainage And Water Management Plan, Including Albion, Caversham, West Swan and Whiteman Park south (DoW, 2009a)

- Local Water Management Strategy: Lots 349 and 350 Park Street, Henley Brook (VDM, 2009)
- Developing a Local Water Management Strategy (DoW, 2008)
- State Planning Policy 2.9 Water Resources (WAPC, 2006)
- Stormwater Management Manual for Western Australia (DoW, 2004-07)
- Better Urban Water Management (WAPC, 2008)
- Decision Process for Stormwater Management in Western Australia (DoW, 2009b)
- Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas (DoW, 2012)
- Determining Foreshore Reserves (Water and Rivers Commission, 2001)

A summary of the key principles and objectives for the Site, based on the guiding documents, is provided in Table 1.

Table 1: LWMS Key Principles and Objectives.

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning, Integrate Stormwater Treatment into the landscape Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions add value while minimising development costs	
Category	**Objectives**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Apply for a groundwater licence for irrigation of POS. Use local, native waterwise plants in POS and streetscape landscaping. Remove wastewater from the site via mains sewerage system.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤1yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (>1yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Attenuate runoff (≤100yr ARI) to pre-development peak flows.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure 1.2m of separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment. Convey excess groundwater to the nearest watercourse.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Adopt a treatment train approach to stormwater management, including bio-retention areas for treatment of frequent (≤1yr ARI). Retain and restore riparian vegetation to promote bio-filtration. Exclude polluting commercial activities within the Site in accordance with SPP 2.2 'Gnangara Groundwater Protection"
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.5m clearance from 100yr ARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation, where possible. Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas,
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.
Post-Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements of proposed stormwater systems. Following completion of construction, monitor groundwater and surface water near sensitive environments.

2 Proposed Development

A brief summary of the pre-development land use and proposed development are provided in this section.

2.1 Land Use

The Site is located in the suburb of Brabham, within the City of Swan (Figure 1). Brabham was formerly part of the suburb of Henley Brook and was gazetted in May 2011.

At present, the Site consists of disused open sandy and grassed area with several mature trees and few open water ponds (Figure 2). An existing drain, known as a branch of St Leonards Creek, is located in the northern boundary of the Site flowing in the south east direction.

The areas surrounding the Site to the west and east exhibit an undeveloped rural land use, the land to the north is currently being developed for residential purposes and the southern side of the Site is bounded by Woollcott Avenue.

2.2 Development Features

The proposed development features approximately 330 residential lots, as shown in (Figure 3). The layout of this development has considered the existing environmental and drainage conditions, as well as surrounding land use and planning constraints.

Public Open Spaces (POS) are proposed in the north adjacent to the creek, the southern boundary and surrounding smaller lots in the centre of the Site. These areas will be used for drainage to maintain existing flow paths and they will include stormwater management systems, integrated through landscaping design. Concepts for the POS are provided in the Landscape Plan (Appendix C).

The western section of the Site, approximately 1.3ha, is an easement for the Parmelia and Dampier Bunbury gas pipelines part. No development or drainage will be located within this area. Adjacent to this easement will be a roadside swale to capture and infiltrate runoff from nearby lots.

The key elements of the development plan are POS areas integrated with stormwater retention and treatment areas and road alignments that convey major events.

3 Site Characteristics

The pre-development environmental conditions provide opportunities and constraints for water management on the Site. A summary of the environmental characteristics are provided in this Section.

3.1 Previous Studies

The environmental characterisation is based on a desktop assessment of the Site and review of the following documents:

- Albion Local Water Management Strategy (JDA, 2008).
- Report on Due Diligence Level Geotechnical Study, Posposed Residentual Development 345 Woollcott Avenue, Brabham (Galt Geotechnics, 2015).
- Lot 345 Woollcott Ave, Brabham, Environmental Assessment (360 Environmental, 2015).

3.2 Topography

The location of the Site is north of Woollcott Ave, and is approximately 4km north of the Reid Highway (Figure 1). It is approximately 20.4ha in size.

Topography of the Site varies between around 35mAHD in the northwest corner to about 25mAHD in the south eastern corner of the Site (Figure 2). The Site generally slopes northwest to southeast.

3.3 Climate

The climate of the south western region of Western Australia is characterised by the Koppen Climate Classification as Dry Subtropical featuring mild winters with low humidity and hot to very hot summers with moderate humidity. The dominate rainfall mechanisms are frontal systems caused by cold fronts associated with low pressure systems that extend across southern Australian between May and October. During the summer months, thunderstorms and ex-tropical cyclones can bring intense rainfall.

The weather station at Midland Rainfall Station (009025), approximately 6km southeast of the Site, provides a climate dataset in a range of approximately 130 years (BoM, 2015a). As demonstrated in Figure 4, there is a variation in the annual totals in the last 100 years data, ranging between 462mm (1979) and 1,217mm (1926). The data indicates a decreasing trend in annual and winter rainfall totals, particularly since 2000 where the annual average rainfall has decreased from 799mm to 705mm (approximately a 12% decrease). Winter rainfall (May-August) has decreased by 14% during the same period.

Evaporation, as shown in Figure 4, is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the

region is water limited between September and April. Between May and August rainfall exceeds evaporation.

The key rainfall characteristic for hydrological analysis is the Intensity-Frequency-Duration (IFD), a statistic derived from frequency analysis to provide estimates of rainfall intensity for a given durations and return periods. Analysis of rainfall and hydrology in the LWMS is based on IFDs published in Australian Rainfall and Runoff (AR&R1987) (Engineers Australia, 1987) and are summarised in Table 2. In recent years, IFDs have been revised utilising more extensive datasets (BoM, 2015b), but corresponding methods and data for hydrological estimation are yet to be published.

Table 2: Rainfall IFDs for Brabham (EA, 1987)

	IFD Rainfall Intensity (mm/hr)				
Duration	1 Year	2 Year	5 Year	10 Year	100 Year
1hr	15.5	20.1	25.5	29.2	48.6
3hr	7.7	9.9	12.3	14.0	22.7
6hr	4.9	6.3	7.8	8.8	14.1
12hr	3.1	4.0	4.9	5.6	8.9
24hr	2.0	2.6	3.2	3.6	5.7
72hr	0.9	1.2	1.5	1.7	2.7

3.4 Geotechnical

The Perth Metropolitan Region 1: 50,000 Environmental Geology series mapping (Sheet 2034 II and Parts of 2034 III & 2134 III) indicates that the Site is located on the degraded surface of the Bassendean dune system (Gozzard, 1986). The geological unit Bassendean Sand covers the majority of the Site (Figure 5) and is described as "very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of aeolian origin".

A geotechnical investigation of the Site was conducted by Galt Geotechnics in February 2015 in support of the proposed residential development of the Site (Appendix D). The investigation included the excavation of 15 test pits with adjacent Perth sand penetrometer tests, four infiltration tests, laboratory testing of selected samples and six cone penetration tests. The locations of the boreholes and test pits are shown in Figure 5.

A summary of the soil profile encountered at the borehole locations is provided below (Galt, 2015):

- Sand (SP): fine to course grained, sub-angular to sub-rounded, grey becoming pale grey/pale yellow, trace rootlets in top 100mm, trace localised layers of very weakly cemented coffee rock with increased organic content (about 5%), generally loose up to 0.3m depth and medium dense to dense below, extending to the maximum depth investigated of 5.8m.

Infiltration testing was carried out at four locations with varied results (Table 3). Testing in the southern area of the Site, HA04, indicates that infiltration in this section will be difficult. The other three permeability tests (HA01-HA03) in the central and northern regions of the Site show suitability of the sand for infiltration with a recorded minimum unsaturated permeability of 11.2m/day.

A design general permeability rate of at least k=5m/day is recommended (notwithstanding one low result obtained on the site, which can be due to the close proximity of the test to groundwater) (Galt, 2015). This rate is dependent on at least 0.5m of clearance to the groundwater table.

Table 3: Permeability Testing

Test Location	Description	Pipe Embedment (m)	Minimum Unsaturated Permeability, k(m/day)		
			Test 1	Test 2	Test 3
HA01	SAND	0.75	70.9	61.3	50.8
HA02	SAND	0.60	57.5	44.8	48.9
HA03	SAND	0.60	12.8	11.5	11.2
HA04	SAND	0.85	3.0	1.6	1.3

Bore Logs from installation of monitoring bores by 360 Environmental are provided in Appendix D. The subsurface conditions encountered during installation of these bores are generally consistent with the Geotechnical Investigation (Galt, 2015).

3.5 Groundwater

The underlying aquifers, quality of pre-development groundwater quality and depth of water below the surface require consideration for management of the total water cycle and are discussed below.

3.5.1 Aquifers

The Site is situated in the Whiteman Park groundwater sub-area. Groundwater resources below this region feature four separate aquifer systems: the Superficial Swan aquifer, the Perth-Mirrabooka aquifer, the Leederville aquifer and Yarragadee aquifer (DoW, 2015a). The shallowest aquifer, The Superficial Swan, consists predominantly of quartz sand and gravel (Bassendean Sands) with a maximum saturated thickness of up to 70m (Gnangara Mound). Recharge to the superficial aquifer occurs through direct infiltration of rainfall, which migrates downward to the water table or less permeable layers, at which point groundwater flows laterally to the aquifer. Water is lost from the aquifer through evapotranspiration from wetlands and shallow groundwater areas, to the ocean and downward leakage to the semi-confined Mirrabooka aquifer. The Mirrabooka aquifer is a water supply resource for drinking water.

The Leederville Aquifer is a major confined aquifer that consists of sandstones, siltstones and shales with a thickness up to 250m. It is a major groundwater source for the Perth region. The deeper Yarragadee aquifer is confined and occurs at depths about 450m

below ground surface. As with the Leederville, the Yarragadee is a major groundwater source for the Perth region.

3.5.2 Groundwater Levels

JDA (2008) established pre-development Average Annual Maximum Groundwater Levels (AAMGL) for the wider Albion area during the preparation of the Albion Local Water Management Strategy. Results indicated that a typical seasonal variation (between summer lows and winter highs) for ground water levels is 1.2m. JDA Contours vary between 23.5mAHD and 28mAHD across the Site.

DoW (2009a) modelled the groundwater for Current (average for last 20 years) and Wet (a high rainfall scenario for 1915 to 1934) Climates. Current Climates Maximum Ground Water Level (CCMGL) across the Site varies between 23.5mAHD and 27mAHD.

360 Environmental installed ten shallow groundwater monitoring bores on the Site in May 2015 and measured water levels monthly until November 2015. These bores are shown in Figure 6 and observed water level data is presented in Appendix E. Maximum Groundwater Levels (MGL) across the Site have been determined from the September data as it is representative of winter conditions.

The Site monitoring data was compared with the Department of Water Monitoring Bore MM71B (AWRC ref: 61418444) in order to understand the observed data in the context of longer term records. This bore, approximately 1.8km southwest of the Site, provides a record of groundwater levels dating back to 1997. The lower rainfall period since 2000 is reflected in lower groundwater levels. Annual maximum levels were generally recorded in September and October each year (DoW, 2015b).

Analysis of the historical record indicates that the MGL is around 0.45m higher than water levels recorded in September 2015, accounting for outliers in the record. AAMGL is approximately 0.15m higher than September 2015 (Appendix E). These corrections were applied to the observed data to determine the groundwater levels across the Site. This data is presented in Table 4 and Figure 6.

Table 4: Groundwater Levels

Bore	Ground Level at Bore (mAHD)	Sept-15 Depth to Groundwater (m)	Sept-15 Groundwater Level (mAHD)	MGL (mAHD)
PB01	25.99	0.54	25.45	25.90
PB02	25.34	0.89	24.45	24.90
PB03	26.84	0.36	26.48	26.93
PB04	26.31	0.77	25.54	25.99
PB05	27.17	0.47	26.70	27.14
PB06	26.48	0.33	26.15	26.60
PB07	29.04	0.78	28.26	28.71
PB08	28.23	0.73	27.50	27.95
PB09	29.04	0.72	28.32	28.77
PB010	30.18	2.11	28.07	28.51
DoW Bore MM71B	24.29 (TOC)	1.22 (mBTOC)	23.07	23.52

The maximum groundwater level is quite shallow across the Site. The monitoring data indicates that the MGL is above the ground level at two sites.

Assessment of the long term record at MM71B indicates that seasonal variation in groundwater is up to 1.5m annually.

3.5.3 Groundwater Quality

Groundwater quality sampling was conducted as part of the Albion LWMS (JDA, 2008). Two bores (ALB4, ALB6) were located directly east of the Site. The groundwater was tested for nutrients with results displayed in the Table 5 below. Results for physiochemical parameters across the entire Albion area were reported as pH of 5.9 and EC of 440μS/cm.

Table 5: Groundwater Quality Results

Physiochemical Parameter	ALB4	ALB6	ANZECC Guideline *	Healthy Rivers Action Plan	
				Short Term	Long Term
Total N (mg/L)	4.8	0.7	1.2	2.0	1.0
TKN (mg/L)	2.8	0.6	-	-	-
NOx-N (mg/L)	2.0	0.06	-	-	-
Total P (mg/L)	0.26	0.03	0.065	0.2	0.1
FRP (mg/L)	0.26	0.02	0.04		

*South-West Australia.

Total Nitrogen and Total Phosphorus exceeds ANZECC and Healthy Rivers Action Plan (HRAP) guideline values for some measurements and pH was found to be acidic and below ANZECC guidelines. The results are typical for groundwater on the Swan Coastal Plain.

3.6 Surface Water

A watercourse known as St Leonards Creek flows through the north-eastern corner of the Site (Figure 7). Through the Site, St Leonards Creek is a watercourse which is both natural and manmade in reaches. The wider St Leonards Creek system has been augmented with constructed drainage channels to aid drainage of the seasonally waterlogged land within the catchment (Ecoscape, 2006).

3.6.1 Site Hydrology

The Site is divided generally into two sub catchments (Figure 7). The northern catchment contributes to the existing St Leonards Creek and the southern catchment flows south, southeast towards Woollcott Avenue.

Flows in St Leonards Creek consist of flows from the Site and upstream from the residential development to the north (Lots 349 and 350). The Local Water Management Strategy for Lots 349 and 350 (VDM, 2009) outlines post development peak flows for the 1yr, 5yr and 100yr ARI events, based on XP-Storm modelling. These are provided in Table 6 below.

In order to determine pre-development flows from the Site, hydrologic and hydraulic modelling was undertaken with the model XP-Storm. The following parameters have been used to determine pre-development runoff:

- Rainfall for the Site is based on 1987 IFD Data (Section 3.3).
- A slope value of 0.007 was used.
- Losses for the Site were defined with an initial (15mm) and continuing proportional loss (85%) approach. These losses are similar to the rural areas (cleared sand) from the Jandakot Drainage and Water Management Plan (DoW, 2009c) model.

Modelling results for the 1yr, 5yr and 100yr ARI events and are shown in Table 6.

The southern catchment on the Site flows southeast towards Woollcott Avenue. This road features a drain within the road reserve that will be upgraded as part of road widening and improvements. Pre-development flows from the Site have been estimated from XP-Storm modelling and are provided in Table 6.

Table 6: Pre-Development Flows

	1yr ARI	5yr ARI	100yr ARI
St Leonards Creek			
Flows: Existing Development Upstream (Lots 349 and 350)	0.057m³/s	0.237m³/s	0.425m³/s
Flows: Site (North Catchment)	0.006m³/s	0.056m³/s	0.129m³/s
Woolcoot Drain			
Southern Catchment	0.007m³/s	0.040m³/s	0.094m³/s

** Flows from Lots 349 & 350, Park Street, Henley Brook, Local Water Management Strategy (VDM, 2009)*

The peak flow rates from the Southern Catchment are comparable with pre-development flow rates from the adjacent Lot 346 and 347 urban development (JDA, 2015), though the Site does not contain a wetland to attenuate flows. The estimated flow from the Site is approximate 0.007m^3/s/ha (100yr ARI) event compared to Lot 346 and 347 which is approximately 0.004m^3/s/ha.

The Albion LWMS (JDA, 2008) outlined previous water quality monitoring information for St Leonards Creek. The estimated average annual rates Total Nitrogen and Total Phosphorus were 1.61kg/ha/yr and 0.78kg/ha/yr respectively.

3.6.2 Foreshore Assessment for St Leonards Creek

The Albion District Structure Plan (DSP) and Albion LWMS clearly identified the requirement for future development and local structure planning to provide for the retention of St Leonards Creek.

At the request of DoW, further information has been collated to determine if the Public Open Space proposed in the LSP is appropriate for protection of the watercourse values as well as accommodate the proposed rehabilitation, recreation facilities and stormwater management. In particular, the DoW has requested discussion and mapping regarding the channel, high water mark, extent of riparian vegetation and proposed buffer for St Leonards Creek.

Following this request, a foreshore assessment for St Leonards Creek has been undertaken and a qualified Ecologist from 360 Environmental undertook a site visit on 9 February 2016 to assess the riparian vegetation associated with St Leonards Creek.

Table 7 presents the findings of the foreshore assessment and the site visit. Further details on the general environmental conditions for the Site are provided in Section 3.8. The foreshore assessment for St Leonards Creek has been undertaken with reference to Operational Policy 4.3: Identifying and establishing waterways foreshore areas (DoW, 2012) and Determining Foreshore Reserves (Water and Rivers Commission, 2001).

Table 7: Foreshore Assessment for St Leonards Creek

Biophysical Criteria	Site Considerations
Topography and Landforms Identify landforms, including any drainage lines that may be important to watercourse function.	As shown in Figure 2, the topography along the creek line ranges from approximately 28 to 29 m AHD. The elevation increases to 35 m AHD to the south-west of the creek and to 32 m AHD to the very north eastern portion of the site. There are no notable landforms within the site as it is relatively flat. A detailed survey of the Creek is provided in Appendix F. The creek generally flows along the line mapped in the District Structure Plan, though it is poorly defined in some areas. The detailed survey identified a diversion drain from the creek to the south. A review of the historical aerial photographs determined that this was constructed between August 2014 and February 2015 prior to ABN taking ownership of the Site. It is thought that this was constructed to lower groundwater levels while the basin for the development to the north was installed. This diversion drain will be removed when the POS is landscaped.
Soils Identify soils that support riparian vegetation. Identify any soil types prone to erosion.	The Perth Metropolitan Region 1: 50,000 Environmental Geology series mapping indicates that Bassendean Sand covers the majority of the Site, including the northern portion which contains the watercourse. A geotechnical investigation of the Site was conducted by Galt Geotechnics in February 2015. The findings of the geotechnical study were mostly in accordance

Biophysical Criteria	Site Considerations
	with the geological mapping. Bassendean Sand was found to cover the entire Site to the full investigated depth (with the exception of minor clayey pockets). Minor clayey pockets exist in the southern portion of the site in the Multiple Use Wetland. The soil profile across majority of the site: Sand (SP) is described in Section 3.4. The soil subsystems mapping shown in Figure 5 indicates that there are peaty soils in a large part of the northern portion of the site around the watercourse. The geotechnical investigation did not find any evidence of peaty soil or a variation in the soil type around the watercourse. Due to the site being relatively flat
Floodway and Floodplain Locate the floodway and floodplain – 1 in 100 year flood levels, peak flow and river hydrology.	Based on the modelling outlined in Section 3.6, the 100yr ARI flow is determined to be 0.554m³/s through the Creek, with 0.425m³/s discharged to the system from the flow to the north. These flows are relatively small and the 100yr ARI floodplain is anticipated to be no more than 3m from the centreline of the creek. Given the extent of the riparian vegetation surrounding the creek, the 100yr ARI floodplain does not increase the foreshore area.
Riparian Vegetation Identify the extent of the riparian vegetation.	The distribution of riparian vegetation associated with St Leonards Creek is an important factor in the definition of the foreshore area. There were two riparian vegetation associations identified along the watercourse, as described below and shown in Figure 8. MpCc - *Melaleuca preissiana* and *Corymbia calophylla* woodland over *Lepidosperma longitudinale*, *Juncus pallidus* and **Watsonia sp.* closed sedgeland. Mp - *Melaleuca preissiana* isolated trees over **Watsonia sp.* and *Juncus pallidus* very open sedgeland over **Ehrharta calycina*, **Cynodon dactylon*, **Eragrostis curvula* and **Paspalidium sp.* grassland over **Conyza bonariensis* and **Hypochaeris glabra* isolated herbs. Photographs of the riparian vegetation are provided in Figure 8. The condition of the riparian vegetation associated with St Leonards Creek ranges from 'Completely Degraded' to 'Very Good-Excellent', with the greatest portion being in 'Very Good-Excellent' condition (Figure 9). Vegetation condition that ranges from 'Very Good-Excellent' is primarily 'Very Good'. The site assessment identified other surrounding vegetation associations which contain wetland species (Figure 9). However, it is clearly evident that these do not form part of the natural creek line.
Habitat Areas Identify valuable habitat areas.	**Conservation Significant Flora** No conservation significant flora are expected to occur in the site. A search of the Department of Parks and Wildlife NatureMap database (DPaW 2015) returned no known occurrences of conservation significant flora species within one kilometre of the centre-point of the Site (Appendix G). The NatureMap search results are based on actual recorded occurrences of individual plants. **Conservation Significant Fauna** A search of NatureMap (DPaW 2015) returned no records of conservation significant fauna within one kilometre of the centre-point of the Site (Appendix G). The *Corymbia calophylla* trees may offer habitat for the Threatened Black Cockatoos species. The areas of vegetation in 'Good' or better condition also provide valuable habitat ground dwelling taxa with the high ground cover potentially providing a refuge from predators.
Adjacent Land Use Pressures Identify adjacent land use pressures with potential to affect the foreshore.	Residential housing is proposed to be developed around the foreshore reserve. Residential development exists to the north and west of the Site. The Parmelia Gas Pipeline Easement exists to the west of the watercourse. Roads will be constructed to the north, south and west of the foreshore reserve as part of the development. Drainage basins will be installed around the foreshore area and within the foreshore reserve.
Heritage Investigate and identify any Aboriginal or other heritage sites that may influence foreshore widths.	A search of the State Heritage Office and Department of Aboriginal Affairs databases did not identify any aboriginal sites of significance within the property (SHO, 2015; DAA, 2015).
Recreational Amenity Investigate and identify any recreational amenity influencing foreshore widths.	The foreshore reserve will be used for recreational amenity and will include basic facilities such as footpaths, play areas and picnic areas. A crossover bridge will be constructed over the creek to control pedestrian access and to allow the public to get close to the natural environment. The Preliminary Landscape Plan for the development is provided in Appendix C.

3.6.3 Foreshore Area Definition

The elements of the foreshore assessment, outlined in Table 7, were considered to define the foreshore area. The key factors are the creek line defined from the detailed survey and the extent of the riparian vegetation, particularly the vegetation mapped as in very good condition. The defined foreshore area is provided in Figure 10.

The foreshore area is contained within the POS areas provided in the Structure Plan, consistent with the areas defined in the District Structure Plan. The remainder of the POS (outside of the foreshore area) will be landscaped and used for drainage, pathways and recreational amenity. Further details are provided in Section 5.2.3.

3.7 Water Resources

The Site is located within the Whiteman Park subarea of the Perth Mirrabooka Groundwater Management Area, on the boundary of the Swan Groundwater Management Area. No groundwater allocation licences currently exists within the Site and the superficial aquifer in the region is fully allocated. However the Site is located at the boundary of Whiteman Park and South Swan subarea and allocation is available in the South Swan subarea.

Potential non-potable water sources are discussed further in Section 4.1. The Site is within a Priority 3 (P3) Public Drinking Water Source Area of the Gnangara Underground Water Pollution Control Area.

3.8 Environmental

Several environmental features either influence or are dependent on the total water cycle for this Site. A brief summary of these is provided below.

3.8.1 Land Use Change

The review of historical imagery did not identify any significant historical causes for concern (Figure 8). Seasonal inundation has appeared to be an ongoing phenomenon for wetlands in the area. The southern side of the St Leonards Creek in the north of the Site have been cleared of the vegetation since 1953.

There have been significant land use changes in the surroundings areas in the past few years. As can be seen in Figure 11, residential developments north and west of the Site have been developed in 2014.

3.8.2 Aboriginal Heritage

The Government of Western Australia's State Heritage Office failed to identify any areas of Aboriginal or European heritage in the vicinity of the Site. A search of the Department of Indigenous Affairs, Aboriginal Heritage Inquiry System (AHIS) did not identify any aboriginal sites of significance within the property (DAA, 2015).

3.8.3 Flora and Fauna

A Flora survey was conducted by Ecologia in 2001. The vegetation condition on the Site ranged from 'Degraded' to 'Completely Degraded' with the majority of the survey area considered to be 'Completely Degraded'. A site visit undertaken in January 2015 by 360 Environmental identified that remnant vegetation over the majority of the site was still in degraded condition with some scattered patches of young trees and scattered established trees with little or no understorey. The vast majority of the site consisted of weedy grasses.

In February 2016, a qualified Ecologist from 360 Environmental undertook a site visit to assess the riparian vegetation associated with St Leonards Creek, which is located in the northern portion of the site. Table 7 and Figure 8 present the findings of the site visit.

There are no Bush Forever areas located near the Site (DER, 2015).

3.8.4 Wetlands

There are no EPP Lakes, Conservation Category or Resource Enhancement wetlands mapped within the Site (EPA 2010, DPAW 2014). A Multiple Use Wetland is mapped across the southern portion of the Site however this will not restrict development (Figure 12). A Resource Enhancement Wetland (REW) is located approximately 30m to the West of the Site (Figure 12).

3.8.5 Acid Sulfate Soils

Regional Acid Sulphate Soil (ASS) mapping indicates that the majority of the Site is "moderate to low risk" (Figure 13). The southern portion of the Site is mapped as "high to moderate risk". This mapping applies to depths of 3m below the natural surface (DEC, 2010).

An ASS Investigation completed by Douglas Partners in 2006 determined that the southern portion of the Site was Medium to High Risk (JDA, 2008).

3.8.6 Contaminated Sites

The DER Contaminated Sites Database was reviewed for known contaminated sites (that is, sites classified as Contaminated-Restricted Use, Remediated for Restricted Use or Contaminated-Remediation Required) in proximity to the Site (DER, 2015). The search results indicate the Site is not listed as a known contaminated site. No contaminated sites are located within 2km of the proposed development.

Furthermore, the review of historical imagery did not identify any significant historical causes for concern of contamination.

3.9 Summary

Based on the geotechnical, hydrological and environmental information, the Site can be considered as posing a high level of risk, based on the DoW's Guidance Note 3 (DoW,

2013a). The Site conditions fulfil the criteria of <1.2m depth to groundwater and proposed offsite drainage with the potential to effect downstream waterways in both St Leonards Creek branch, north of the Site and the existing drain south of the Site.

The strategies for water management and implementation have been prepared in sufficient detail to account for the level of risk posed by the development. A summary of gaps in the data and considerations for water management are provided below.

3.8.1 Gap Analysis

Numerous studies and field have been undertaken across the Site, to provide a foundation for the development of the water management strategies. No further studies are required to inform the water management strategies for the Site.

3.8.2 Site Considerations

The desktop assessment and previous investigations have identified a number of constraints and opportunities that require consideration in management of the total water cycle. These are summarised in Table 8.

Table 8: Key Site Considerations

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning, Integrate Stormwater Treatment into the landscape Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions add value while minimising development costs	
Category	**Site Considerations**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	The Site currently has no groundwater licence. The superficial aquifer (Perth Mirrabooka Management Area, Whiteman Park Subarea) is fully allocated. The Leederville and Yarragadee Aquifers in this area are fully allocated.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	St Leonards Creek flows through the northern part of the Site, flowing east towards the Swan River. The southern portion of the Site flows in a south easterly direction towards the roadside drain along Woollcott Avenue. Geotechnical information indicates the sandy soils across the Site promote infiltration, with a design rate of 5m/day recommended (Galt, 2015).
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Groundwater data measured onsite (May - Nov 2015) indicates there is <1.2m of clearance to groundwater across parts of the Site. A comparison with long term monitoring records (DoW Bore MM71B) supports the groundwater monitoring results. Two bore identified Maximum Groundwater Level above the surface (Bore PB03 and PB06).
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Groundwater quality was tested at two bores nearby to the Site with results typical for the Swan Coastal Plain. Total Nitrogen and Total Phosphorus exceed ANZECC guidelines and pH acidic.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	The Site is within the catchment of the St Leonards Creek that flows towards the Swan River. No Conservation Category Wetlands or Bush Forever areas are located within the Site.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	No water logging was identified during a visit to the Site in May 2015. ASS investigations indicate that the risk for the Site is moderate to high. No contaminated sites exist on or within 2km of the Site.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	The remnant vegetation may offer social aesthetic and cultural value, though it has been identified as generally degraded. St Leonards Creek is a significant feature, though it is partly degraded. There are no areas of Aboriginal Heritage on this Site.
Further Planning To ensure delivery of best practice stormwater management through planning.	The guiding water management document for the Site is the Albion Local Water Management Strategy (JDA, 2008) which provides a summary of key water investigations (Similar to a District Water Management Strategy.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	The UWMP will need to incorporate further data and adjust strategies/plans accordingly. Clearance to groundwater may require dewatering for construction activities, such as sewer installation.
Post-Development To implement stormwater systems that are economically viable in the long term.	Post-Development groundwater targets are based on Albion Groundwater Monitoring Data (JDA, 2008).

4 Water Sustainability Initiatives

The supply of water and sustainable use within the proposed development are key components of the LWMS.

4.1 Water Supply

Potable water for households within the development will be supplied from scheme water. The Water Corporation's (WC) Integrated Water Supply Scheme (IWSS) supplies scheme water from the following sources: 18% surface water (dams), 43% groundwater and 39% desalinated seawater (WC, 2015a). For the Site, both at the lot scale and development scale, measures to limit the supply of potable water will be implemented.

At the development scale, a non potable source will be used for temporary irrigation of POS. As discussed in Section 3.7, the aquifers underlying the Site are fully allocated. A temporary licence application been approved for supply of water for construction and to establish the vegetation within the POS. The vegetation species will be selected to be drought tolerant and not require any ongoing irrigation.

Development scale water reuse schemes are not proposed for the development.

4.2 Water Conservation

Significant savings in scheme water are possible through conservations measures provided by Water Corporation (WC, 2015b) and through the Building Codes of Australia. Consistent with these measures, households within the development will feature:

- Showerheads installed with a rating better than the minimum WELS 3 Star.
- Taps installed with a rating better than minimum WELS 4 Star.
- Dual flush toilets with a rating better than minimum WELS 4 Star.
- Water using appliances, such as washing machines and dishwashers installed with a rating of WELS 4 Star or better.
- Baths and Spas are low volume and small surface area.
- Hot water systems located less than 20m from the point of use and / or a recirculation or heat pump is installed.

Conservation measures for ex-household use include:

- Garden designs will incorporate waterwise or endemic plant species.
- Garden beds will be mulched to a minimum of 5cm with Smart Approved WaterMark mulch.
- Garden beds will use dripper or subsurface irrigation systems.

- Minimal use of lawn areas.

The type of vegetation throughout the development, both within the gardens and POS, significantly influences the water use throughout the development. For the Site, turfed areas are not proposed, with the majority of the POS to be planted with local, native vegetation. Gardens within the lots will contain waterwise species of vegetation, with recommendation provided to home owner through marketing brochures and building displays.

Estimates of water use and potential savings through these measures will be provided in the UWMP, following the finalisation of the lot layouts and sizes.

4.3 Waste Water Management

Waste water from the development will be managed through connection to the mains sewerage system.

5 Stormwater Management Strategy

The stormwater management strategy has been prepared in accordance with the guiding principles (Section 1.2) and site considerations (Section 3). The strategies preserve and enhance the ecological and social aspects of the Site and provide measures to mitigate the risk of flooding and waterlogging on the development.

5.1 Stormwater Management Concepts

The stormwater management system concepts for development of the Site have been prepared to meet the objectives and principles of urban water management outlined in Table 1 (Section 1.2). In addition, the proposed conceptual design is consistent with design objectives from the Albion Local Water Management Strategy (JDA, 2008). Specifically the system will manage catchment runoff to near pre-development peak flow rates.

Key elements of the stormwater management conceptual design are:

- Maintain the existing catchments and flow paths to the north and south of the Site through earthworks and alignment of road networks. POS, Drainage and Foreshore reserve areas adjacent to St Leonards Creek and the Woollcott Avenue Drain will feature drainage infrastructure.
- Adopt a treatment train approach to water quality management and protection of receiving environments, including infiltration of frequent events close to source and bio-retention areas to strip nutrients.
- Frequent events (≤1yr ARI Event) infiltrated within the majority of lots through the use of soakwells, with runoff from roads and smaller lots infiltrated via a bio-retention system within the POS and road reserves.
- Major events will be discharged offsite at near pre-development peak flow rates. Attenuation of discharge offsite will be achieved with the use of a drainage infrastructure (swales and basins).
- Restore and rehabilitate St Leonards Creek to ecological functions, provide the community with amenity and provide hydraulic functions.
- Modification of the Woollcott Avenue drain with general road upgrades to convey runoff downstream (final form, either drain or pipe, to be determined in detailed engineering design)
- Importation of fill to ensure at least 1.5m of clearance between lots and maximum groundwater levels.

5.2 Stormwater Management System

A major and minor approach to the design of stormwater management systems has been adopted for the Site. The minor system consists of underground pipes, kerbs and gutters deigned to convey runoff up to the 5yr ARI event and ensure serviceability of the road network. The major system consists of roads, swales, POS, St Leonards Creek and the Woollcott Avenue Drain and provides protection of the community from extreme flooding events (up to the 100yr ARI event) that exceed the capacity of the minor system. Details of these systems are described below.

5.2.1 Minor System (Frequent Events)

Management of the frequent event (1yr 1hr) event is largely related to the protection of receiving environments. Runoff from this event is the most likely to mobilise pollutants within the catchments and therefore measures are required to retain and treat this storm event on site. The drainage catchments for the Site are provided in Figure 14.

At the lot scale, the 1yr 1hr event (approximately 16mm) will be retained within the lot boundary and infiltrated using soakwells. Impervious areas, such as driveways, paving and roof will be connected directly to the soakwells. The system is supported by the clearance to groundwater (>1.5m) and favourable subsurface conditions (Section 3.4).

Installation of soakwells is difficult on smaller lots owing to the building footprint and clearances required. Therefore lot connections will be provided for all lots <300m^2. Where possible, pipeless systems will be considered where runoff is directed via overland flow paths. Use of these systems will be determined during detailed engineering design and presented in the UWMP.

Bio-retention systems within the POS and road reserve will be installed for runoff from the 1yr 1hr ARI event from road reserve and smaller lots where soakwells cannot be utilised (<300m^2). These systems will be located at the outlets of the road drainage network or non-active frontages (Figure 14). Details on the bio-retention system specification are provided in Section 5.4.

Details of road drainage network, including pipe sizes, will be determined through engineering design and will be provided in the UWMP in the form of engineering drawings. This infrastructure will be sized to ensure serviceability of the road network during the 5yr ARI event.

The use of pipe networks will be minimised owing to the high infiltration rates and sandy soils across the Site with infiltration promoted through the network via soakage pits (where possible) and infiltration in the road reserve. For Catchment 1, north of St Leonards Creek, a pipeless road drainage system will be implemented, with runoff conveyed along road surface. This type of system is possible owing to the depth to groundwater (>1.5m), sandy soils and relatively short road lengths.

Runoff from events up to the 5yr ARI event will be conveyed to the Woollcott Avenue Drain (south catchment) or St Leonards Creek (north catchment). Details of the respective flow rates and drainage infrastructure are provided in Section 5.2.2.

5.2.2 Major System (Extreme Events)

The major drainage system will consist of the POS and a modified St Leonards Creek. Events larger than the 5yr ARI event will be conveyed via the road network to the POS areas in the south, central and north of the Site (Figure 14).

The five drainage catchments for the Site are shown in Figure 14, with a breakdown in Table 9. For each of the two catchments (1 & 2) draining towards St Leonards Creek, a swale will be installed in the POS parallel to the creek, in order to attenuate flows to pre development rates. The catchment (3) to the west of the Site will drain towards a swale within the road reserve that retains up to the 100yr ARI event. The remaining catchments (4 & 5) drain towards the swale in the southern POS that attenuates flows prior to discharge to the Woollcott Avenue drain. Catchment 4 initially drains to the central POS where a basin allows for retention of frequent events (<5yr ARI) higher in the catchment, with overflow to the southern POS/ Drainage Reserve conveyed via a piped network.

Table 9: Catchment Area Breakdowns

Catchment	Traditional Lots (ha)	Compact Lots (ha)	Cottage Lots (ha)	Roads (ha)	POS (ha)	Equivalent Impervious Area (ha) – 1yr ARI	2% of Equivalent Imp. Area (m^2) ^
Catchment 1	0.50	0.12	0.0	0.19	0.55	0.20	45
Catchment 2	1.31	0.17	0.0	1.11	1.08	0.99	195
Catchment 3	0.75	0.20	0.10	1.03	0.04	0.85	180
Catchment 4	2.34	0.43	0.43	1.42	0.11	1.23	270
Catchment 5	3.80	0.82	0.0	1.71	0.67	1.44	290

^Equivalent Impervious Area is area based on Runoff Rates (Table 10). These areas do not include contribution from Traditional Lots and Compact Lots, as runoff from frequent events (1yr ARI) is contained within lots (soakwells).

The stormwater management system is configured to ensure that post-development flows are similar to pre-development runoff for the 5yr and 100yr ARI event. The post-development scenario for the Site was modelled using XP-Storm to determine the basin and swale configurations. Table 10 outlines the runoff coefficients used in the post-development model. It should be noted that these values are conservative estimates and that the breakdown of lot densities are estimates only and will be confirmed in the UWMP.

Table 10: Post-Development Runoff Coefficients

Land Use	Initial Loss (mm)	Runoff Coefficient (≤5yr ARI)	Runoff Coefficient (>5yr ARI up to 100yr ARI)
Traditional Lots (interconnected Soakwells, no overflow)	10	20%	40%
Compact and Cottage Lots (no Soakwells with Direct Connection)	0	50%	70%
Road Reserve	0	80%	80%
POS	0	10%	10%

The stormwater system is designed to provide sufficient protection to the community. The proposed stormwater management system is presented in Table 11 and Figure 14.

Flow paths for the 1yr, 5yr and 100yr ARI events are shown in Figure 15 and demonstrate areas that are inundated during each event. Similarly, a cross section of the stormwater system is shown with the maximum water levels. The system allows for minimum habitable floor levels to be at least 0.5m above the proposed top water level in POS.

Table 11: Stormwater Management System

Post-Development Catchments	#1	#2	#3	#4	#5
Detention/Retention					
Type	Swale	Swale	Swale	Basin	Swale
Location	POS	POS	Road Reserve	POS	POS
Base Area	50m²	180m²	1,050m²	270m²	200m²
Invert	29.0mAHD	29.0mAHD	>28.70mAHD	28.0mAHD	>25.50mAHD
Depth to Groundwater	0.5m	0.5m	>0.7m	0.5m	>0.5m
Side Slopes	1:6	1:6	1:1	1:6	1:6
Maximum Depth	0.75m	0.75m	0.30m	0.8m	1.1m
Outflow Location	St Leonards Creek	St Leonards Creek	N/A	Southern POS	Woollcott Avenue Drain
Outlet Type	Rock-Pitched	Rock-Pitched	N/A	375mm Pipe	300mm Pipe
Outlet Invert	29.75mAHD	29.75mAHD	N/A	28.10mAHD	26.0mAHD
1yr ARI					
Bio-Retention Area	45m²	195m²	180m²	270m²	290m²
Location	In Swale	In Swale	In Swale	In Basin	In Swale
5yr ARI					
Flood Rise	0.75m	0.75m	0.18m	0.4m	0.7m
Top Water Level Area	590m²	1,890m²	1,050m²	470m²	1,960m²
Volume	230m³	770m³	190m³	150m³	750m³
Peak Outflow	0.003m³/s	0.013m³/s	N/A	N/A	0.036m³/s

Critical Duration	1hr	1hr	72hr	1hr	6hr
Pre-development Peak Flow	0.015m³/s	0.035m³/s	N/A	N/A	0.040m³/s
100yr ARI					
Flood Rise	0.75m	0.75m	0.18m	0.8m	0.90m
Top Water Level Area	590m²	1,890m²	1,050m²	740m²	2,490m²
Volume	230m³	770m³	315m³	385m³	1,200m³
Peak Outflow	0.029m³/s	0.091m³/s	N/A	N/A	0.094m³/s
Critical Duration	1hr	1hr	72hr	1hr	6hr
Pre-development Peak Flow	0.041m³/s	0.087m³/s	N/A	N/A	0.094m³/s

The proposed stormwater system design is conceptual only. The UWMP will provide the final configuration that may be modified following a review of additional earthwork and road design levels. Associated landscaping and engineering drawings will also be included in the UWMP.

5.2.3 St Leonards Creek

As discussed in Section 3.6, St Leonards Creek flows through the north eastern portion of the Site, conveying water from the Site and stormwater discharge from basins in Lots 349 and 350 (north of the Site). A desktop and field assessment of the creek identified a poorly defined morphology in parts that has been disturbed by previous land uses on the Site. Significant remnant vegetation is limited to immediately adjacent to the creek.

Consistent with the Foreshore Assessment (Section 3.6.3), the defined Foreshore Area is within the proposed POS boundary, offering protection of the creek. A cross section of the proposed St Leonard's Creek concept, developed for the District Structure Plan, is provided in Appendix H (JDA, 2008). Landscaping concepts (including cross sections), consistent with the Foreshore Assessment and developed for the LSP are provided in Appendix C. The proposed foreshore area provides protection of all of the riparian vegetation which includes a large patch of 'Very Good-Excellent' and 'Good' quality vegetation. The revegetation proposed will enhance the creek's ecological values and amenity.

With development of this Site, St Leonards Creek will be rehabilitated and restored to improve ecological and hydrological functions and amenity. The following stormwater and landscaping treatments will be undertaken:

- Maintain the hydraulic performance of the existing creek by retaining the channel invert and slope (where the riparian vegetation has been determined to be in very good condition);
- Installation of swales to provide attenuation of flows to pre-development rates;

- Bio-retention areas within swales planted with local native riparian species to provide water quality treatment, habitat and refuge;
- Selective planting of native vegetation within degraded areas of the Foreshore Area and POS;
- Protect existing flora and fauna by removing weeds, preventing uncontrolled access by people, traffic and bikes, remove rubbish and increase community access and appreciation of St Leonards Creek;
- Retention of riparian vegetation (very good condition) to assist in secondary nutrient stripping, erosion prevention and maintenance of habitats; and,
- Key design criteria of the landscape design will be for it to continue and operate in perpetuity.

Further details on the creek, including detailed cross-sections, profiles, engineering drawings and landscaping plans will be provided in the UWMP.

5.3 Groundwater Management

Based on the groundwater monitoring data and analysis (Section 3.5.2) there is shallow groundwater across the Site, with maximum levels at or near the surface (Figure 6). To ensure there is adequate separation to the groundwater, fill will be imported. A minimum of 1.5m of clearance above the maximum groundwater level will be provided. Preliminary cut and fill depths are provided in Appendix I and demonstrate that the majority of Site will have between 1.5m and 3m of fill imported.

Where fill is required, it will be clean sand that has less than 2% of organic matter and a fines content of less than 5% (Galt, 2015). Site material may be reused as inert structural fill however this will be subject to further geotechnical testing. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of the earthwork design.

Subsoils will not be installed owing to the importation of fill outlined above. As detailed earthwork designs proceed, subsoils may be considered. Details of the subsoils will be provided in an addendum to the LWMS, and outline a groundwater plan with free-draining outlets and water quality treatment for outflows (DoW, 2013b).

The ASS mapping, outlined in Section 3.8.5, demonstrates that there are some areas with a medium to high of risk of ASS. If dewatering activities associated with excavation are required during construction a dewatering management plan will be prepared. This plan will be informed by a further detailed investigation of ASS and additional groundwater monitoring.

5.4 Protection of Receiving Environments

The receiving environments are St Leonards Creek and ultimately the Swan River downstream of the Site. Protection of these environments involves managing the post-development use of nutrients and the export of pollutants off site. A treatment train approach, including the use of structural and non-structural controls, will be implemented to achieve this protection.

5.4.1 Water Quality

Non-structural controls are an essential part of the treatment train process as they contribute to the reduction stormwater volumes and pollutants. They differ from structural controls as they are not fixed, permanent infrastructure and can offer relatively inexpensive and flexible approaches (DoW, 2004-2007).

For this Site, the following non-structural controls will be implemented:

- Planning: wetland buffers, residential lot density
- Construction: erosion and dust control
- Maintenance: street sweeping, stormwater infrastructure maintenance
- Education: WSUD community education
- Monitoring: pre-development and post-development

Implementation of these non-structural controls occurs during various stages of development. Key aspects of these measures that will contribute significantly to the reduction of post-development nutrient application are the higher lot densities (R40 and R60) that will reduce areas available for domestic gardens and a review of post-development monitoring results to determine any additional measures that are required. Construction management practices are discussed further in Section 6.2.

Structural controls for the Site will be implemented to retain and infiltrate the frequent (up to 1yr 1hr) events close to source throughout the catchment. On the larger lots (R20 and R25), soakwells will be installed to retain runoff from impervious areas, such as driveways, paving and the roof. Pipeless drainage systems, such as median and roadside swales will be implemented where possible. Throughout the pipe drainage system for the road network, soakage pits will be installed to promote infiltration.

Runoff from frequent events from the cottage lots and road reserves will be directed towards a bio-retention areas located within the POS. The bio-retention will feature filter media designed to remove nutrients and suspended soils. Final design including landscaping plans will be provided in the UWMP. The current area (0.01ha) is indicative only, and will be dependent on the final lot density and configuration.

These methods are based on the Stormwater Management Manual of Western Australia (DoW, 2004-2007). Specific targets for improvement in water quality will be detailed in the UWMP.

5.4.2 Wetland Management

There are no Conservation Category Wetlands within the Site. The nearest Resource Enhancement Wetland (REW) is to the west. No drainage from the Site will be directed towards this REW.

6 Implementation Strategy

The success of the water management strategies relies heavily on their implementation throughout all stages of development including further planning, construction and post-development.

6.1 Subdivision Phase

Following approval of the LSP, a Subdivision Application will be submitted. In support of this application, an Urban Water Management Plan will be prepared.

6.1.1 Urban Water Management Plan

The UWMP will document the final water management plans for this Site. It will include a summary of the Site conditions in a number of plans; environmental, geotechnical, surface water, groundwater and Site condition plans.

A key focus of the UWMP will be to provide detail of the final stormwater system design, including engineering drawings of infrastructure, details of control point inverts, and the locations and clearance to groundwater. Further information that is obtained from any additional monitoring and details on the final lot density will allow for an analysis of the conceptual designs provided in the LWMS.

The following information will also be provided in the UWMP:

- Details on the piped road drainage network provided in engineering drawings.
- Details on any pipeless drainage systems that are implemented.
- Details on the Woollcott Avenue drain upgrade.
- Details on modifications to St Leonard's Creek, including planting and landscaping.
- Further detail of the landscaping design, including POS areas and water requirements, and water use sustainability initiatives.
- Design of the bio-retention system and non-structural controls.
- Measures to manage construction works to prevent acid sulphate soil issues, erosion or dewatering impacts.
- Details of the water safety audit of swales within the POS.

6.2 Construction Phase

Water management during the construction phase of the protection requires consideration of direct impacts from construction activities and maintaining pre-development hydrological performance prior to completion of the post-development stormwater system.

6.2.1 Abstraction Licensing

Water will be required for construction activities such as dust suppression. A temporary water licence, as discussed in Section 4.1, has been approved for establishment of vegetation. Abstractions will be carried out in accordance to conditions of this licence.

A licence application for dewatering will be prepared as required. Owing the risk of ASS across the Site, this may be supported by a Dewatering Management Plan to ensure risks are mitigated.

6.2.2 Management of Subdivisional Works

Potential impacts from construction activities related to the water cycle include:

- Nuisance dust generation during bulk earthworks
- Erosion of exposed surfaces
- Inappropriate disposal of waste building material

All of these potential impacts are manageable through appropriate engineering design and appropriate site management practices. Contractors and staff will be notified of the requirement to implement management practices to limit any potential impacts resulting from construction activities.

Timing of the construction activities will be dependent on a number of factors not related to water management. Where possible, the construction schedule should allow for work to be undertaken when impacts on the water cycle will be minimised. For example, excavation work is appropriate between January and April when groundwater levels are at a minimum, and works within St Leonards Creek should be undertaken in summer.

6.2.3 Monitoring Program

Groundwater monitoring on the Site is not required during the construction phase of development as information that will inform design has previously be collected and the performance of post-development designs are not able to be assessed. Monitoring during this phase will be limited to ensuring construction practices are not impacting on the receiving environments. Details will be provided in the UWMP, but may include visual inspections or short-term detailed water sampling (DoW, 2012).

The UWMP will also provide contingency measures for any breaches identified from the monitoring program.

6.3 Post Development

Following the completion of construction activities, maintenance of the stormwater system and assessment of the system performance will be required to determine whether additional water management measures are required.

8.3.1 Maintenance

Operation and maintenance of the stormwater management system will initially be the responsibility of the developer, until handover of the development to the City of Swan. The following measures will be undertaken to ensure the system functions correctly:

- Removal of debris to prevent blockages
- Street sweeping to reduce particulate build up on road surfaces
- Cleaning of sediment build up and litter layer from the bio retention systems
- Assessment of the health of vegetation in bio-retention and modified areas and removal and replacement of dead plants where necessary.

8.3.2 Monitoring Program

Post-development monitoring is required to demonstrate that the final stormwater management system is capable of the performance outlined in the UWMP (DoW, 2012). For this Site, post-development monitoring of groundwater levels and quality will be performed over a period of five years (reviewed after three years). The program for post-development monitoring is outlined in Table 12.

Table 12: Post Development Monitoring Program

Monitoring Type	Parameter	Location	Method	Frequency & Timing
Groundwater Level	Water Level (mAHD)	1 bore within northern and southern POS	Electrical depth probe or similar	One summer and two winter readings per year
Groundwater Quality	pH, EC, Nitrogen, Phosphorus	1 bore within northern and southern POS	Pumped bore sample	One summer and one winter sample per year
Surface Water Quality	pH, EC, TSS, Nitrogen, Phosphorus	From the St Leonards Creek upstream and downstream of the Site	Grab sample	Minimum of two samples per year, likely during winter months

Proposed post-development groundwater bore locations are shown in Figure 16.

Trigger values are required to provide a post development comparison and assess the structural performance of the stormwater management system. These are reflective of the existing water quality at the Site and are outlined in Table 13. A breach is considered to occur when post-development monitoring records a value that exceeds the pre-development values.

Table 13: Groundwater Quality Trigger Values

Physiochemical Parameter	Monitoring Range	Trigger Value	ANZECC Guideline Values*	Healthy Rivers Action Plan	
				Short Term	Long Term
EC (mS/cm)	0.44	0.44	0.12 – 0.30	-	-
pH	5.9	5.9	6.5 – 8.0	-	-
Total N (mg/L)	0.7 – 4.6	2.65	1.2	2.0	1.0
TKN (mg/L)	0.6 – 2.6	1.60		-	-
NOx-N (mg/L)	0.06 – 2.0	1.03	-	-	-
Total P (mg/L)	0.03 – 0.26	0.15	0.065	0.2	0.1
FRP (mg/L)	0.02 – 0.26	0.14	0.04	-	-

South-West Australia.

Contingency measures for any breaches identified from the post development monitoring program are outlined in Table 14. There will be implemented should re-sampling confirm a breach has occurred.

Table 14: Contingency Measures

Monitoring Type	Criteria for Assessment	Contingency Action
Groundwater Quality	Nutrient concentration in bores to be improved compared to targets established by pre-development monitoring.	1. Identify and remove any point source 2. Review operational and maintenance (e.g. fertiliser) practises 3. Consider alterations to bio-retention areas, landscaping regimes and soil amendment 4. Consider alterations to the stormwater management system 5. Consider initiation of community based projects

The final post development monitoring program and contingency implementation plan will be provided in further detail in the UWMP.

6.4 Roles and Responsibilities

Table 15 details the roles and responsibilities for water management during the subdivision and construction phase of the development and post-development.

Table 15: Roles and Responsibilities

Action	Developer	City of Swan / DoW
Preparation of UWMP	✓	
Assessment / Approval of the UWMP		✓
Design of Stormwater System	✓	
Construction of Stormwater System	✓	
Construction Phase Monitoring	✓	
Maintenance Prior to Handover	✓	
Post-Development Monitoring	✓	
Maintenance Following Handover		✓

7 Conclusion

The key management strategies from the LWMS, discussed in detail in Sections 4 to 6 are summarised in Table 16.

Table 16: Key Management Features

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management)	
Integration of water and land use planning Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Ensure stormwater management is part of total water cycle management Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions Integrate Stormwater Treatment into the landscape Add value while minimising development costs	
Category	**Key Management Features**
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	A temporary licence application to establish vegetation has been approved. Households will adhere to WC waterwise home guidelines. Local, native waterwise plants used in landscaping (no turf installed).
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Existing flow paths and catchments will be maintained. Frequent events (≤1yr ARI) will be infiltrated within larger lots through the use of soakwells. Runoff from roads and smaller lots will drain to bio-retention areas and infiltrate in pits. Major events (up to 100yr ARI) will be attenuated in the POS before discharging to St Leonards Creek and Woollcott Avenue Drain at near pre-development rates.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water logging.	Where required by local conditions or engineering design, fill will be imported to provide 1.5m of clearance to MGL. The use of subsoils is not anticipated. Any fill will be free draining, cohesionless, well graded sand. The groundwater management strategy will be reviewed in the UWMP with additional monitoring data.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	A treatment train approach to water quality improvement is adopted. Higher density lots (compact and cottage lots) reduce the garden areas and nutrient application. Bio-retention systems will provide treatment to frequent events.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	The treatment train approach (above) will provide water quality improvement measures for water discharged to the downstream Swan River System.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Detailed ASS investigations will be required for excavation works. The habitable floor level will be 0.5m above the 100yr ARI flood level.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	St Leonards Creek will be rehabilitated and restored to provide ecological and hydraulic functions. Vegetation will be retained for the Creek where possible.
Further Planning To ensure delivery of best practice stormwater management through planning.	The UWMP will document the final stormwater management strategy incorporating any additional monitoring data or engineering, planning and landscaping requirements.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post-Development To implement stormwater systems that are economically viable in the long term.	A post-development monitoring program will be implemented to demonstrate that the management strategies are capable of the intended purpose.

8 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the Site that is the subject of this report. However, due to the characteristics of the Site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole Site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

9 References

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FIGURES

Legend

Site Location(20.3 ha)

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LOCALITY MAP

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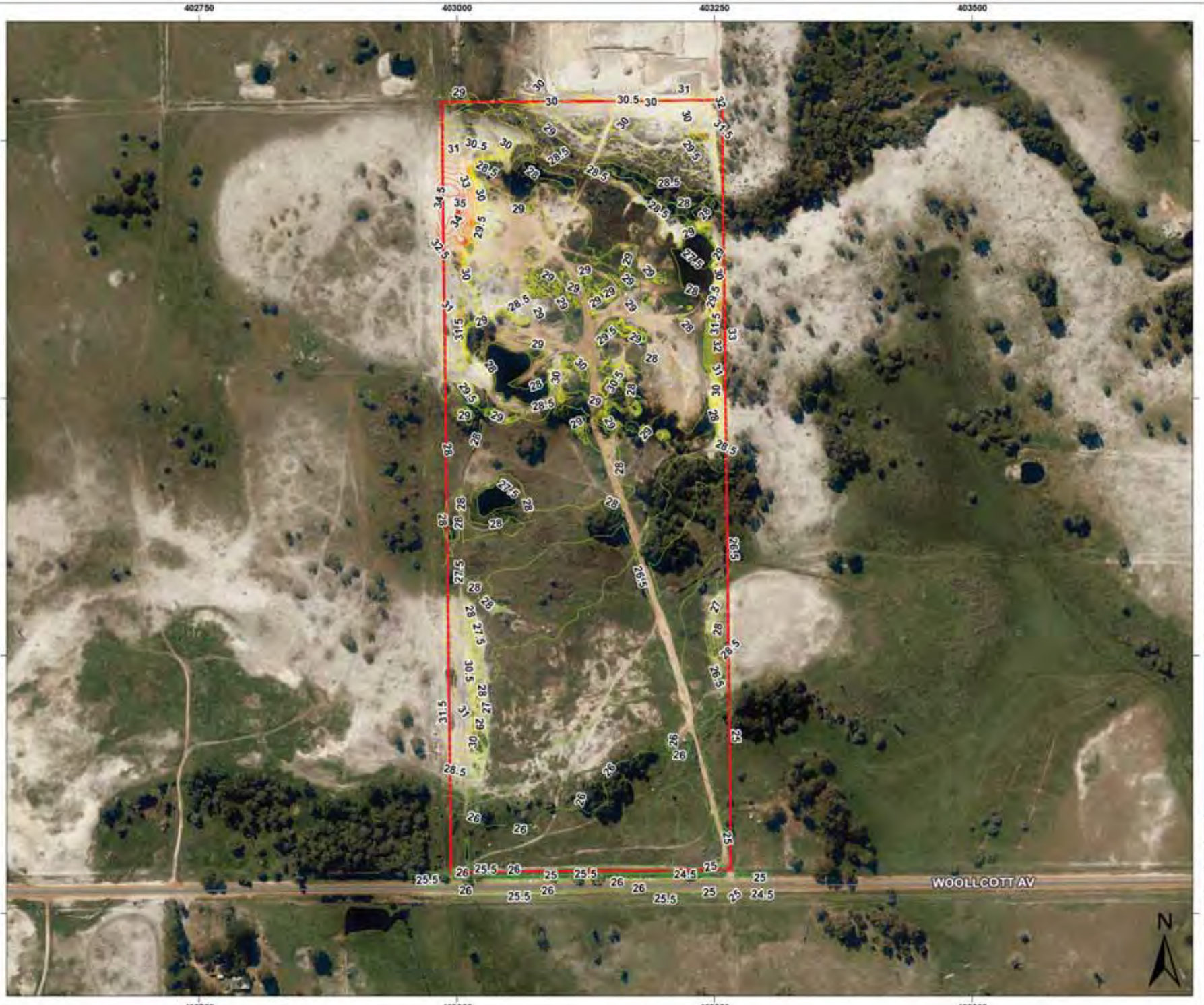
ABN Group
Lot 345, Woolcott Ave, Brabham

Local Water Management Strategy

Figure 1 - Site Location



Legend

Site Location

Elevation Contours (mAHD)

24.5	30.5
25	31
25.5	31.5
26	32
26.5	32.5
27	33
27.5	33.5
28	34
28.5	34.5
29	35
29.5	35.5
30	

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Local Water Management Strategy

Figure 2 -
Topography

Legend

- Site Location
- Pipeline Easement
- Public Open Space
- Residential
- Roads

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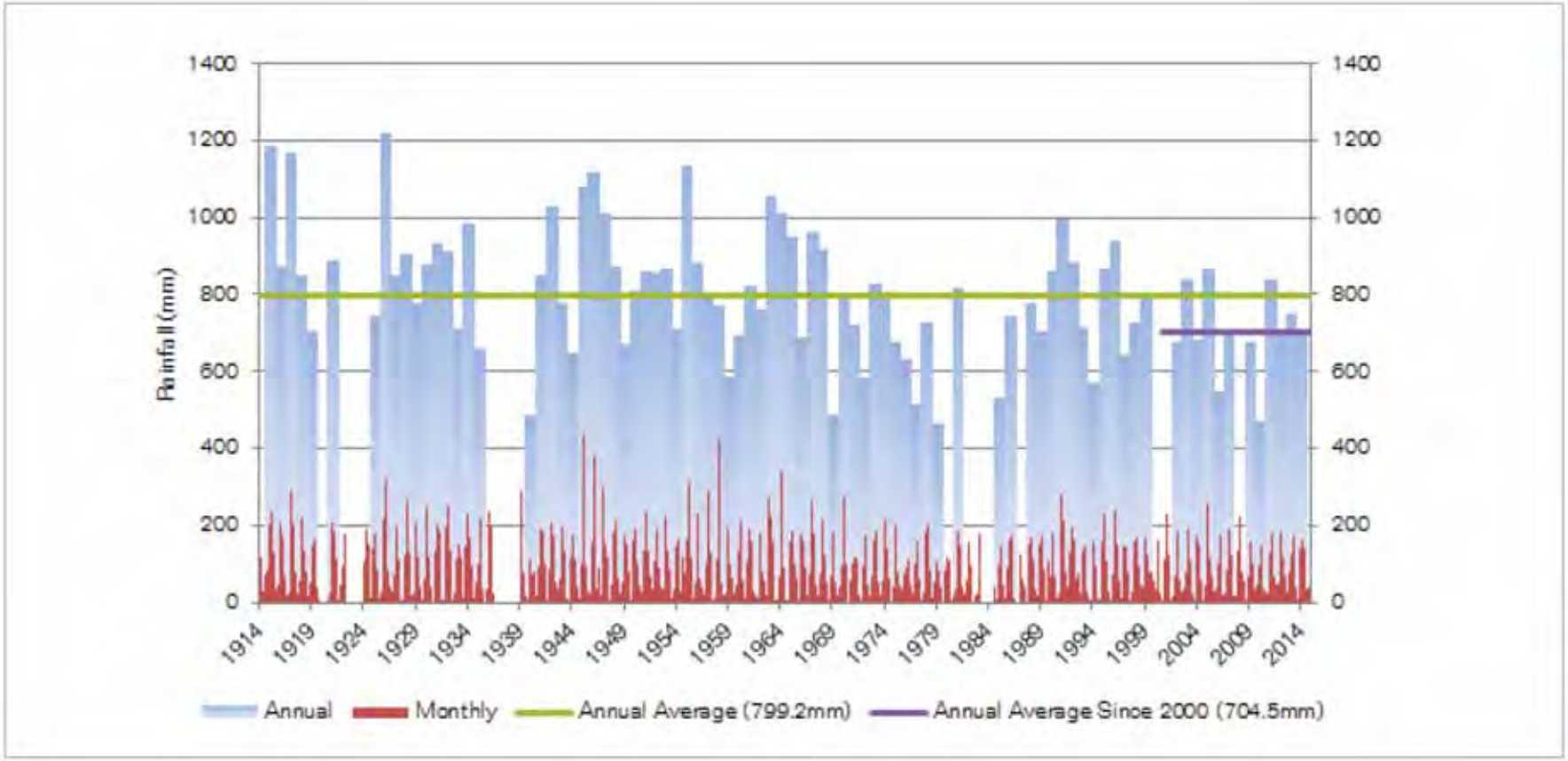
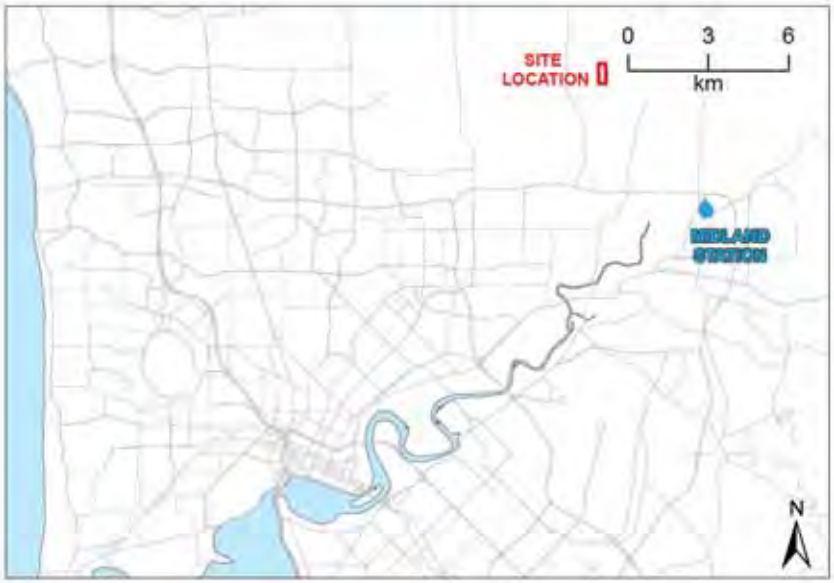
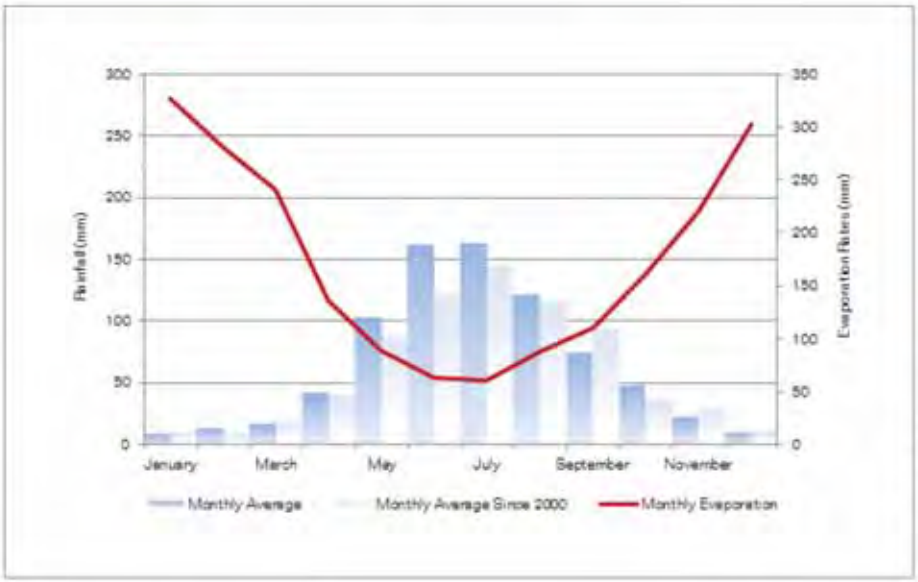
Local Water Management Strategy

Figure 3 -
Structure Plan







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- Site Location
- Weather Stations

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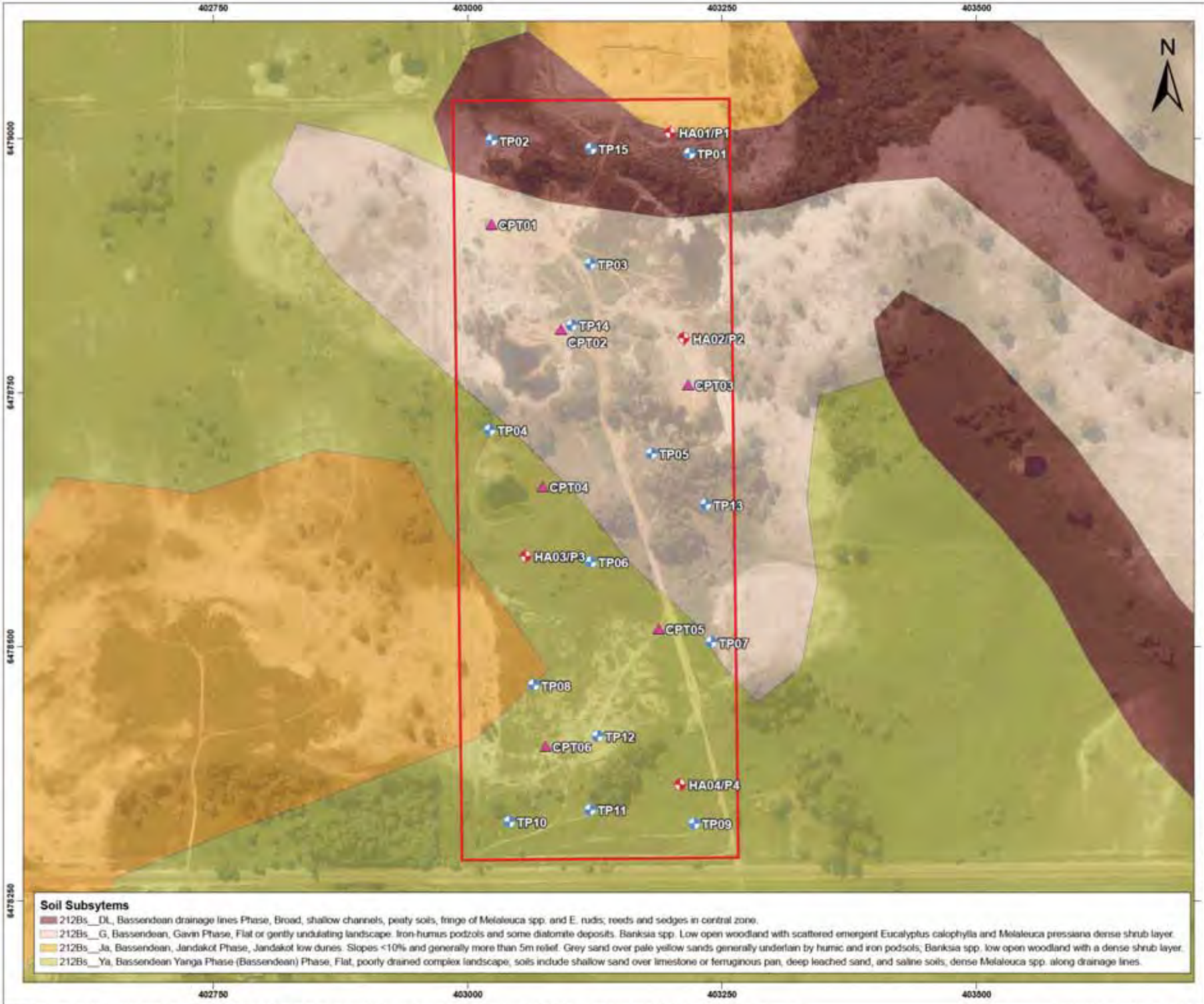
Local Water Management Strategy

Figure 4 - Midland Station Rainfall and Evaporation Data



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- Site Location
- Cone Penetration Test CPT
- Hand Auger Borehole/ Permeability Test
- Test Pit

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Local Water Management Strategy

Figure 5 -
Geotechnical Information

Legend

- Site Location
- MGL (360, Dec 2015)
- AAMGL (JDA, 2008)
- Monitoring Bores AAMGL (360, Dec 2015)

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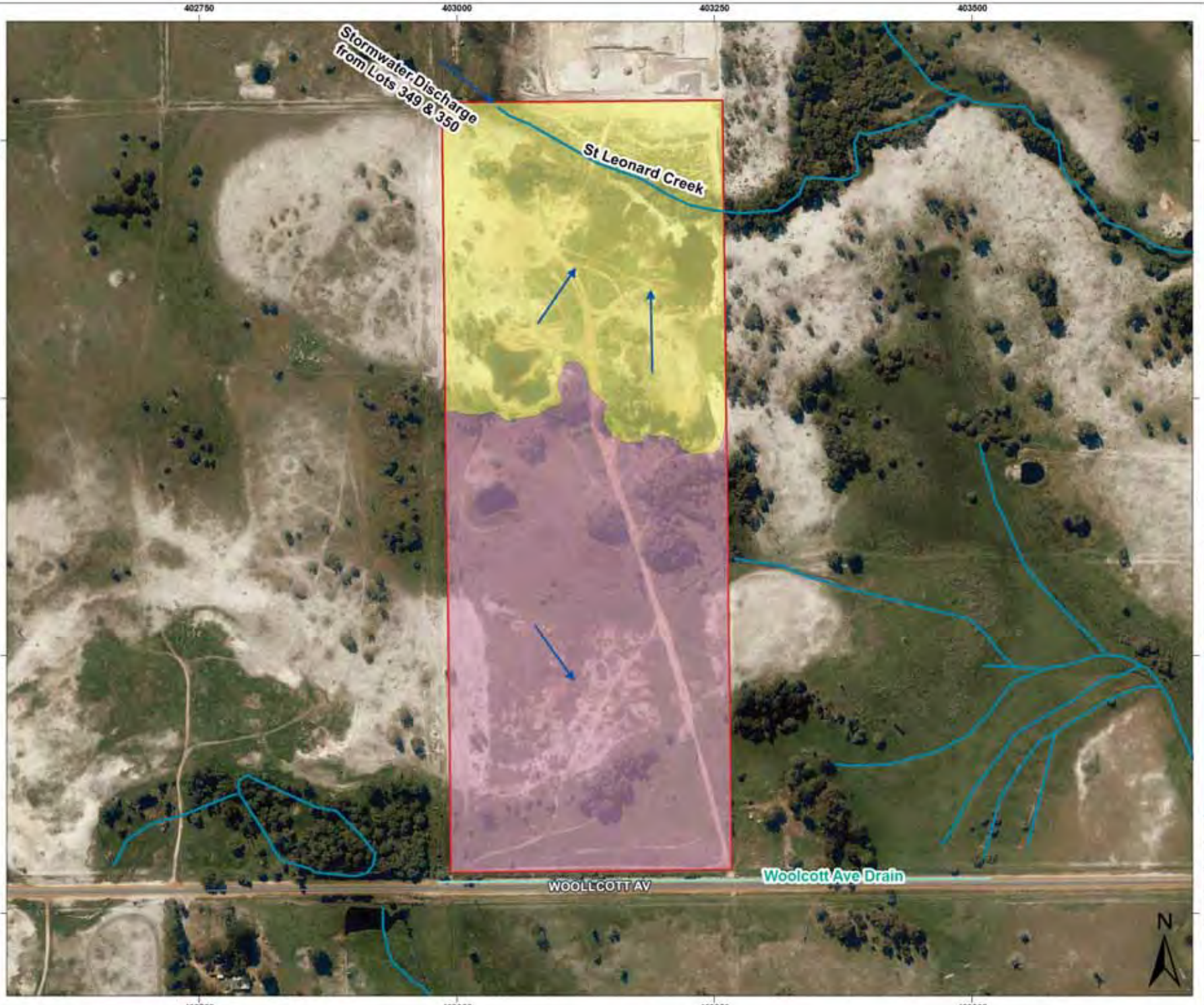
Local Water Management Strategy

Figure 6 - Average Annual Maximum Groundwater Levels



Legend

- Site Location
- Flow Direction
- Watercourse
- Woolcott Ave Drain

Pre-development Catchments

- North Catchment
- South Catchment

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Figure 7 -
Surface Water Drainage

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Legend

- Site Boundary
- Subdivision Plan
- Creek
- Riparian Vegetation Extent (0.567 ha)

Surrounding Vegetation Types

- MpAs (0.125 ha)
- MrMp (0.089 ha)
- MrTo (0.062 ha)
- Pe (0.093 ha)
- XpDbPo (0.245 ha)

Riparian Vegetation Types

- Mp (0.164 ha)
- MpCc (0.403 ha)

- CADASTRAL BOUNDARY SOURCED FROM LANDGATE 2006
- LOCALITY MAP SOURCED FROM LANDGATE 2006
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GDA 1994 MGA Zone 50

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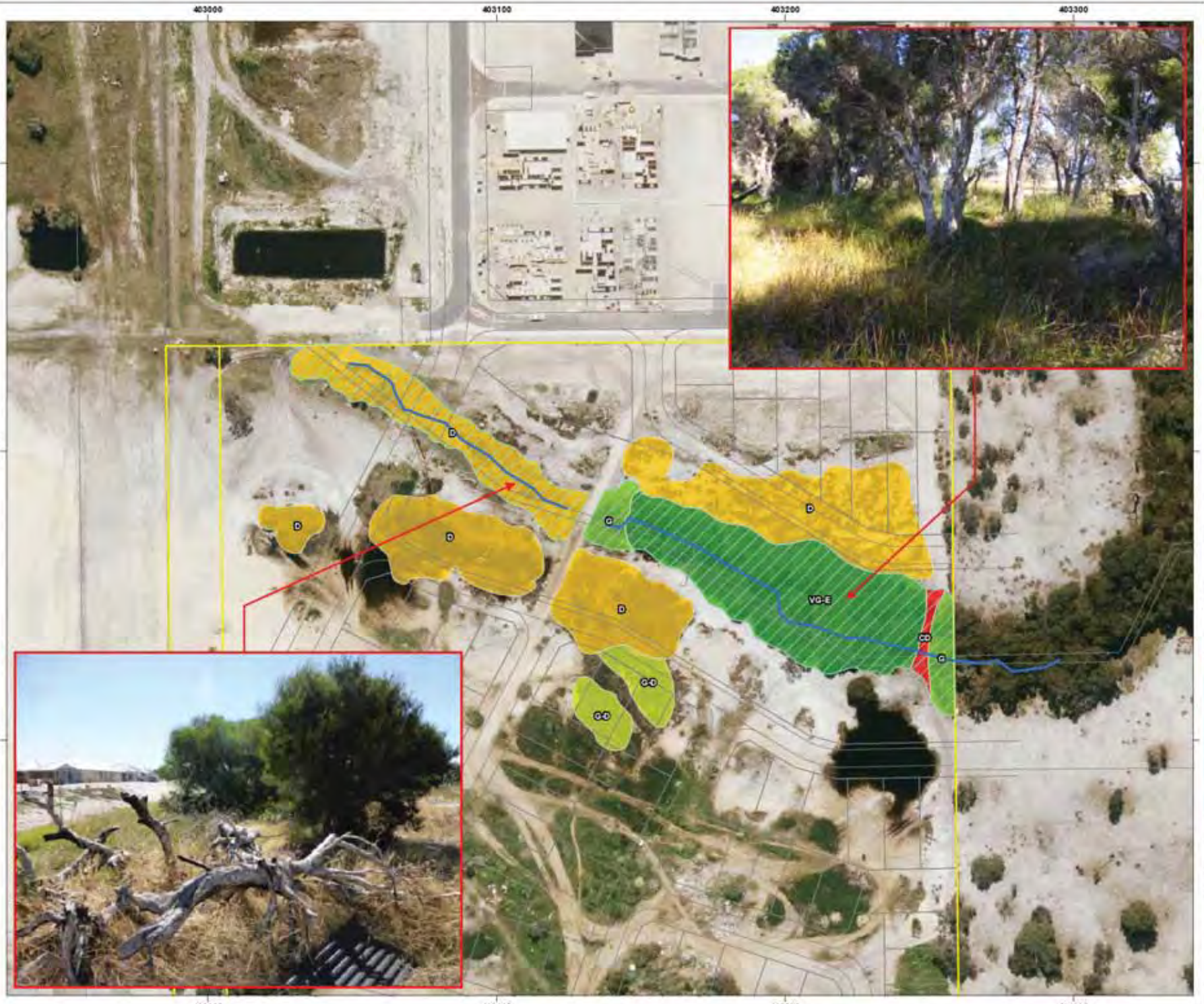
Brabham

Local Water Management Strategy

Figure 8
Vegetation Types



Legend

- Site Boundary
- Subdivision Plan
- Creek
- Riparian Vegetation Extent (0.567 ha)

Vegetation Condition

- **VG-E:** Very Good-Excellent (0.331 ha)
- **G:** Good (0.059 ha)
- **G-D:** Good-Degraded (0.073 ha)
- **D:** Degraded (0.705 ha)
- **CD:** Completely Degraded (0.013 ha)

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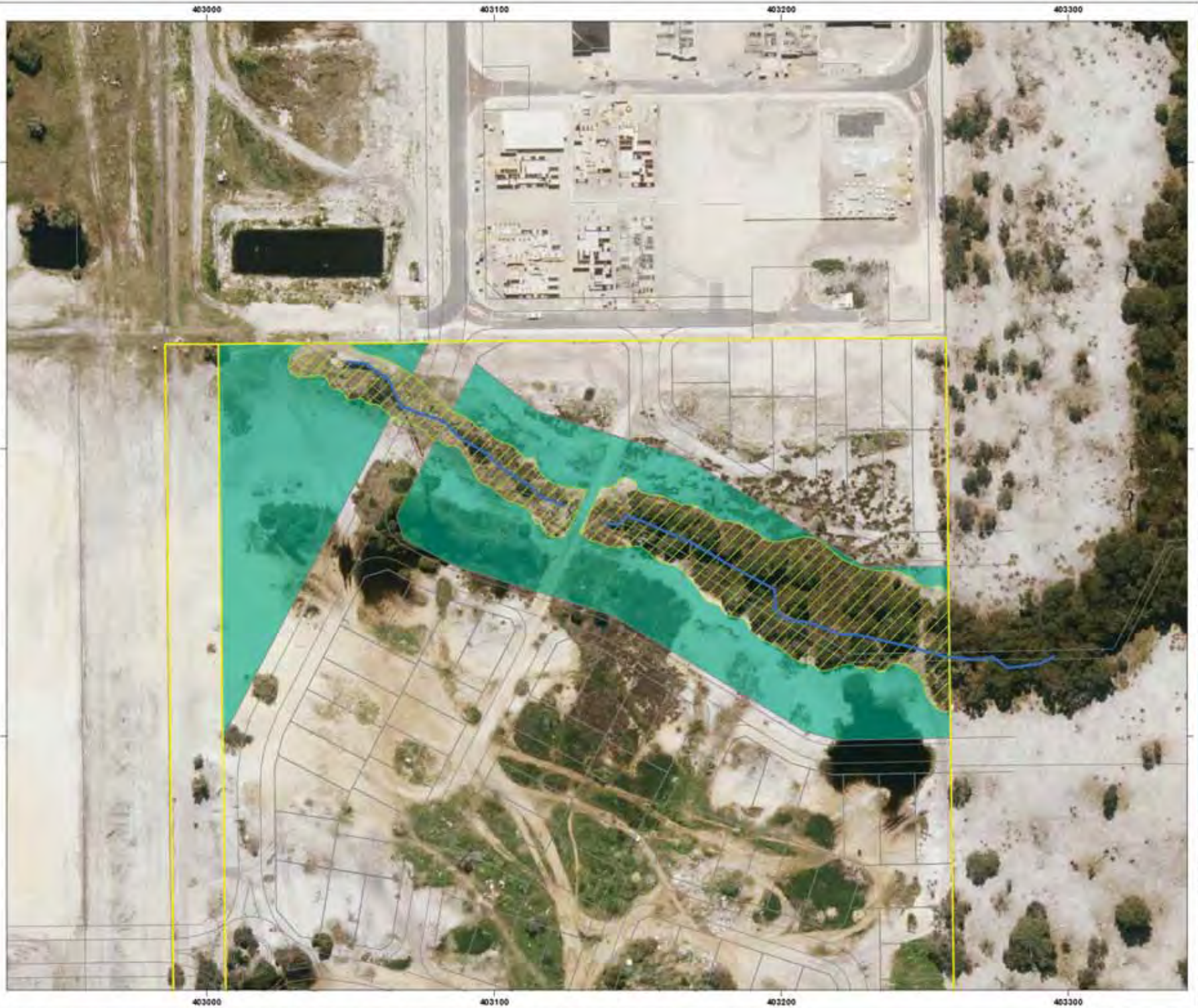
Local Water Management Strategy

Figure 9
Vegetation Condition



Legend

- Site Boundary
- Subdivision Plan
- Creek
- Foreshore Area (0.567 ha)
- POS

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LOCALITY MAP

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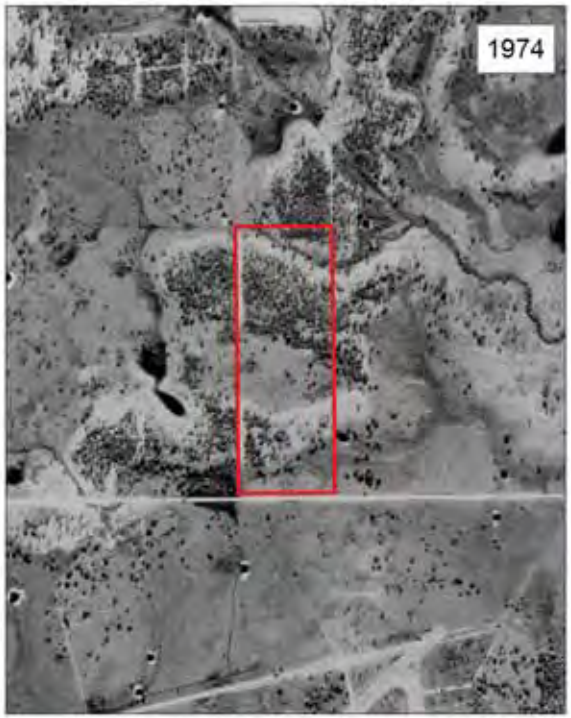
Local Water Management Strategy

Figure 10
Foreshore Area



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Site Location

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Lot 345, Woolcott Ave, Brabham

Local Water Management Strategy

Figure 11 - Historical Imagery

Legend

- Site Location
- Bush Forever Sites

Geomorphic Wetlands

- Resource Enhancement
- Multiple Use

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GDA 1994 MGA Zone 50			
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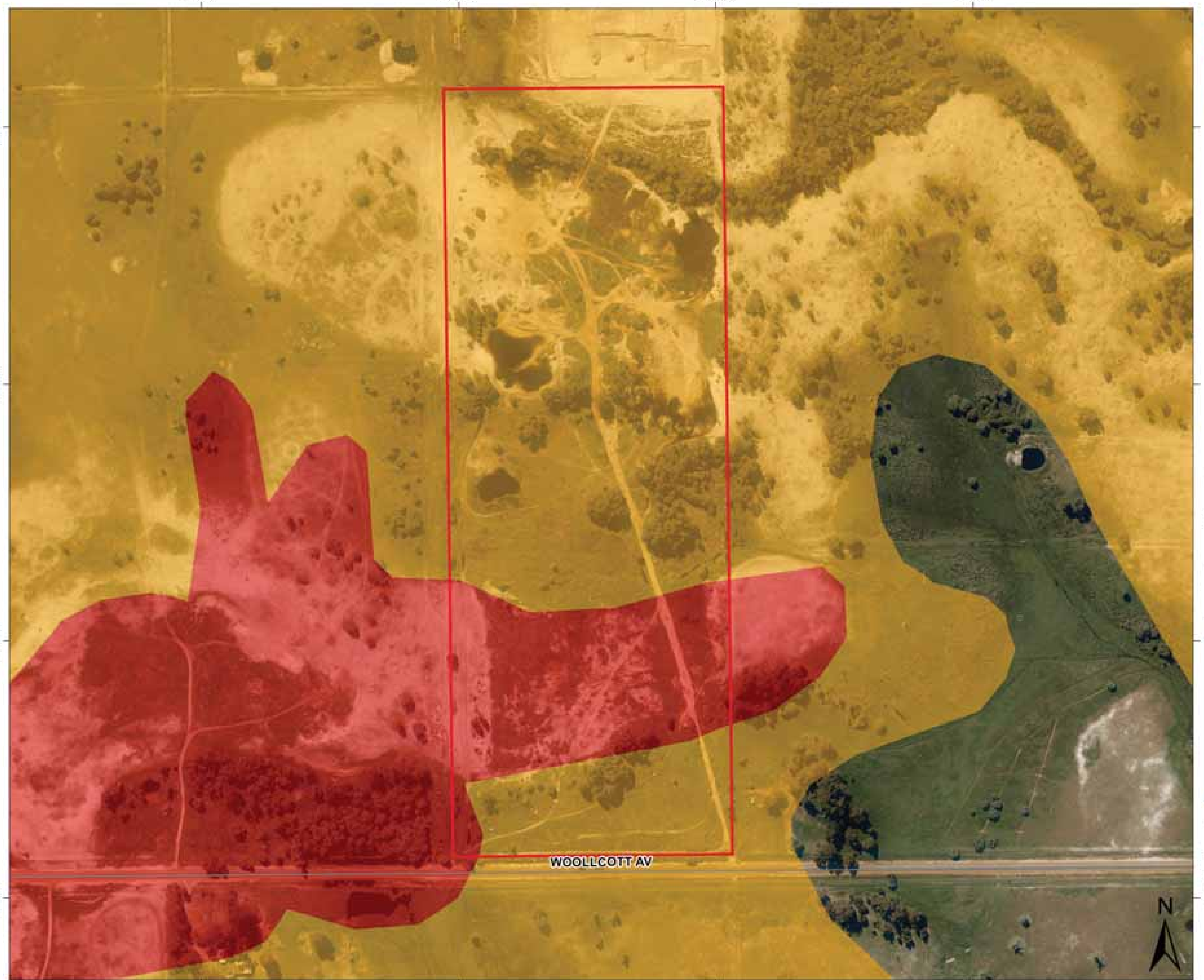
Local Water Management Strategy

Figure 12 -
Environmental Features



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Site Location

Acid Sulfate Soils Disturbance Risk

High to moderate risk

Moderate to low risk

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Local Water Management Strategy

Figure 13 -
Acid Sulfate Soils Risk Mapping

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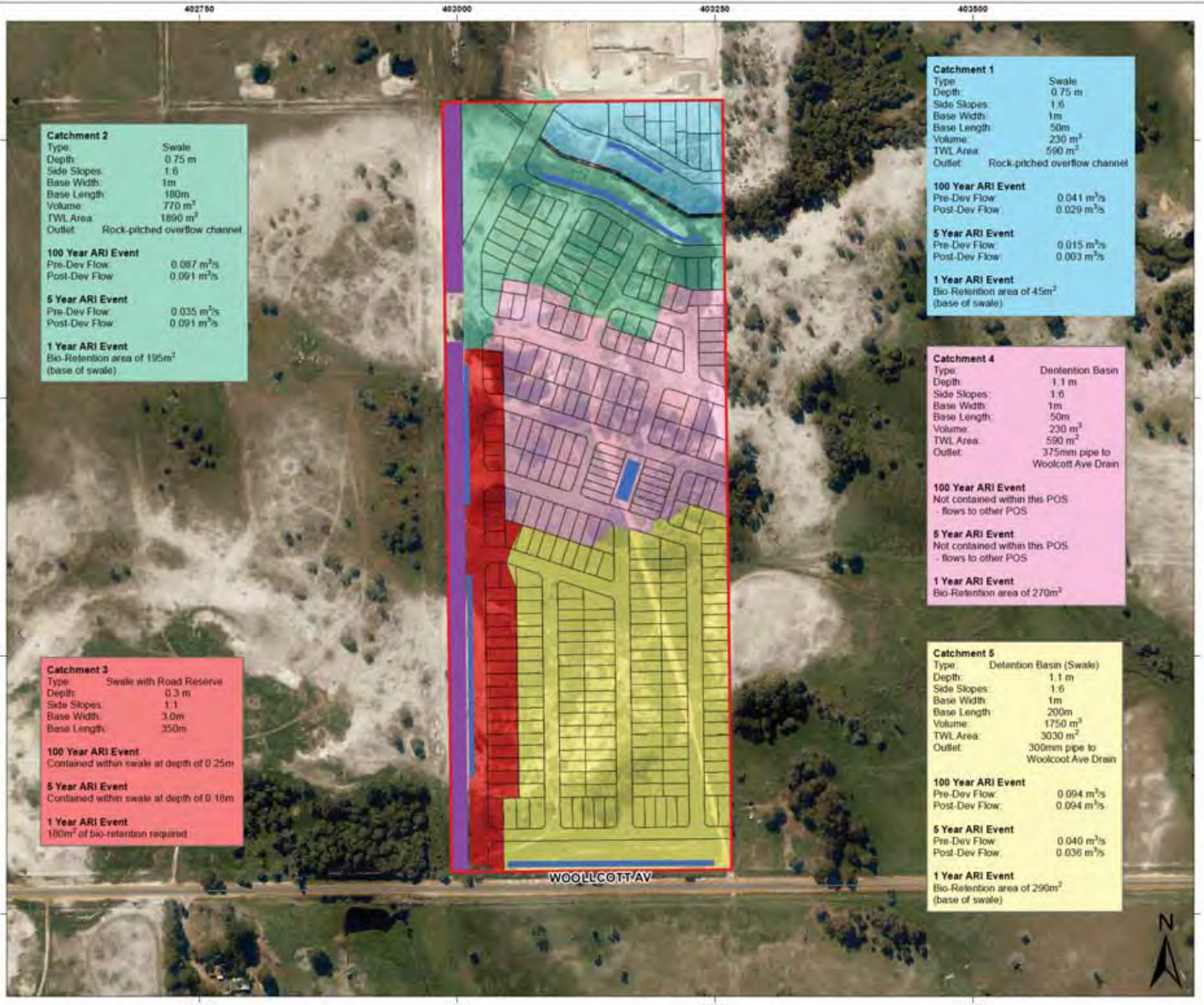

Catchment 2

Type:	Swale
Depth:	0.75 m
Side Slopes:	1:6
Base Width:	1m
Base Length:	180m
Volume:	770 m^3
TWL Area:	1890 m^2
Outlet:	Rock-pitched overflow channel

100 Year ARI Event

Pre-Dev Flow:	0.087 m^3/s
Post-Dev Flow:	0.091 m^3/s

5 Year ARI Event

Pre-Dev Flow:	0.035 m^3/s
Post-Dev Flow:	0.091 m^3/s

1 Year ARI Event
Bio-Retention area of 195m^2
(base of swale)

Catchment 1

Type:	Swale
Depth:	0.75 m
Side Slopes:	1:6
Base Width:	1m
Base Length:	50m
Volume:	230 m^3
TWL Area:	590 m^2
Outlet:	Rock-pitched overflow channel

100 Year ARI Event

Pre-Dev Flow:	0.041 m^3/s
Post-Dev Flow:	0.029 m^3/s

5 Year ARI Event

Pre-Dev Flow:	0.015 m^3/s
Post-Dev Flow:	0.003 m^3/s

1 Year ARI Event
Bio-Retention area of 45m^2
(base of swale)

Catchment 4

Type:	Dentention Basin
Depth:	1.1 m
Side Slopes:	1:6
Base Width:	1m
Base Length:	50m
Volume:	230 m^3
TWL Area:	590 m^2
Outlet:	375mm pipe to Woolcott Ave Drain

100 Year ARI Event
Not contained within this POS
- flows to other POS

5 Year ARI Event
Not contained within this POS
- flows to other POS

1 Year ARI Event
Bio-Retention area of 270m^2

Catchment 3

Type:	Swale with Road Reserve
Depth:	0.3 m
Side Slopes:	1:1
Base Width:	3.0m
Base Length:	350m

100 Year ARI Event
Contained within swale at depth of 0.25m

5 Year ARI Event
Contained within swale at depth of 0.18m

1 Year ARI Event
180m^2 of bio-retention required

Catchment 5

Type:	Detention Basin (Swale)
Depth:	1.1 m
Side Slopes:	1:6
Base Width:	1m
Base Length:	200m
Volume:	1750 m^3
TWL Area:	3030 m^2
Outlet:	300mm pipe to Woolcoot Ave Drain

100 Year ARI Event

Pre-Dev Flow:	0.094 m^3/s
Post-Dev Flow:	0.094 m^3/s

5 Year ARI Event

Pre-Dev Flow:	0.040 m^3/s
Post-Dev Flow:	0.036 m^3/s

1 Year ARI Event
Bio-Retention area of 290m^2
(base of swale)

Legend

- Basin/ Swales
- Site Location
- Site Layout

Catchment

- Catchment 1
- Catchment 2
- Catchment 3
- Catchment 4
- Catchment 5
- Pipeline Easement

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- PROPOSED STRUCTURE PLAN SOURCED CLE 2015
- AERIAL PHOTOGRAPHY SOURCED LANDGATE NOV 2014
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f (08) 9381 2360
w www.360environmental.com.au

0 50 100 150 200
Meters
1:3,500 @ A3

LOCALITY MAP

PROJECT ID	DATE
1062	4/05/2016

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
CS	AN	RP	1

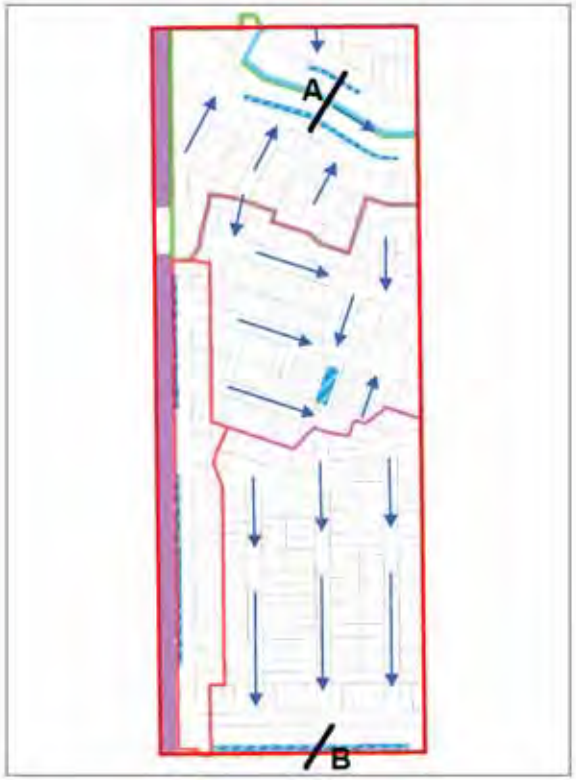
ABN Group
Lot 345, Woolcott Ave, Brabham

Local Water Management Strategy

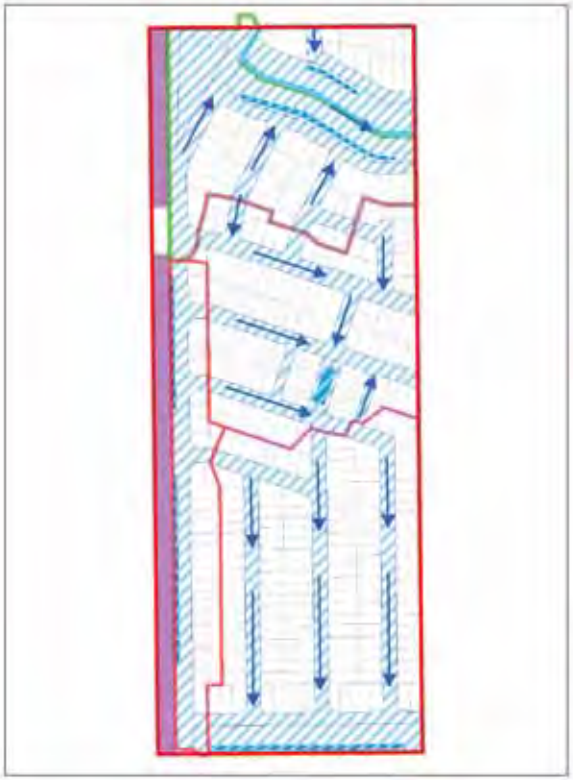
Figure 14 -
Conceptual Stormwater System

1 Year ARI Event Plan

5 Year ARI Event Plan



100 Year ARI Event Plan



Legend

- Site Location
- Proposed Site Layout
- Pipeline Easement
- Inundation Events
- Basin/ Swales
- Catchment 1
- Catchment 2
- Catchment 3
- Catchment 4
- Catchment 5
- Flow Direction

N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED FROM LANDGATE 2006
- CLIENT DATA SITE LAYOUT 2014
- AERIAL PHOTOGRAPHY SOURCED FROM LANDGATE 2013
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0 75 150 225 300
Meters
1:5,500 @ A3

LOCALITY MAP

PROJECT ID	DATE
1062	4/05/2016

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

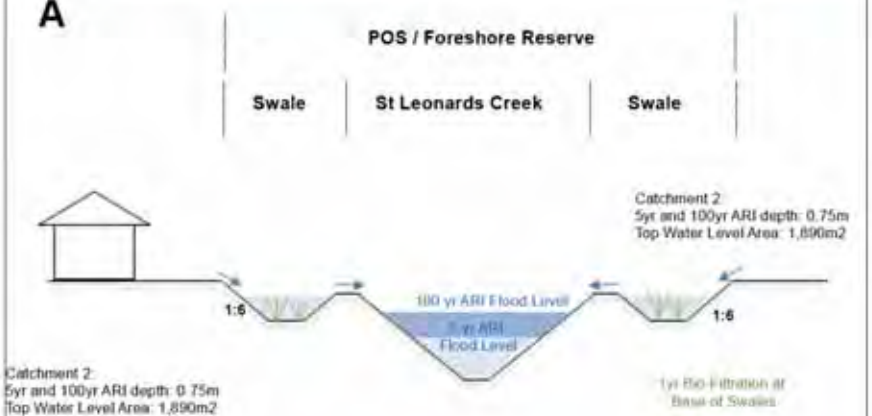
CREATED	CHECKED	APPROVED	REVISION
CS	AN	RP	1

ABN Group
Lot 345, Woolcott Ave, Brabham

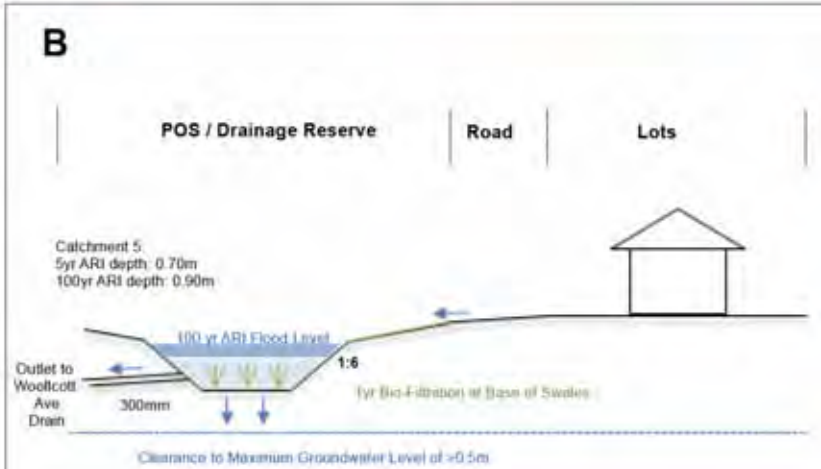
Local Water Management Strategy

Figure 15 - 1 year, 5 year and 100 year ARI Event Plans

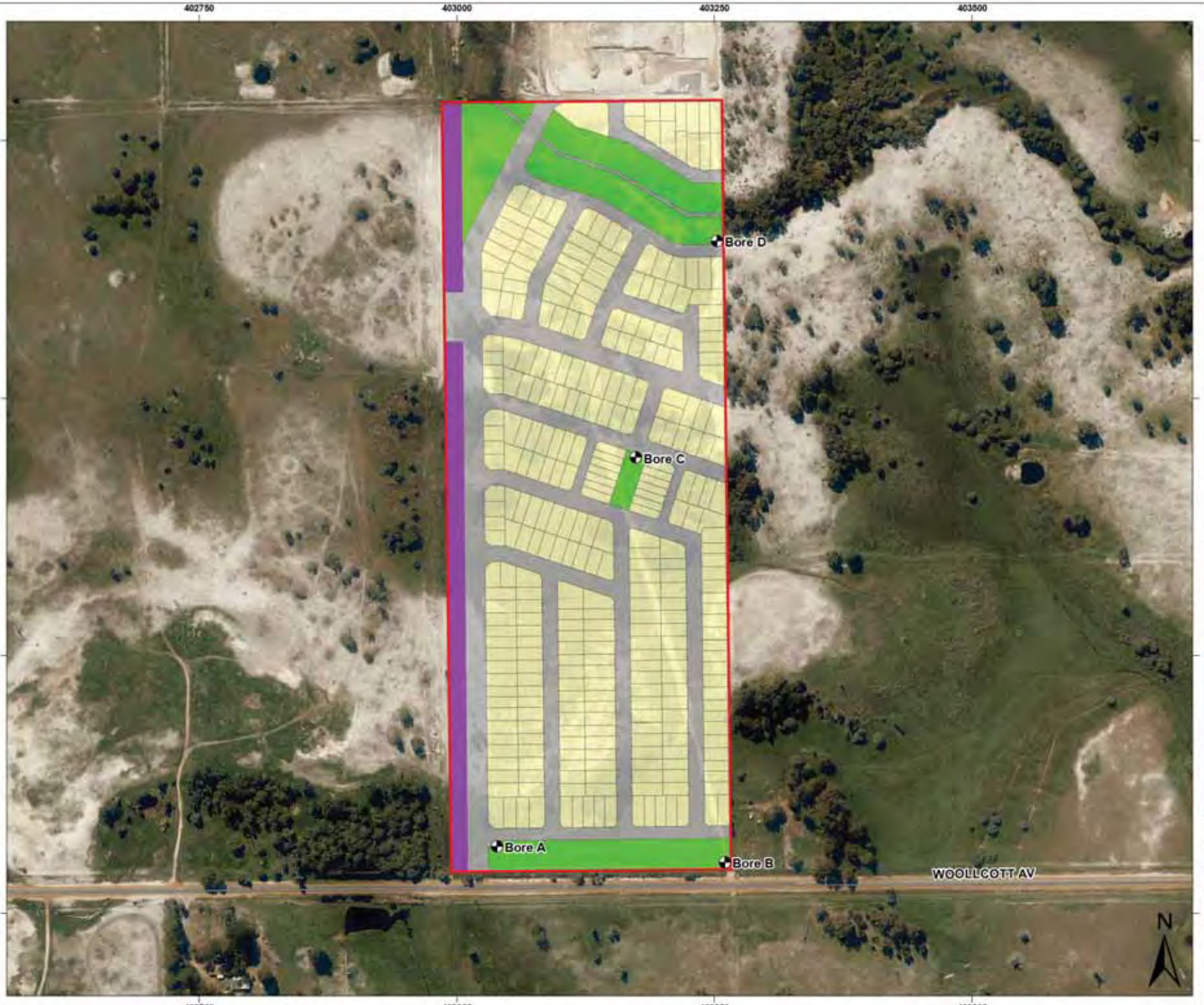
A



B



Further Information Available In Landscaping Plans (Appendix C)



Legend

- Site Location

Proposed Structure Plan

- Public Open Space
- Residential
- Roads
- Bores

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE 2006
- PROPOSED STRUCTURE PLAN SOURCED CLE 2015
- AERIAL PHOTOGRAPHY SOURCED LANDGATE NOV 2014
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0 50 100 150 200
Meters
1:3,500 @ A3

LOCALITY MAP

PROJECT ID	DATE
1062	1/03/2016

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
CS	AN	RP	1

ABN Group
Lot 345, Woolcott Ave, Brabham

Local Water Management Strategy

Figure 16 - Post Development Monitoring Locations

APPENDIX A: LOCAL WATER MANAGEMENT STRATEGY CHECKLIST

Better Urban Water Management (WAPC, 2008)

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
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 BMP's and critical control points	Executive Summary	The executive summary is a table of the key points of the proposed Local Water Management Strategy	☐	
Introduction					
Total water cycle management – principles & objectives Planning background Previous Studies		Section 1.1, 1.2 and Table 1	A summary of the guiding documents and design principles are outlined. Specific objectives for the site are summarised in Table 1.	☐	
Proposed Development					
Structure plan, zoning and land use. Key landscape features Previous land Use	Site context plan Structure Plan	Section 2, App A, App B, Figure 3, Figure 8	The proposed LSP is provided in Appendix B with lot, road and POS layouts shown in Figure 3. Historical aerial photos are presented in Figure 8.	☐ ☐	
Landscape- proposed POS areas, POS credits, water source, bore(s),	Landscape Plan	Appendix B	POS areas and vegetation types are presented in the	☐	

lake details (if applicable), irrigation areas.			Landscape Plan.		
Design Criteria					
Agreed design objectives and source of objective		Section 1, Table 1	Site specific design objectives and criteria are summarised in Table 1.	☐	
Pre-development environment					
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 3, Table 6	This is presented in Section 3, and key site considerations are summarised in Table 8	☐	
Site conditions – existing topography. Contours, aerial photo underlay, major physical features	Site condition plan	Section 3.2, Section 3.8.1, Figure 2	A pre-development aerial photo is shown in Figure 2. Existing land use is discussed in Section 3.8.1.	☐	
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations	Geotechnical Plan	Section 3.4, Section 3.8.5, Figure 5, Figure 13	The geotechnical investigation is summarised in Section 3.4. ASS is discussed in Section 3.8.5.	☐	
Environmental – areas of significant flora and fauna, werlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	Section 3.8, Figure 12	Figure 9 demonstrates the wetland locations. Other environmental factors are discussed in Section 3.8	☐	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 3.6, Figure 7	The location of the Peel Sub Drain system is shown in Figure 7. Section 3.6 described the surface water features.	☐	

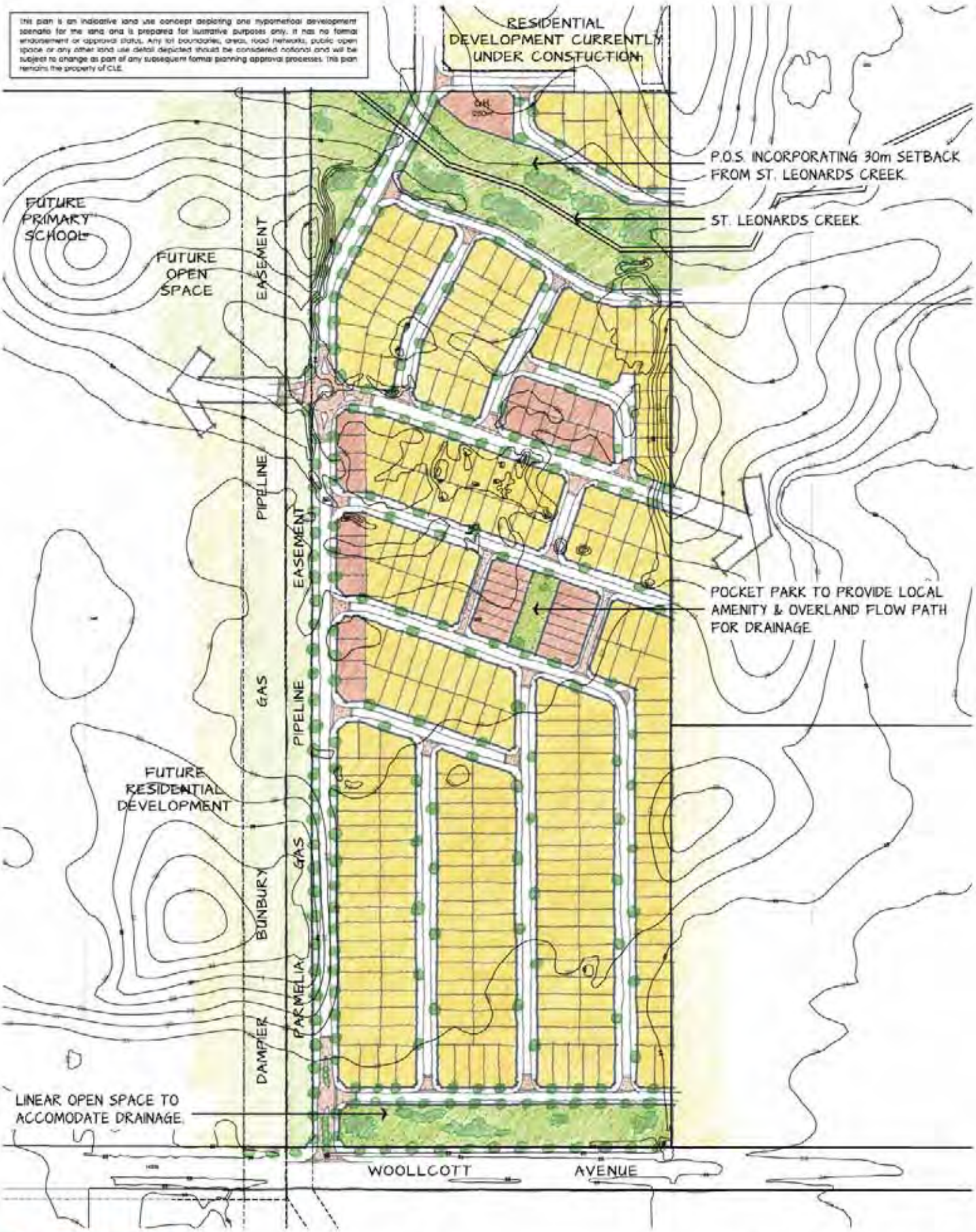
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Section 3.5, Figure 6	Groundwater monitoring results are discussed in Section 3.5. Water levels are presented in Figure 6.	☐	
Water use sustainability initiatives					
Water efficiency measures – private and public open spaces including method of enforcement		Section 4.2	Section 4.2 outlines water conservation measures.	☐	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 4.1	Water supply options are discussed in Section 4.1.	☐	
Wastewater management		Section 4.3	Section 4.3 provides the wastewater management strategy.	☐	
Stormwater management strategy					
Flood protection – peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100 year event Plan Long section of critical points	Section 5.1, Section 5.2.2, Figure 14, Figure 15, Table 9	The management strategies for the 100yr ARI event are discussed in Section 5.2.2. Table 9, Figures 14 and Figures 15 provide the control points and levels.	☐	
Manage serviceability – storage and retention for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	10yr event Plan	Section 5.1, Section 5.2.2, Figure 14, Figure 15, Table 8	The 5yr event plan is provided in Figure 15. Table 9 outlines volumes and levels. Section 5.2.2 discusses serviceability.	☐	

Protect ecology – detention areas for the 1 yr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event Plan Typical cross sections	Section 5.1, Section 5.2.1, Section 5.4, Figure 14, Figure 15	Section 5.1 and 5.2.1 outline the stormwater management strategy for the 1yr ARI event. Measures to protect receiving environments are discussed in Section 5.4.	☐	
Groundwater management strategy					
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	Section 5.3	Section 5.3 provides the management plans for groundwater.	☐	
Actions to address acid sulphate soils or contamination		Section 5.3, Section 6.2.1	The measures to mitigate ASS risk are provided in Section 5.3 and Section 6.2.1.	☐	
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 prior to detailed design		Section 6.1	The requirements for the UWMP are outlined in Section 6.1.	☐	
Monitoring					
Recommended future monitoring plan including timing, frequency, locations and parameters, together with		Section 6.1.2, Section 6.2.3,	Pre-development (Section 6.1.2), construction (Section	☐	

arrangements for ongoing actions		Section 6.3.2	6.2.3) and post-development monitoring (Section 6.3.2) is discussed.		
Implementation					
Developer Commitments		Section 6	The developers commitments through subsequent phases of development are discussed in Section 6.	☐	
Roles, responsibilities, funding for implementation		Section 6.4, Table 11	Table 15 outlines the roles and responsibilities beyond the LWMS.	☐	
Review		Section 6	Opportunities for review are discussed in Section 6.	☐	

APPENDIX B: LOCAL STRUCTURE PLAN

(CLE, 2015)



CLE

3403-22-01 (31.08.2015), NIs

LSP CONCEPT PLAN

Figure 9

APPENDIX C: LANDSCAPE PLANS

(LD Total, 2016)

LD TOTAL
LEADERS IN LANDSCAPING
64 MILL POINT ROAD,
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ALCOCK BROWN-NEAVES GROUP

Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

3RD MAY 2016 / REV D / N.T.S

LANDSCAPE PLAN N.T.S

3RD MAY 2016- REV D N.T.S

Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

LD TOTAL
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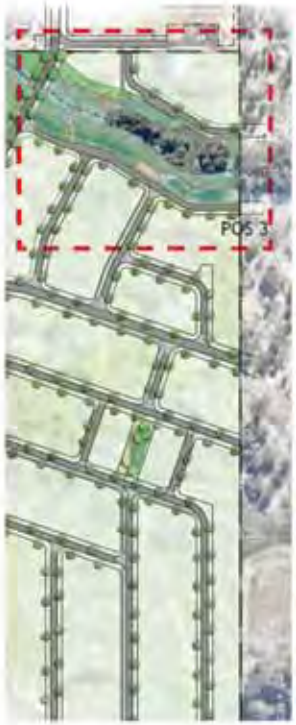
LEGEND

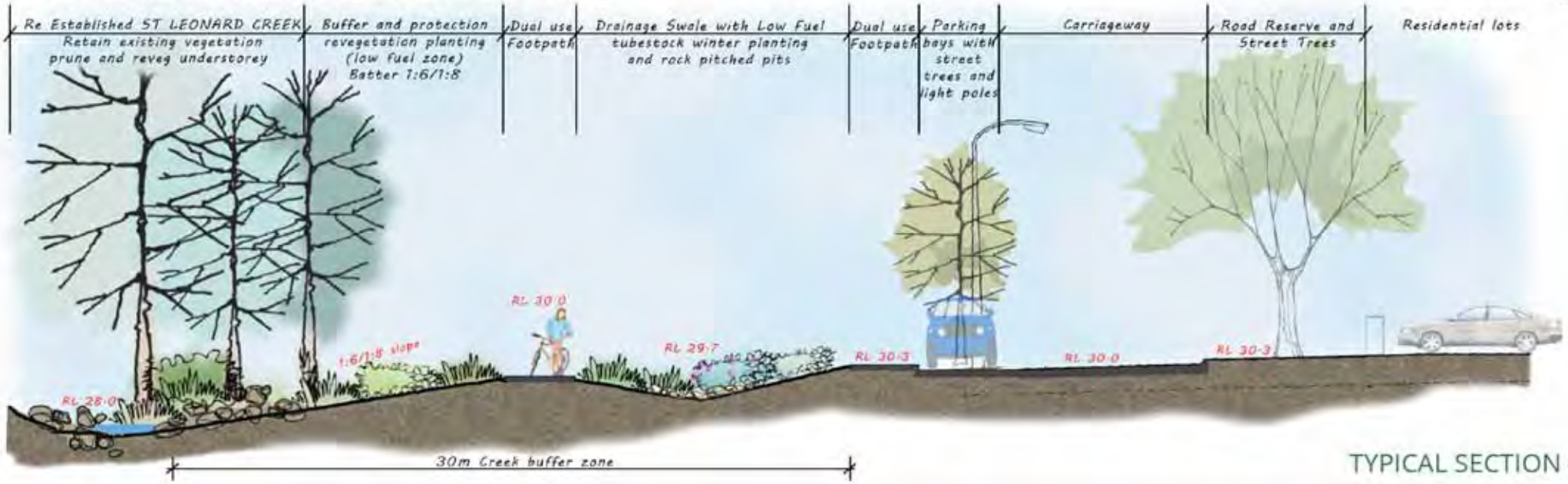
1. EXISTING ST.LEONARD CREEK
2. BUFFER AND PROTECTION REVEGETATION WINTER PLANTING (LOW FUEL ZONE)
3. RETAINED EXISTING VEGETATION
4. TUBESTOCK SWALE PLANTING
5. PEDESTRIAN FOOTBRIDGE
6. PROPOSED CONCRETE FOOTPATH
7. CHILDREN'S PLAY/PICNIC NODE
8. FEATURE SEATING NODE
9. EXERCISE NODE
10. PROPOSED STREET TREE PLANTING
11. PARMELIA GAS PIPELINE EASEMENT WITH WINTER TUBESTOCK PLANTING
12. ROCK PITCHED PITS
13. LOW LIMESTONE WALL
14. STREET PARKING BAYS

VEGETATION CONDITION:
VG-E - VERY GOOD - EXCELLENT
G - GOOD



KEY PLAN

POS 3 – FORESHORE RESERVE PLAN / POS 4 N.T.S



TYPICAL SECTION - A - A

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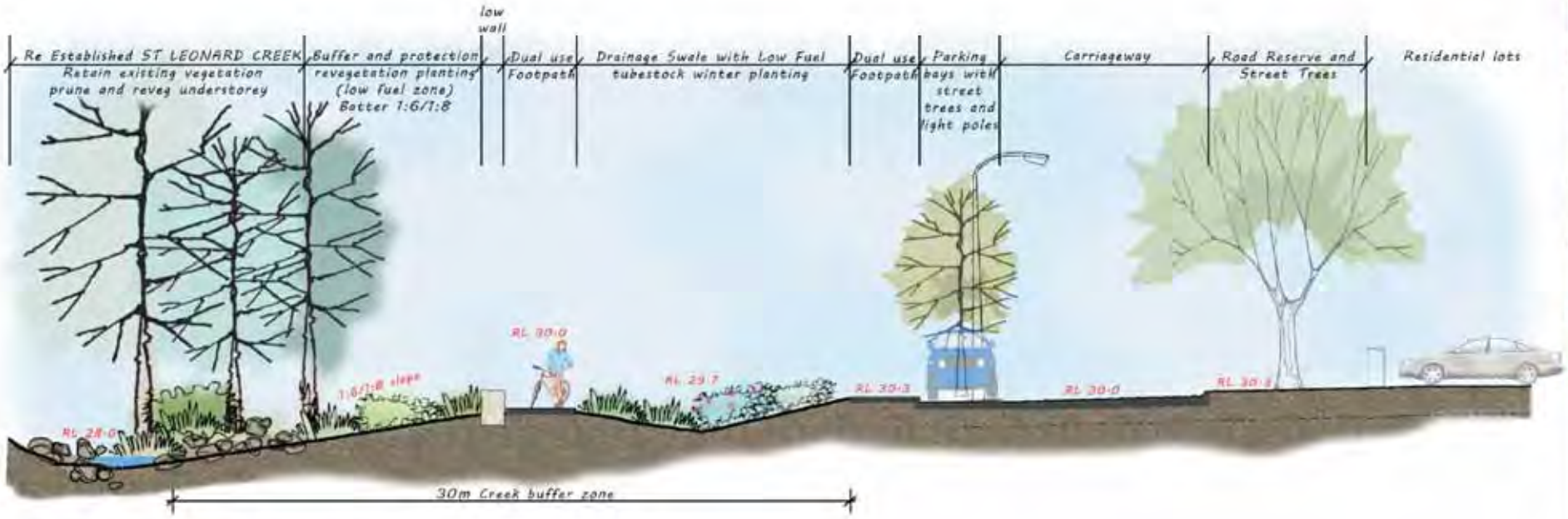
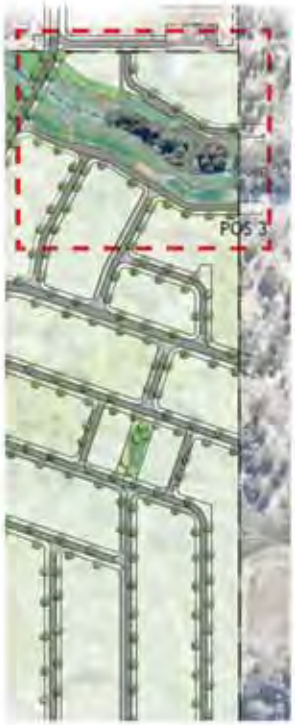


TYPICAL SECTION - B - B



KEY PLAN

LD TOTAL
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Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

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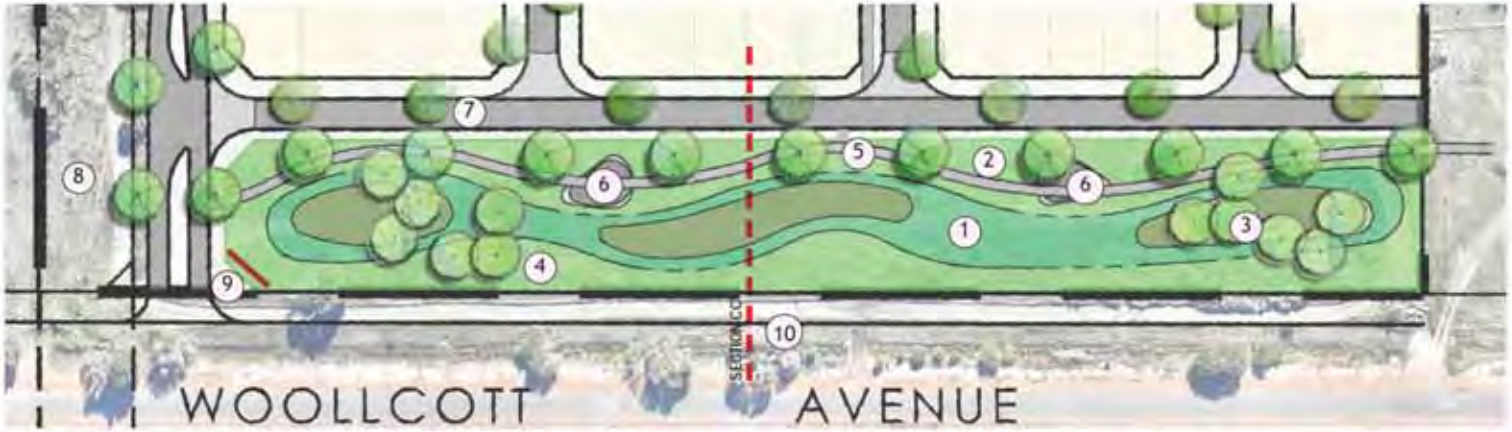
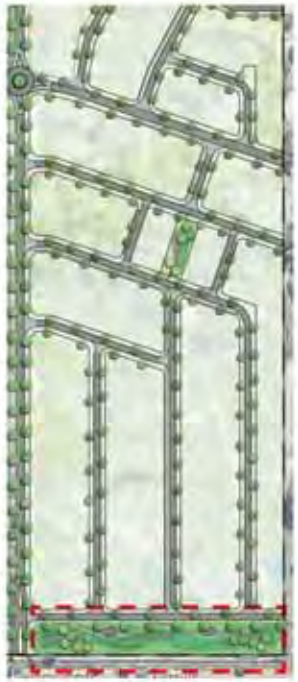


POS 1 PLAN N.T.S

LEGEND

1. DRAINAGE BASIN REVEGETATION WINTER PLANTING ONLY (LOW FUEL ZONE)
2. 10.0M WIDE SWALE LANDSCAPE AREA
3. CLUSTER OF SMALL TREE PLANTING ON DRAINAGE BASIN
4. TUBESTOCK PLANTING ON BUND
5. PROPOSED CONCRETE FOOTPATH
6. EXERCISE STATION WITH EQUIPMENT
7. PROPOSED STREET TREE PLANTING
8. PARMELIA GAS PIPELINE EASEMENT WITH TUBESTOCK PLANTING (WINTER)
9. ENTRY SIGNAGE
10. WOOLLCOTT AVENUE 12.0M WIDE DRAINAGE RESERVE



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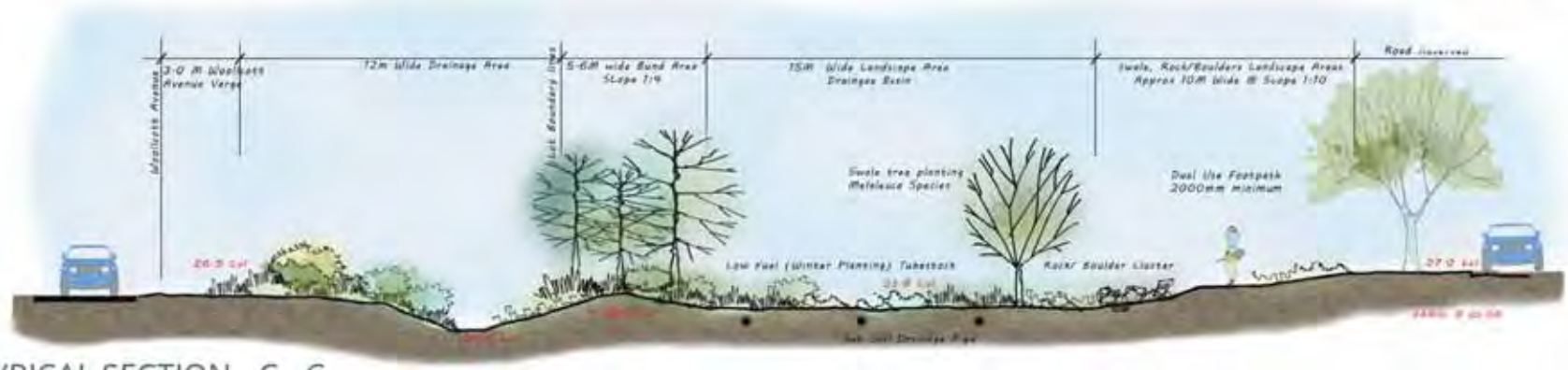

TYPICAL SECTION - C - C

LD TOTAL
LANDSCAPE ARCHITECTS
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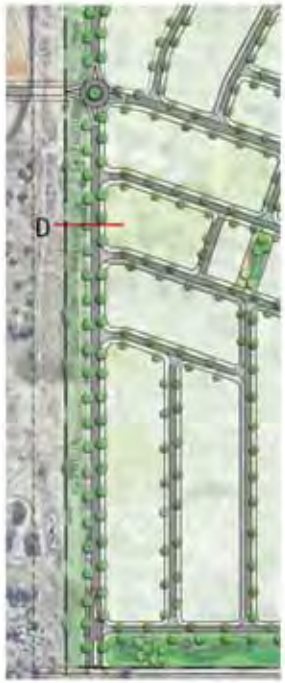

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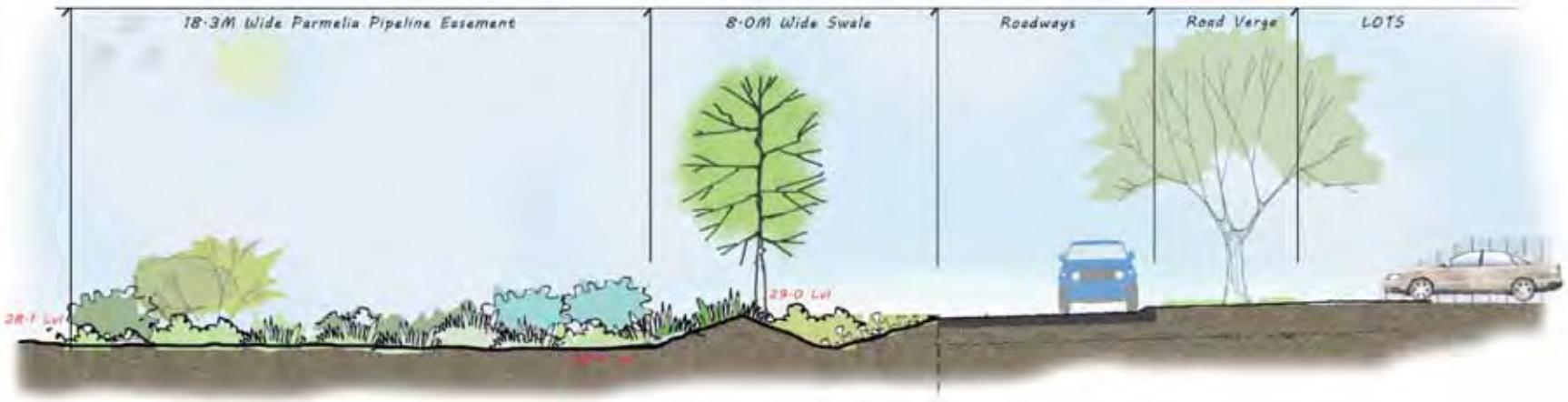

TYPICAL SECTION - D -D

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Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

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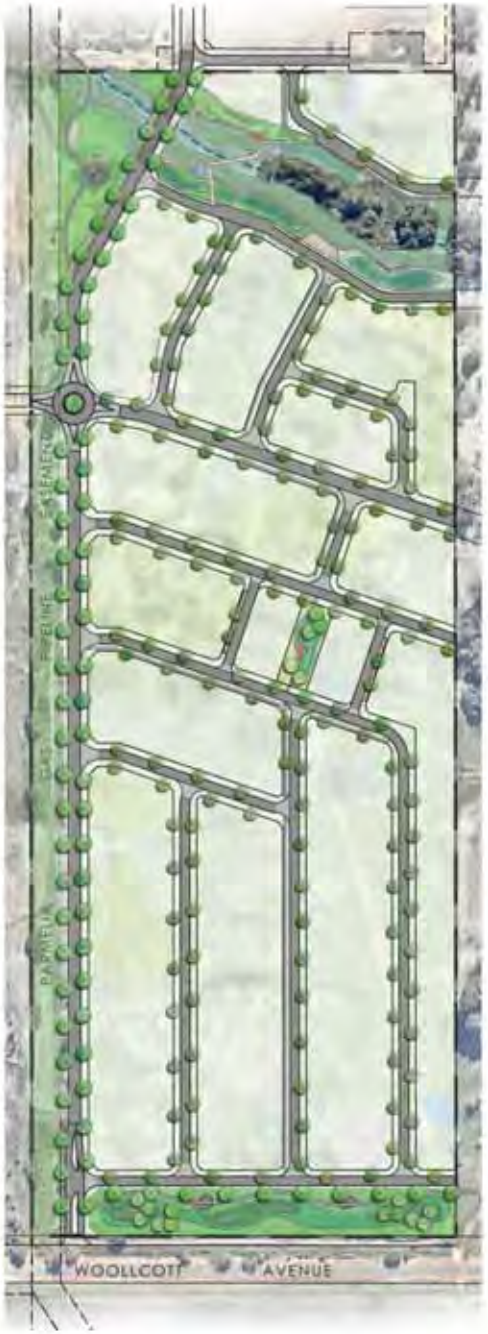

Tubestock Planting (Winter)

NOTE: No turf/grass will be proposed in the landscape as this will be a 'dry' landscape

Reed Planting along St Leonards Creek

Draft Materials for use


Boulders


Crushed pea gravel


Blue metal


Concrete footpath


Recycled plastic timber

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Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

3RD MAY 2016 - REV D - N.T.S

APPENDIX D: GEOTECHNICAL STUDY

(Galt Geotechnics, 2015)

Report on

DUE DILIGENCE LEVEL GEOTECHNICAL STUDY PROPOSED RESIDENTIAL DEVELOPMENT 345 WOOLLCOTT AVENUE, BRABHAM

Submitted to:

ABN Group
Ground Floor, 131 Hasler Road
OSBORNE PARK WA 6017

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J1501018 001 R Rev0

20 February 2015

TABLE OF CONTENTS

TABLES (WITHIN TEXT)

FIGURES

APPENDICES

1. INTRODUCTION

This report presents the outcomes of a due-diligence level geotechnical study conducted by Galt Geotechnics Pty Ltd (Galt) for the proposed residential development at 345 Woollcott Avenue, Brabham ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The study was authorised by Jeremy Cordina of Alcock Brown-Neaves Group in an email dated 30 January 2015.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the site is rectangular in shape and covers 20.2 ha in plan area (18.8 ha allowing for an easement for the Parmelia gas pipeline on the western boundary of the site). Publicly available topography shows that the site surface level is generally at around RL 26 m in the south and around RL 28 m to RL 29 m AHD in the north, with a number of local low points, mainly in the north.

A review of aerial photography shows that the site is bounded by Woollcott Avenue to the south, a residential development (Whiteman Edge) to the north and existing undeveloped rural properties to the east and west. The site is undeveloped and the surface comprises a mix of open sandy areas, grassed areas and several stands of mature trees, mainly in the centre of the site.

It is apparent that sand mining has been undertaken on dunes previously on the site, throughout the 1970s and 1980s. This has resulted in lowering of surface levels by about 3 m to 5 m compared to similar dune levels on adjacent sites. This has also resulted in the site surface being lowered below the groundwater table as surface water is now present across several parts in the north of the site.

We assume that the site will be subdivided into single residential lots as is being done on a number of nearby sites. Level differences are likely to be accommodated by gravity retaining walls.

Some sand filling will be necessary to raise site surface levels for the development.

3. PROJECT OBJECTIVES

The due diligence study is intended to inform the purchaser about geotechnical risks on the site and provide a geotechnical basis for making a financial commitment. A detailed investigation will be required prior to detailed design.

The objectives of the study were to:

- broadly assess subsurface soil and groundwater conditions across the site, with a particular emphasis on:
  - the thickness of sand overlying clayey soils;
  - the depth to groundwater and/or surface expressions of groundwater; and
  - the reactivity of clayey soils;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide recommendations and geotechnical design parameters for earth retaining structures;
- recommend appropriate site preparation procedures including compaction criteria, with a particular emphasis on any unusual/onerous site preparation measures required for this site;
- make a preliminary assessment of the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration;
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others; and

- provide recommendations for detailed geotechnical studies required for detailed design.

4. FIELDWORK

Fieldwork was conducted on 6 and 16 February 2015 and comprised:

- a walkover of the site including taking photographs;
- cone penetration testing (CPTs) at 6 locations, extending to depths between 4.2 m and 5.8 m;
- excavation of test pits at 15 locations, extending to depths of between 1.6 m and 3.0 m;
- testing with a Perth sand penetrometer at each test pit location, extending to a depth of 0.9 m; and
- infiltration tests using the 'inverse auger hole' technique at 4 locations between depths of 0.6 m and 0.85 m below ground.

General

Test locations were selected by a geotechnical engineer from Galt. The locations of the test pits, cone penetration tests and permeability tests were recorded using a handheld GPS accurate to about 5 m in the horizontal plane. Our engineer observed the CPT testing and test pitting, logged the materials encountered in the test pits, drilled the hand auger boreholes and performed the infiltration testing.

The test locations are shown on Figure 1, Site and Location Plan and details are summarised in Table 1. Photographs of the site are presented in Appendix A, Site Photographs.

Table 1: Summary of Tests

Test Name	Test Depth (m)	Depth to Water Table (m)	Reason for Termination	Stratigraphy[1]
CPT01	5.5	0.8	Target Depth	SAND
CPT02	4.5	1.2	Target Depth	SAND
CPT03	4.3	*	Target Depth	SAND
CPT04	5.9	1.0	Target Depth	SAND
CPT05	4.2	*	Target Depth	FILL: Clayey SAND overlying SAND
CPT06	4.2	*	Target Depth	SAND
TP01	2.0	1.8	Collapse	SAND
TP02	2.0	1.7	Collapse	SAND
TP03	2.1	1.6	Collapse	SAND
TP04	1.8	1.5	Collapse	SAND
TP05	1.6	1.3	Collapse	SAND
TP06	3.0	1.9	Target Depth	SAND
TP07	2.0	1.5	Collapse	FILL: Clayey SAND overlying SAND
TP08	1.9	1.3	Collapse	SAND
TP09	1.7	1.4	Collapse	SAND
TP10	2.1	1.5	Collapse	SAND

Test Name	Test Depth (m)	Depth to Water Table (m)	Reason for Termination	Stratigraphy[1]
TP11	3.0	1.4	Collapse	SAND
TP12	1.9	1.3	Collapse	SAND
TP13	3.0	1.5	Target Depth	SAND
TP14	2.0	1.3	Collapse	SAND
TP15	2.2	1.8	Collapse	SAND

Note: 1 – Stratigraphy from CPTs inferred from Robertson et al. (1986)
* – Water table depth not recorded

Test Pits

Test pits were excavated using an 8 tonne Volvo BL71 tractor mounted backhoe equipped with a 600 mm toothed bucket. The backhoe was supplied and operated by All West Plant Hire. Test pit reports are presented in Appendix B, Test Pit Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports.

Perth Sand Penetrometer Tests

Perth sand penetrometer (PSP) tests were carried out in accordance with AS 1289.6.3.3 although to a greater depth than the 0.45 m covered in the standard.

The test locations were adjacent to each test pit as shown on Figure 1, Site and Location Plan and the PSP records are presented in Appendix C, Perth Sand Penetrometer Test Results.

Cone Penetration Tests

CPTs were undertaken using an 11 tonne track mounted CPT rig supplied and operated by Probedrill Pty Ltd. The results of the CPTs are provided in Appendix D, Cone Penetration Test Results along with a method of interpretation proposed by Robertson et al (1986).

Permeability Tests

Permeability testing was carried out in hand augered boreholes using the method described by Cocks[1]. The spoil from the boreholes was sand. The results of the permeability testing are presented in Appendix E, Permeability Test Results and summarised in Table 2.

Table 2: Summary of Permeability Test Results

Test Location	Description	Pipe Embedment (m)	Minimum Unsaturated Permeability[1], k (m/day)		
			Test 1	Test 2	Test 3
HA01	SAND	0.75	70.9	61.3	50.8
HA02	SAND	0.60	57.5	44.8	48.9
HA03	SAND	0.60	12.8	11.5	11.2
HA04	SAND	0.85	3.0	1.6	1.3

Note: The minimum unsaturated permeabilities shown are typically recorded towards the end of the test, with pressure head varying between about 0.5 m and dry (0 m).

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

5. SITE CONDITIONS

5.1 Geology

The Perth sheet of the 1:50,000 scale Environmental Geology series maps indicates that the area is underlain by two soil units:

- Peaty CLAY (southern one-third of site), described as *dark grey and black with variable sand content, of lacustrine origin;* and
- Bassendean sand (northern two-thirds of the site, plus far southern fringe), described as *SAND – white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.*

The Bassendean sand is shown to overlie Guildford Formation soils at shallow depth across the middle and southern parts of the site.

The findings of our study are mostly in accordance with the geological mapping. However, Bassendean sand was found to cover the entire site to the full investigated depth (with the exception of minor clayey pockets in parts). In addition, we did not find any evidence of the Peaty CLAY as described by the Environmental Geology series maps.

5.2 Subsurface Conditions

The subsurface conditions are relatively consistent across the site. In general, the typical soil profile comprises:

- SAND (SP): fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey/pale yellow, trace rootlets in top 100 mm, trace localised layers of very weakly cemented coffee rock with increased organic content (about 5%), generally loose up to 0.3 m depth and medium dense to dense below, extending to the maximum depth investigated of 5.8 m.

Note: Below 3.0 m depth, the subsurface conditions are inferred from CPT data.

We note that localised areas of clayey sand were encountered (e.g. CPT05, TP07). These were inferred to be fill, probably remnants of unsuitable material encountered during the sand mining operation. These layers were thin (about 0.3 m). The CPTs indicated the presence of thin, slightly clayey horizons at depth in some areas. These clayey pockets are unlikely to be represent a significant volume of the near-surface soils based on the information gathered to date.

6. LABORATORY TEST RESULTS

Laboratory testing on soil samples was undertaken by Mining & Civil Geotest in their NATA accredited laboratory and comprised the determination of:

- particle size distribution on 2 samples;
- organic content on 1 sample; and
- Atterberg limits and linear shrinkage on 1 sample.

Laboratory test results along with the test methods followed are included in Appendix F, Laboratory Test Results Geotechnical and are summarised in Table 3, Summary of Laboratory Test Results.

Table 3: Summary of Laboratory Test Results

Test ID	Depth (m)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)	OC (%)
TP05-1	0.9-1.1	0	96	4	-	-	-	4
TP07-1	0-0.15	0	51	49	29	16	6.5	-

LL: Liquid Limit PI: Plasticity Index LS: Linear Shrinkage
OC: Organic Content

7. GEOTECHNICAL ASSESSMENT

7.1 Preliminary Site Classification

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

We have assessed the site in accordance with AS2870 (2011) "Residential Slabs and Footings". We consider that a site classification of "Class A" is appropriate provided the site preparation measures outlined in Section 7.4 are followed.

We note that the "Class A" site classification should not be taken as an indication of a small scope of earthworks being necessary to develop the site. The principal encumbrance to development of the site is the shallow (locally surface) groundwater table. The site surface will need to be raised to comply with local council requirements.

7.2 Groundwater

The Perth Groundwater Atlas (1997) shows the historical maximum groundwater levels at the site to vary between RL 29 m (northwest) to RL 26 m (southeast) which is within about 1.0 m of the current site surface level (**Note:** The site appears to have been excavated to around RL 28 m AHD and lower in northern parts of the site). As a result ground water was present above the surface level in central to north parts of the site. Images of these areas have been included in Appendix A, Site Photographs. The areas are also visible on the aerial photograph in Figure 1.

Therefore, as noted above, raising the site surface levels to some level above the historical maximum groundwater level will be required. We recommend at least a 1.2 m separation of permeable, granular fill from the site surface to the maximum groundwater level.

7.3 Retaining Structures

Retaining structures may be designed in accordance with AS 4678-2002 "Earth-Retaining Structures". For the design of retaining structures, the following parameters in Table 4 are appropriate.

Table 4: Retaining Wall Design Parameters

Soil Type	Bulk Density (t/m^3)	Soil Friction Angle (°)	Wall Interface friction angle			
			$\delta = 0°$		$\delta = 0.5\Phi$	
			Coefficient of Active Earth Pressure K_a	Coefficient of Passive Earth Pressure K_p	Coefficient of Active Earth Pressure K_a	Coefficient of Passive Earth Pressure K_p
Medium dense sand	17	35	0.27	3.7	0.24	6.1
Dense and compacted sand compacted sand	18	37	0.25	4.0	0.21	7.0

Notes:

1. Earth pressure coefficients are provided in this table for conditions of zero friction between the wall and the soil and with wall friction of 0.5Φ. The retaining wall designer should make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction. A horizontal ground surface behind the wall has been assumed.

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.

7.4 Site Preparation

The site preparation measures outlined below are aimed at preparation of the site prior to construction of the building and pavement subgrades. Landscaped areas (if any) will not require this preparation.

The following site preparation measures must be followed:

- Remove all topsoil and vegetation from the site, including grubbing out of roots. A topsoil strip of 150 mm should be assumed. **Note**: the removal of large trees will require excavation to depths of 1 m or more which will require geotechnical remediation. Topsoil should be retained for potential screening and re-use in structural fill (refer to Section 7.6).
- Remove any rubbish and deleterious material (present in several localised areas across the site, see Attachment A, Site Photographs).
- Excavate to the required levels, if at all. Segregate any clayey pockets in stockpile for potential re-use in deep fill. Clayey soils can be identified by their cohesive texture.
- Where fill is required to build up levels (mainly in the central and northern regions of the site), use approved fill (see Section 7.6), placed and compacted in layers of no greater than 300 mm loose thickness (see Section 7.5).
- Compact the exposed sandy ground to achieve the level of compaction specified in Section 7.5 to a depth of at least 0.9 m below the base.
- Any areas of loose sand or unsuitable material must be removed and replaced with approved fill as outlined in Section 7.6.
- Excavate for pad and strip footings (including retaining wall footings) and compact the exposed bases to achieve the level of compaction specified in Section 7.5 to a depth of at least 0.9 m below the underside of all footings. Remove, replace and compact as required with approved fill any zone not achieving the level of compaction specified in Section 7.5.

Bulk filling of the site with imported sand fill will be relatively expensive. The large volume of sand potentially available on site (subject to any environmental/acid sulfate soil considerations) should be considered for use as fill.

We consider that it would be possible to strip and stockpile the sand from the site in sections, extending below groundwater table (this would necessitate dewatering) and then build up the site with a lower quality (general) fill prior to capping the site with (say) 1.5 m to 2.0 m of sand fill extracted from on-site borrow.

Possible materials that could be used in the lower fill are:

- 'Recycled' sand fill, which often contains significant organic and fines portions, as well as minor construction rubble, etc.
- Crushed concrete or other construction debris.
- Clay or clayey sand (derived from nearby developments, given that many sites in the area are removing clayey fill).
- Screened sandy topsoil derived from other sites, with up to 6% organic content.

7.5 Compaction

In situ sand and granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio of at least 95% of maximum modified dry density (MMDD) as determined in accordance with AS 1289 5.2.1.

After compaction, verify that the level of compaction has been achieved by testing to a minimum depth of 0.9 m:

- On each lift of fill on a 40 m grid
- At each spread footing location;
- At 15 m centres along pavement subgrades;
- At 15 m centres along strip footings, including retaining wall footings; and
- On a grid of 15 m centres below on-ground slabs and pavements.

Where clean sand is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control. The following minimum PSP blow counts must be met:

- 150 mm-450 mm: 8
- 450 mm-750 mm: 10
- 750 mm-1050 mm: 11

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 required to achieve the required dry density ratio.

Over-excavation and replacement of loose materials may be required where the minimum density 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 structures. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[2] provides assistance with the selection of compaction equipment for use adjacent to structures.

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

7.6 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". Sand fill must comprise clean sand that has less than 2% organic matter and a fines content of less than 5%.

Generally, the sandy material present on site is considered suitable for re-use as inert structural fill (other than any organic rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size)).

'Coffee Rock'

The 'coffee rock' present on site will not be suitable for re-use as permeable structural fill without blending with clean sand (1 part 'coffee rock' to 2 parts clean sand (<5% fines, <1% organics)), subject to the 'coffee rock' having a maximum particle size of 200 mm. The 'coffee rock' is easily identifiable by its dark brown to black colour in contrast to the generally pale coloured sand on site.

Topsoil

Sand topsoil may be re-used as structural fill provided it is screened (over a 50 mm or finer screen) and blended with clean sand fill (<5% fines, <1% organics) to produce a blended material with <5% fines and <2% organics. It is our experience that this will produce a relatively permeable blend. This is likely to require between 1 part and 2 parts clean sand to 1 part screened topsoil. The blended sand must be subjected to laboratory testing for particle size distribution and organic content prior to its use. If permeability is an issue for the blended fill, the blend ratio must be determined on site by permeability testing of compacted trial pads.

Site-derived Clayey Sand

Where clayey sand is encountered, we must be engaged to comment on its potential re-use as fill. It is likely that this material can be used in deep fill areas without detriment to the site classification. Significant quantities of site-derived clayey fill are not expected.

Various General Fill Materials

Where 'general fill' is proposed in accordance with our suggestions in Section 7.4, we must review the proposed material and develop a suitable filling method with the earthworks contractor and client. This may require additional sampling, laboratory testing and field trials.

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

7.7 Stormwater Disposal

The results of infiltration tests are included in Appendix E, Permeability Test Results. The minimum measured unsaturated permeability of the sand was 1.3 m/day. This was recorded in P04 located in south east corner of the site where a proposed drainage basin is to be situated. The three permeability tests (P01-P03) in the central and northern regions of the site recorded a minimum unsaturated permeability of 11.2 m/day.

We consider that the sands at the site are generally suitable for the disposal of stormwater by infiltration by means of soak wells. We expect that a general permeability rate of at least k=5 m/day will apply (notwithstanding one low result obtained on the site, which may be due to the close proximity of the test to groundwater). We note that this

permeability rate (k~5 m/day) only applies where stormwater disposal occurs above the groundwater table (at least 0.5 m above).

The permeability of any stormwater disposal system may be expected to decrease over time due to compaction of sands during site preparation and clogging of the pore spaces by fines during the life of the stormwater disposal system.

7.8 Pavement Design

Where design of flexible pavements is undertaken, a subgrade California bearing ratio (CBR) of 12% may be assumed for pavement thickness design. This CBR assumes that the site preparation requirements outlined in Section 7.4 have been carried out in pavement subgrade areas.

8. FUTURE STUDIES

We consider that the following works will be required for detailed design purposes:

- Additional infill testing across the site to check for clayey or peaty horizons in areas between existing test locations.
- Evaluation of general fill sources, if required.
  If sand borrow and dewatering is to be done, an acid sulfate soils (ASS) and dewatering assessment.

9. CLOSURE

We draw your attention to Appendix G, "Understanding Your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimize risks associated with groundworks for this project. 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.

GALT GEOTECHNICS PTY LTD

Owen Woodland CPEng

Geotechnical Engineer

Martin Ward

Geotechnical Engineer

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Figures

Galt GEOTECHNICS

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CLIENT	ABN GROUP
PROJECT	PROPOSED RESIDENTIAL DEVELOPMENT
LOCATION	345 WOOLCOTT AVENUE BRABHAM
TITLE	TEST LOCATION PLAN
Job No.	J1501018
Fig No.	FIGURE 1
Rev	A

Appendix A: Site Photographs

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Photograph 1: Looking north east from TP02

Photograph 2: Looking north from TP03

Photograph 3: Looking west from TP03

Photograph 4: Looking west from TP06

Photograph 5: Looking south from TP07

Photograph 6: Looking west from TP12 towards localized fly-tipped rubbish

Photograph 7: Looking west from TP14 at surface expression of groundwater table

Photograph 8: Looking north from site entry (Woollcott Avenue)

Appendix B: Test Pit Reports

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ABN: 73 292 586 155

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 (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

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

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces 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
	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

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	

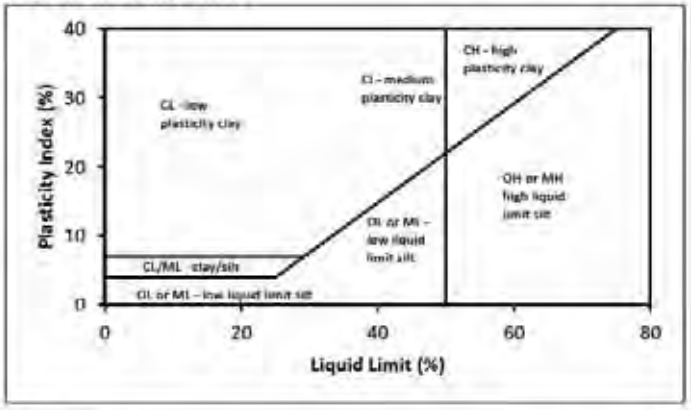
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

Galt GEOTECHNICS

TEST PIT: TP01

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403216 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478985 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ 1.8	0.0 – 2.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	L	
										Pale grey	M	MD	
											W		
										Hole terminated at 2.00 m Collapse Groundwater encountered at 1.8 m			

Sketch & Other Observations

Comments:

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

Galt GEOTECHNICS

TEST PIT: TP02

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403041 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478994 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	L	
			0.5								M	MD	
			1.0										
			1.5										
		▼ (1.7)								Brown/black, increased organic content (5-10%) ("coffee rock")	W		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.7 m			

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:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478875 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrick	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming orange-brown and then yellow below 0.2 m, trace rootlets in top 100 mm	D	L	
			0.5									MD	
			1.0							Pale yellow	M		
		▼ (1.6 m)	1.5							Black-brown, with increased organic content (5-10%) ("coffee rock")	W		Localised pockets of SAND with some CLAY (Guildford): 10-15% low to medium plasticity
			2.0										
			2.5							Hole terminated at 2.10 m Collapse Groundwater encountered at 1.6 m			

Sketch & Other Observations

Comments:

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

Galt GEOTECHNICS

TEST PIT: TP04

Sheet 1 OF 1

Job Number: J1501018	**Easting:** 403041 m	**Contractor:** All West Plant Hire	**Date:** 06/02/2015
Client: ABN Group	**Northing:** 6478710 m	**Machine:** Volvo BL71	**Logged:** MW
Project: Proposed Residential Development	**Datum:** MGA94 Zone 50	**Operator:** Derrik	**Checked Date:** 19/02/2015
Location: 345 Woolcott Avenue, Brabham		**Bucket:** 600 mm toothed	**Checked By:** ORW
		Width: 2 m **Length:** 3 m	

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace non-plastic fines, with some roots/rootlets (1-20 mm in diameter) in top 100 mm	D	MD	
										Grey	M		
		▼	1.5							Pale grey/brown	W		
			1.8							Hole terminated at 1.80 m Collapse Groundwater encountered at 1.5 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP05

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403186 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478689 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, with some rootlets in top 100 mm, trace non-plastic fines	D	L	
			0.2							Pale grey	M	MD	
			0.9		B(TP05-01)					Brown/black, weakly cemented nodules ("coffee rock")			
			1.1							Pale grey			
		▼ 1.3									W		
			1.6							Hole terminated at 1.60 m Collapse Groundwater encountered at 1.3 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP06

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478582 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 500 mm	D	L	
			0.5 – 1.5								M	MD	
		▼ (1.9 m)								Brown-grey, trace rootlets			
			2.0 – 3.0							Grey becoming pale grey	W		
			3.0							Hole terminated at 3.00 m Target depth Groundwater encountered at 1.9 m			
			3.5										

Sketch & Other Observations

Comments:

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

TEST PIT: TP07

Job Number:	J1501018	**Easting:**	403237 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478507 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0		B(TP07-01)				SC	FILL: Clayey SAND, fine to coarse grained, sub-angular to sub-rounded, dark grey/brown, low to medium plasticity fines (~50%), trace rootlets in top 100 mm	D	L	
									SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey			
	F		0.5							Pale grey			
			1.0								M	MD	
	E	▼	1.5								W		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.5 m			

Sketch & Other Observations

Comments:

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

![Galt Geotechnics]

TEST PIT: TP08

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403081 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478457 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey/brown, trace rootlets in top 100 mm	D	L	
			0.5							Grey with layers of pale yellow and localised pockets of orange	M	MD	
			1.0										
		▼ (1.3)			B(TP08-01)						W		
			1.5										
			2.0							Hole terminated at 1.90 m Collapse Groundwater encountered at 1.3 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP09

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403229 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478326 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines, trace rootlets in top 100 mm		MD	
										Pale grey	D - M		
			0.5							Orange-brown, trace fine to medium grained gravel	M		
			1.0							Grey/orange mottled blue, with some low to medium plasticity fines			East half of test pit: iron cemented coffee rock refused
		▼ (1.4)	1.5								W		
			2.0							Hole terminated at 1.70 m Collapse Groundwater encountered at 1.4 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP10

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403058 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478329 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100mm	D	L - MD	
										Pale grey	M		
	F	▼ 1.5	1.5							Brown/black, increased organic content (5-10%), weakly cemented pockets ("coffee rock")			
	E									Grey	W		
			2.0										
			2.5							Hole terminated at 2.10 m Collapse Groundwater encountered at 1.5 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP11

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403134 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478338 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	Groundwater at 1.4 m	0.0 – 3.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace rootlets in top 100 mm	D	MD	
										Pale grey	M		
										Dark grey/brown becoming grey	W		
			3.0							Hole terminated at 3.00 m Collapse Groundwater encountered at 1.4 m			

Sketch & Other Observations


Comments:

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

TEST PIT: TP12

Galt GEOTECHNICS

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403139 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478415 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey, trace rootlets in top 100 mm	D	MD	
			0.5								M		
			1.0										
		▼ (1.3 m)								Pale yellow	W		
			1.5							Brown/black ("coffee rock")			
										Pale grey			
			2.0							Hole terminated at 1.90 m Collapse Groundwater encountered at 1.3 m			

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:	J1501018	**Easting:**	403234 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478642 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation: METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	Field Material Description: GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ (1.5)	0.0 – 3.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, with some roots/rootlets (1-30 mm) in top 600 mm	D	MD	
			~1.3							Pale grey/pale yellow			
			~1.9							Brown/grey			
			~2.2							Grey			
			3.0							Hole terminated at 3.00 m Target depth Groundwater encountered at 1.5 m			

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:	J1501018	**Easting:**	403106 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478811 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	MD	
										Orange-brown	M		
			0.5										
										Pale yellow			
			1.0										
		▼ (1.3)											
			1.5							Pale grey	W		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.3 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP15

Galt GEOTECHNICS

Job Number:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478988 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ 1.8	0.0 – 2.2						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm Pale grey Brown	D M W	MD	
										Hole terminated at 2.20 m Collapse Groundwater encountered at 1.8 m			

Sketch & Other Observations

Comments:

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

Appendix C: Perth Sand Penetrometer Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

PERTH SAND PENETROMETER FIELD TEST DATA (Standard Depth 900mm)
(AS12896.3.3)

Client: ABN Group
Project: Proposed Residential Development
Location: 345 Woollcott Avenue, Brabham

Job No: J1501018
Date: 16/02/2015
Engineer: MW

Test No:	1	2	3	4	5	6
Location:	TP01	TP02	TP03	TP04	TP05	TP06
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	2	1	2	1	2
150-300	3	3	3	4	3	4
300-450	4	3	4	4	4	4
450-600	4	4	4	5	4	4
600-750	5	5	5	5	5	4
750-900	5	5	5	6	5	5
900-1050						

Test No:	7	8	9	10	11	12
Location:	TP07	TP08	TP09	TP10	TP11	TP12
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	1	1	2	2	1
150-300	3	3	4	3	4	3
300-450	4	3	4	4	4	3
450-600	5	4	4	3	4	4
600-750	5	4	5	3	4	4
750-900	5	5	5	4	5	4
900-1050						

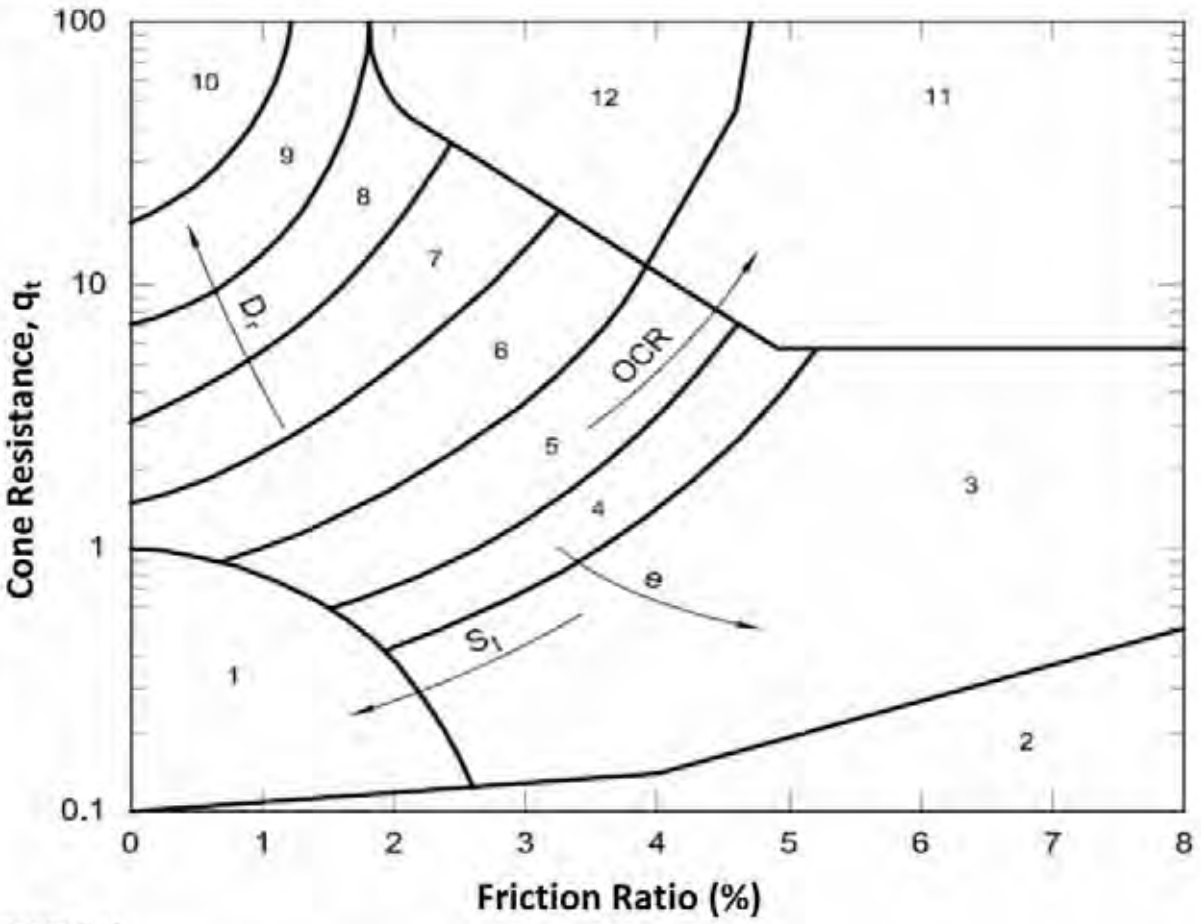
Test No:	13	14	15			
Location:	TP13	TP14	TP15			
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	1	2			
150-300	3	4	4			
300-450	4	5	5			
450-600	4	5	5			
600-750	5	6	6			
750-900	5	6	6			
900-1050						

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						
900-1050						

Perth Sand Penetrometer tests done in accordance with AS 1289.6.3.3 (except blow counts are reported per 150 mm, rather than 300 mm)
R: Refusal

Appendix D: Cone Penetration Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155



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: ABN

PROJECT: Residential Development

LOCATION: Brabham

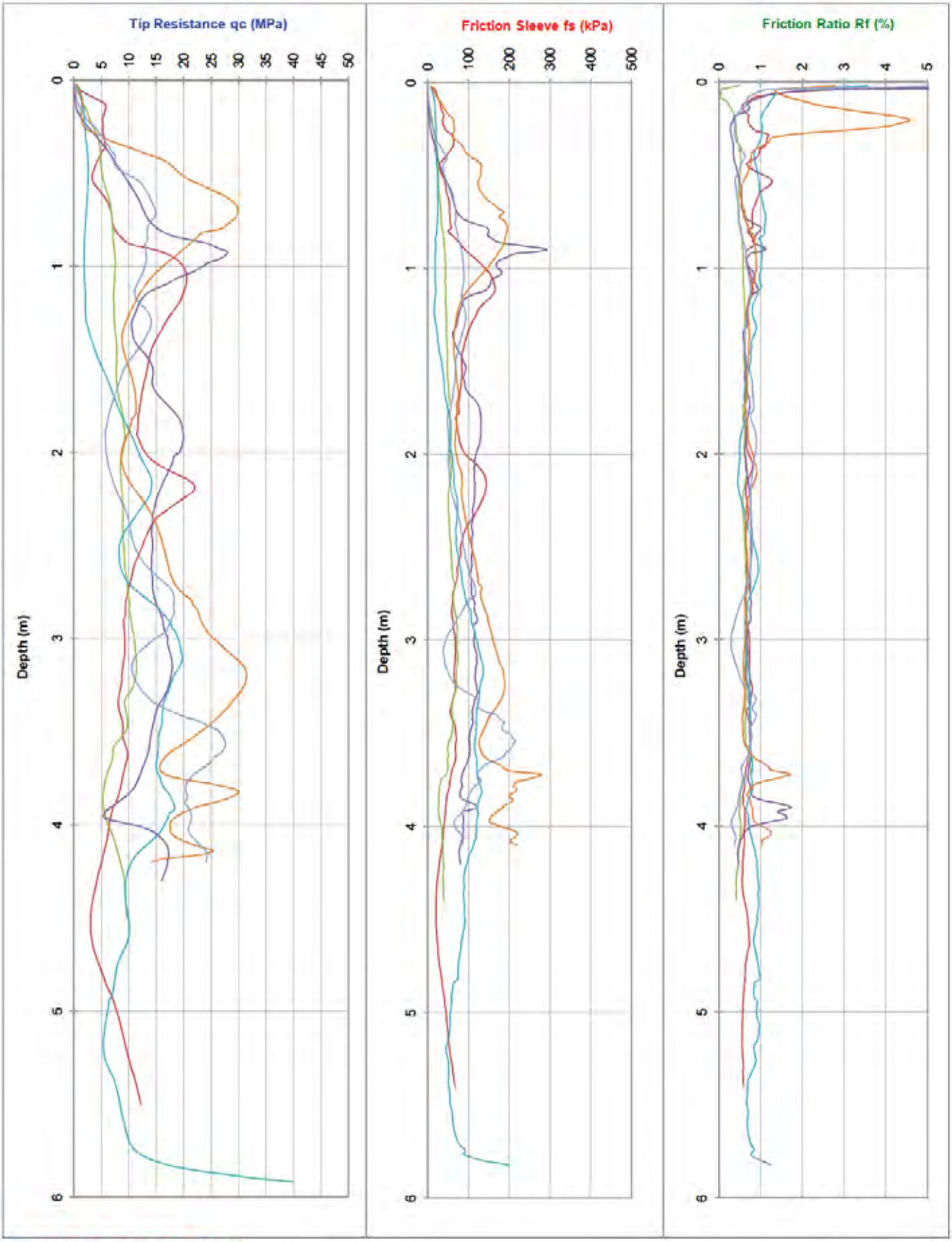
RL (m):

Date: Friday, 6 February 2015

Probe No.: All Data

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m):

Refusal:

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

File:

Cone I.D.:

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

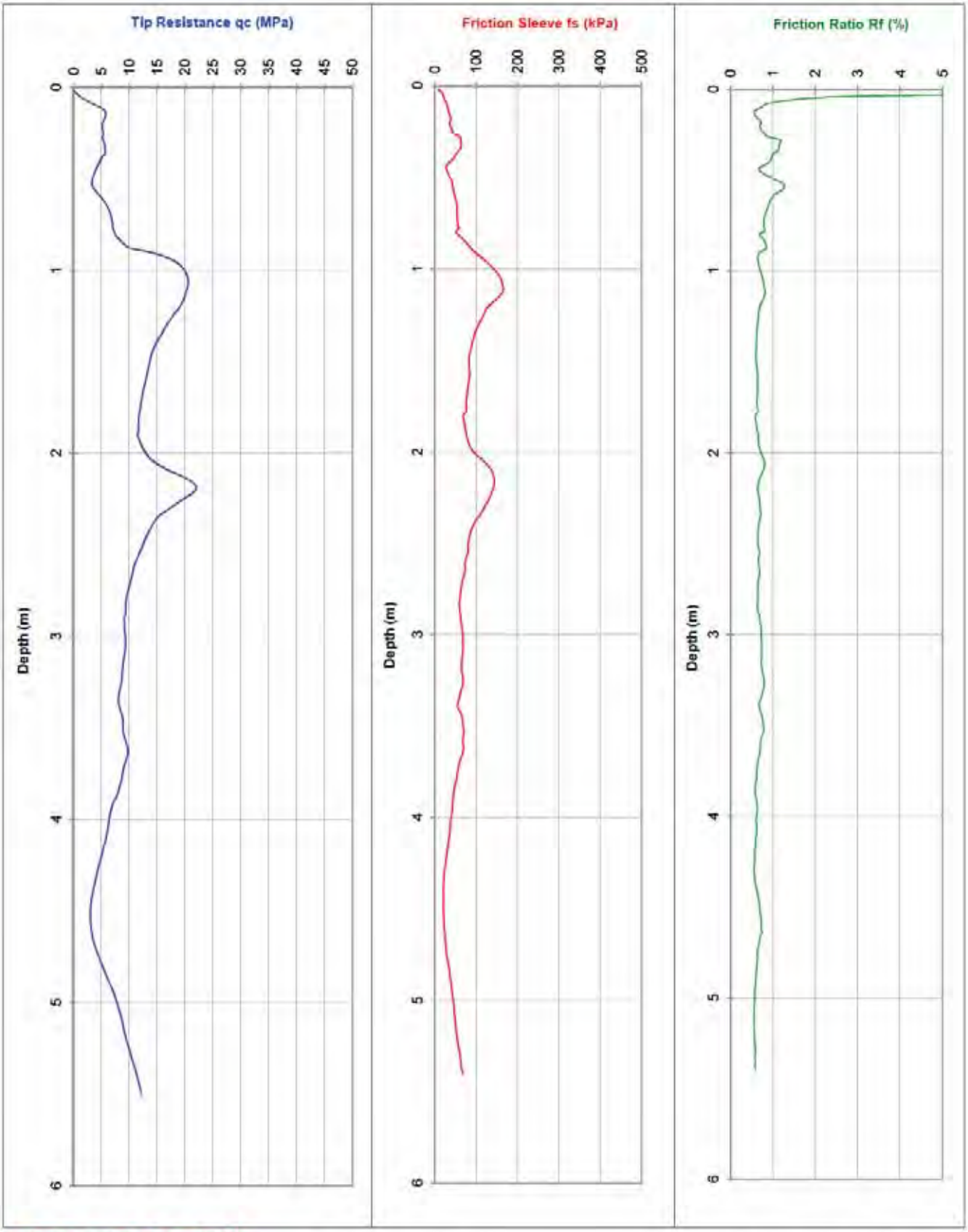
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 1

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): Dry to 0.8

Refusal:

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

File: GL0683M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

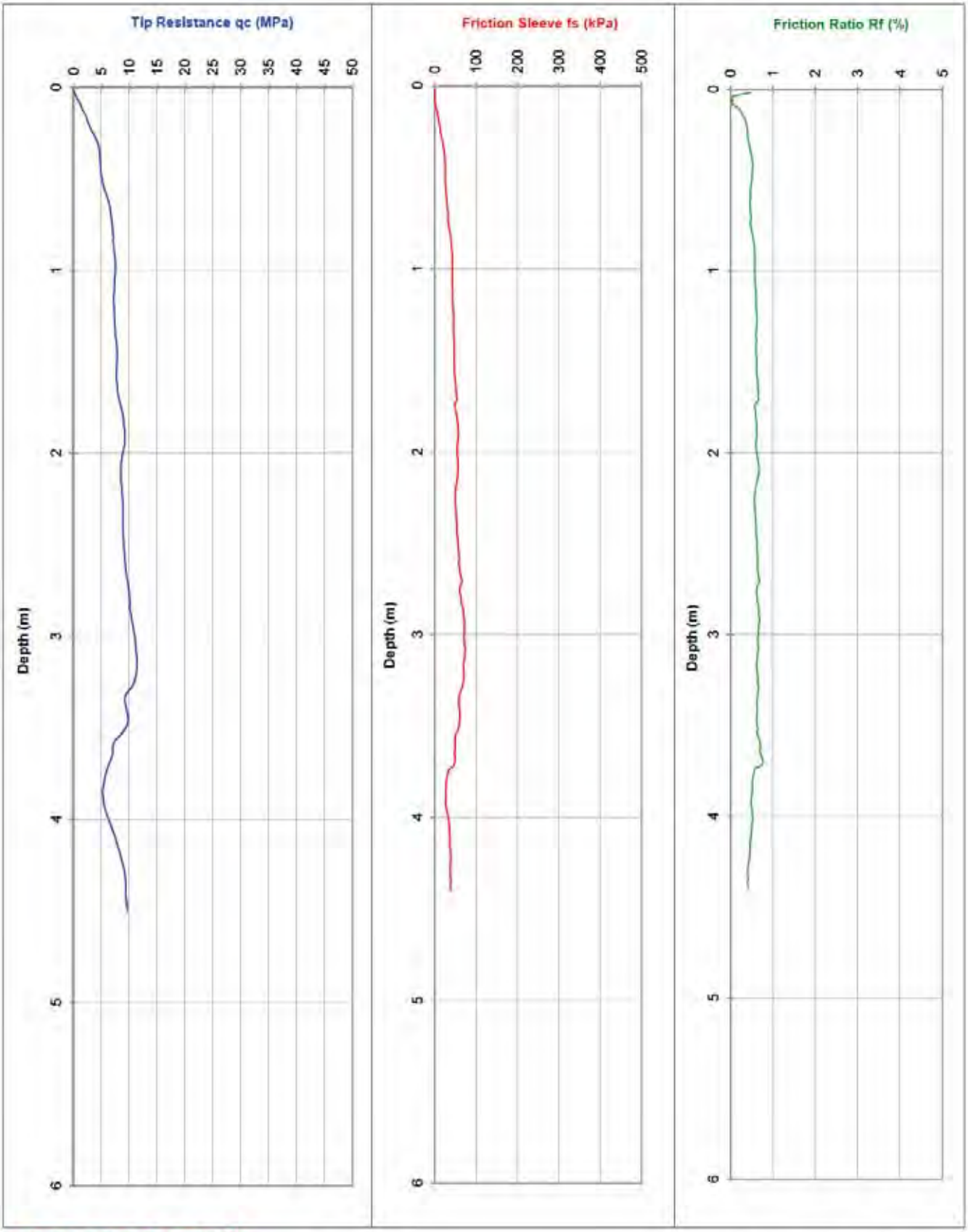
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 2

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): 1.2

Refusal:

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

File: GL0684M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

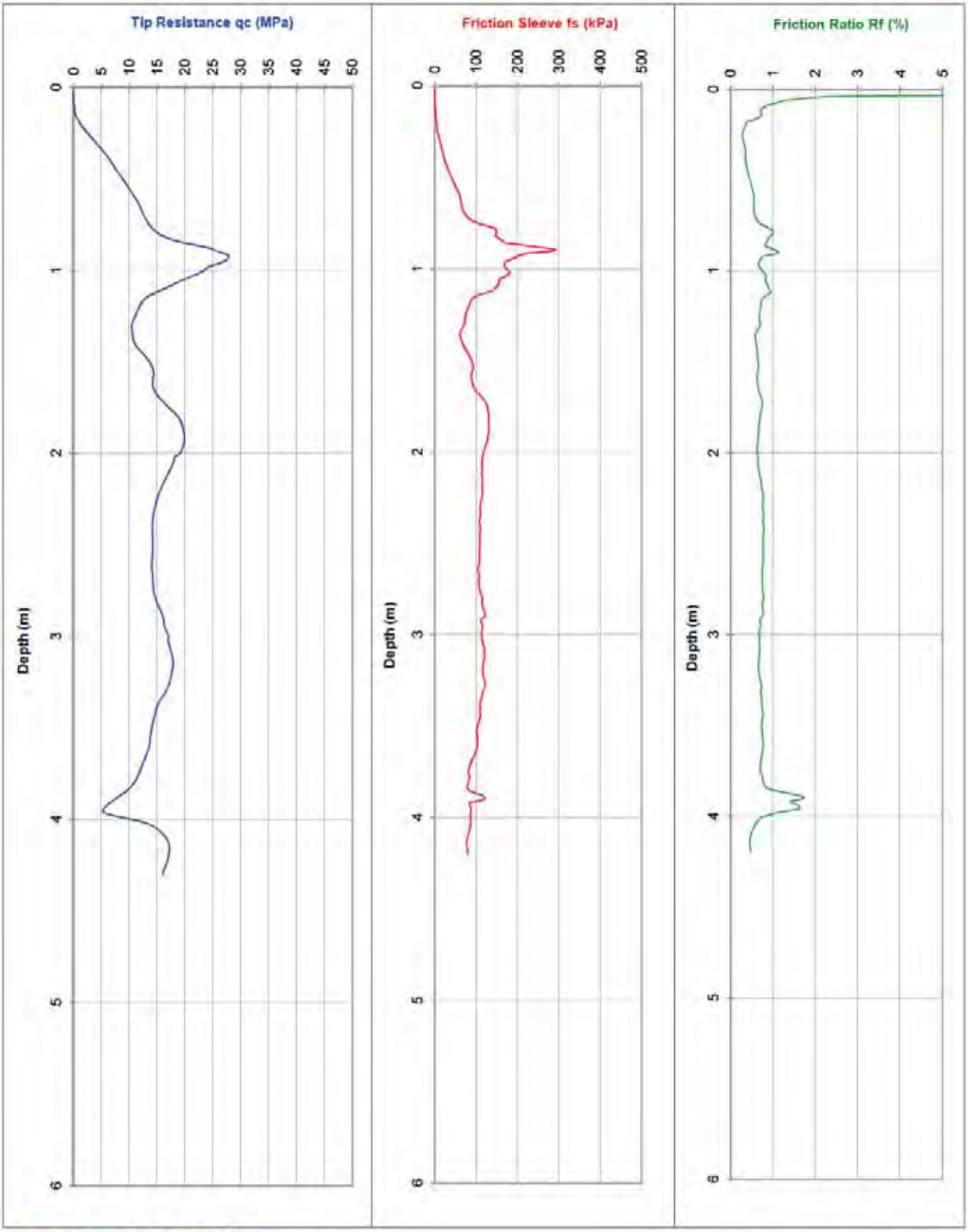
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 3

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0685M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

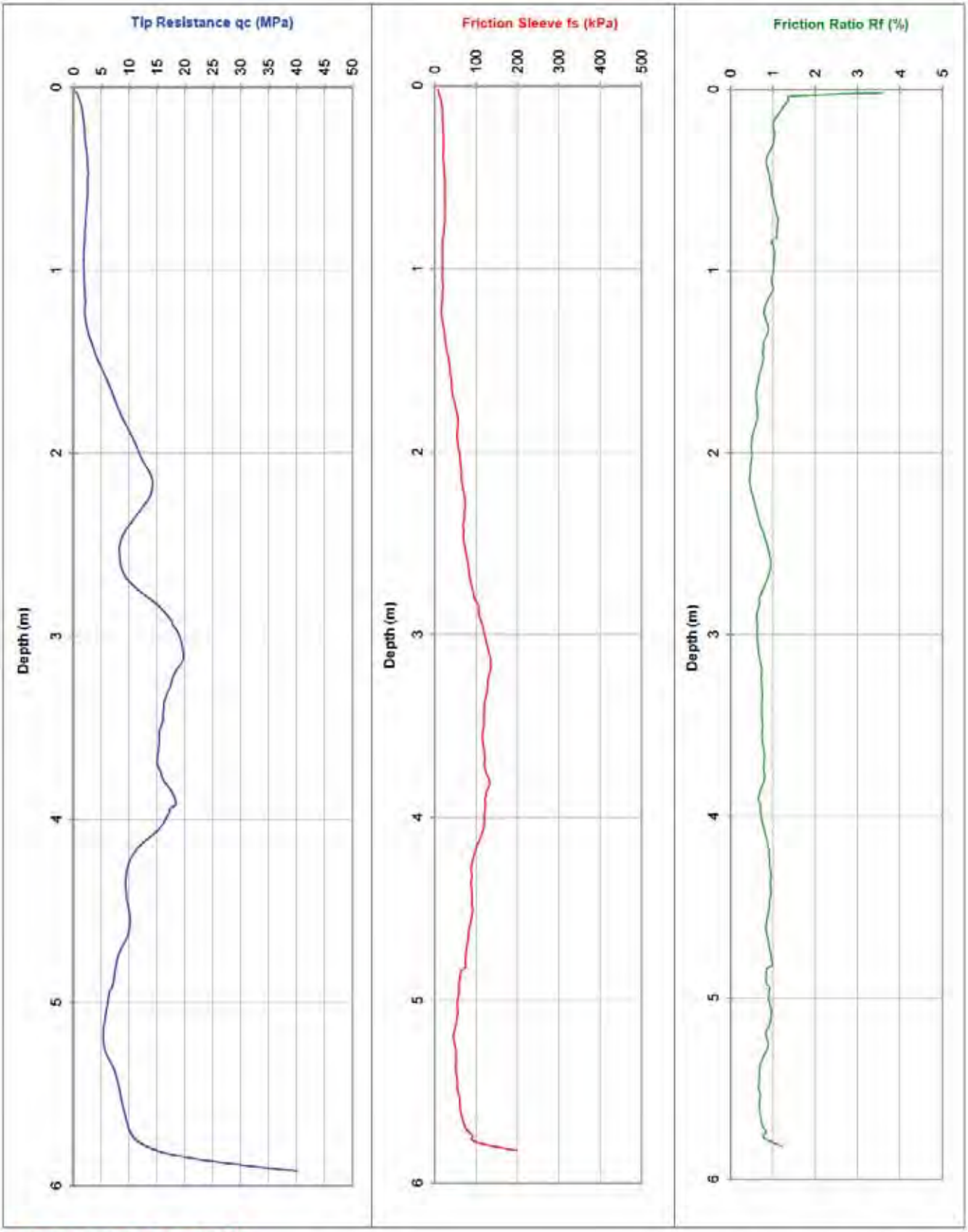
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 4

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): 1.0

Refusal:

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

File: GL0686M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

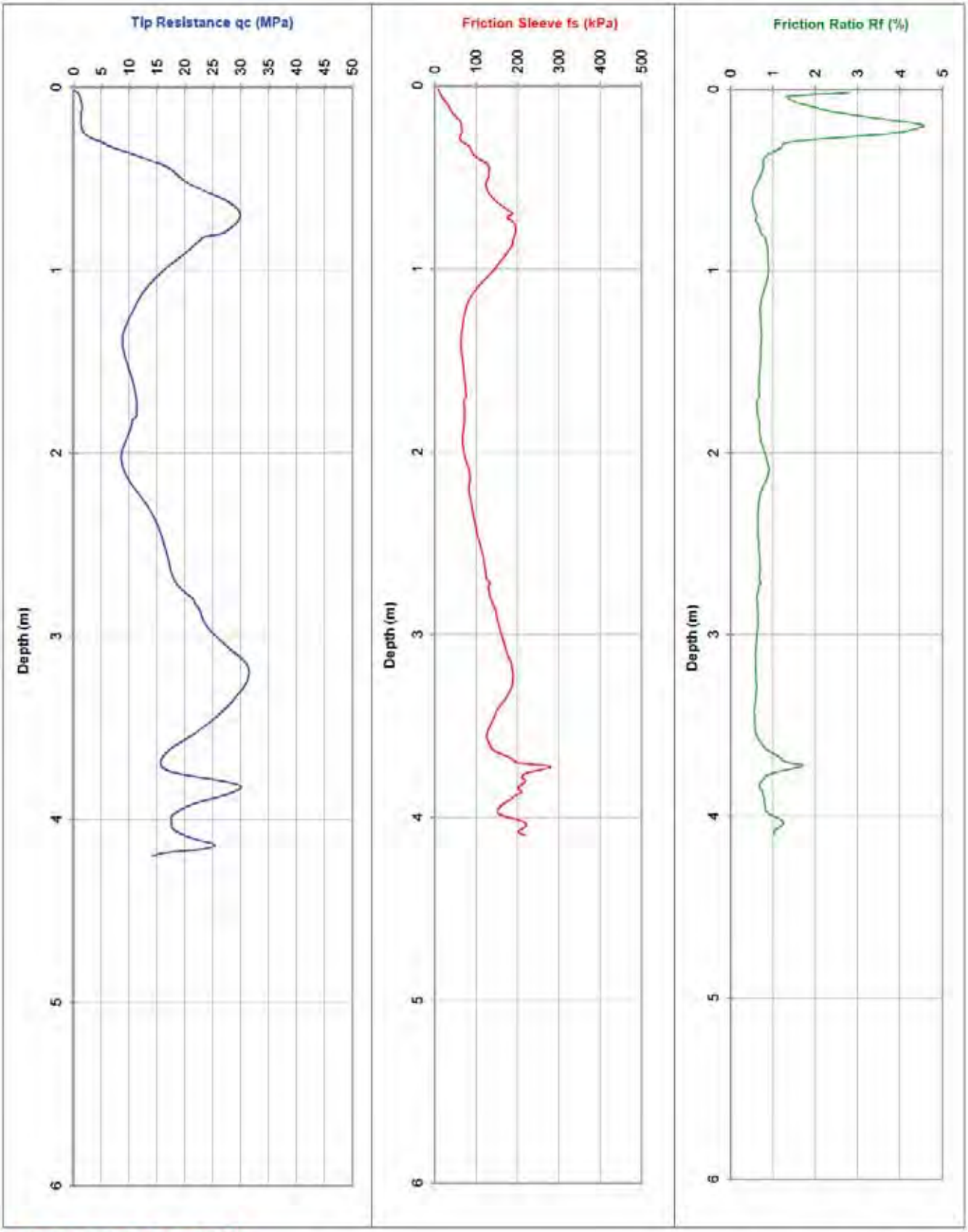
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 5

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0687M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

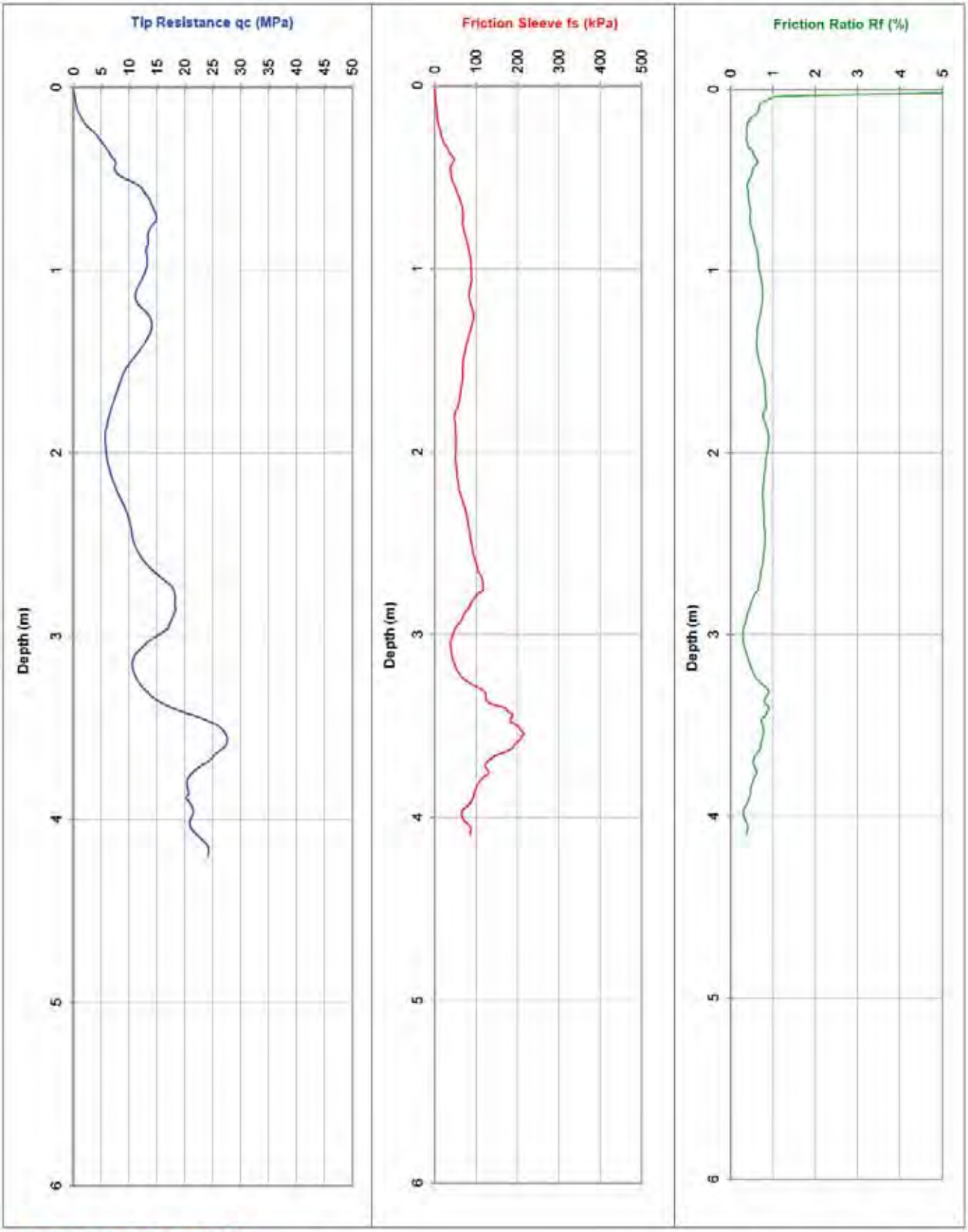
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 6

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0688M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

Appendix E: Permeability Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Permeability Calculation - Inverse Auger Hole Method

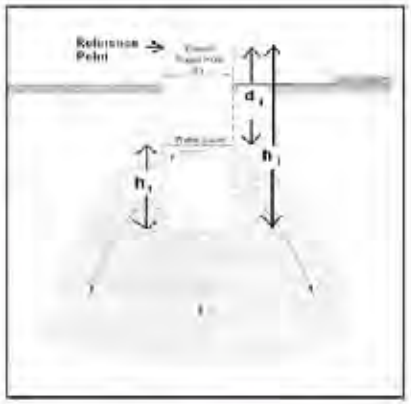
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P01
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 Septembre 2007, pp101-114



Spreadsheet Legend

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	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.75	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

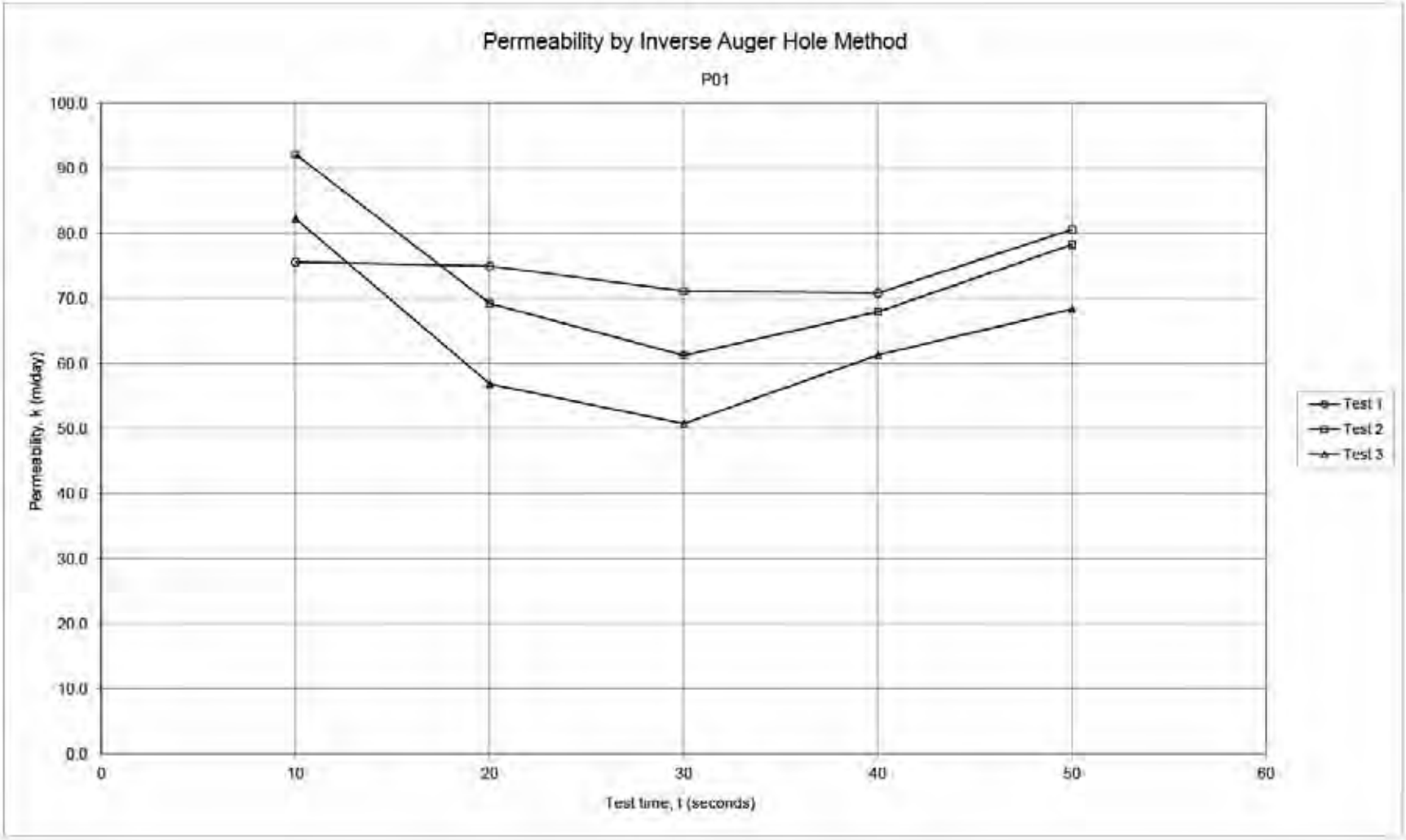
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.46	0.29		
10	0.57	0.18	8.8E-04	75.6
20	0.64	0.11	8.7E-04	75.0
30	0.68	0.07	8.2E-04	71.2
40	0.71	0.04	8.2E-04	70.9
50	0.74	0.01	9.3E-04	80.6
		AVERAGE	8.6E-04	74.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.48	0.27		
10	0.6	0.15	1.1E-03	92.2
20	0.64	0.11	8.0E-04	69.2
30	0.67	0.08	7.1E-04	61.3
40	0.71	0.04	7.9E-04	68.0
50	0.74	0.01	9.1E-04	78.3
		AVERAGE	8.5E-04	73.8

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.48	0.27		
10	0.59	0.16	9.5E-04	82.3
20	0.62	0.13	6.6E-04	56.9
30	0.65	0.1	5.9E-04	50.8
40	0.7	0.05	7.1E-04	61.3
50	0.73	0.02	7.9E-04	68.4
		AVERAGE	7.4E-04	63.9


Permeability by Inverse Auger Hole Method
P01
Permeability, k (m/day)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

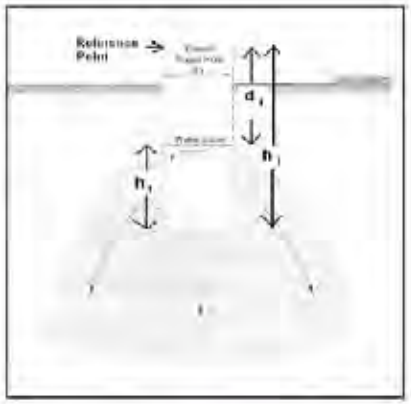
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P02
Test Depth:	0.6 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 Septembre 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	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.6	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 P

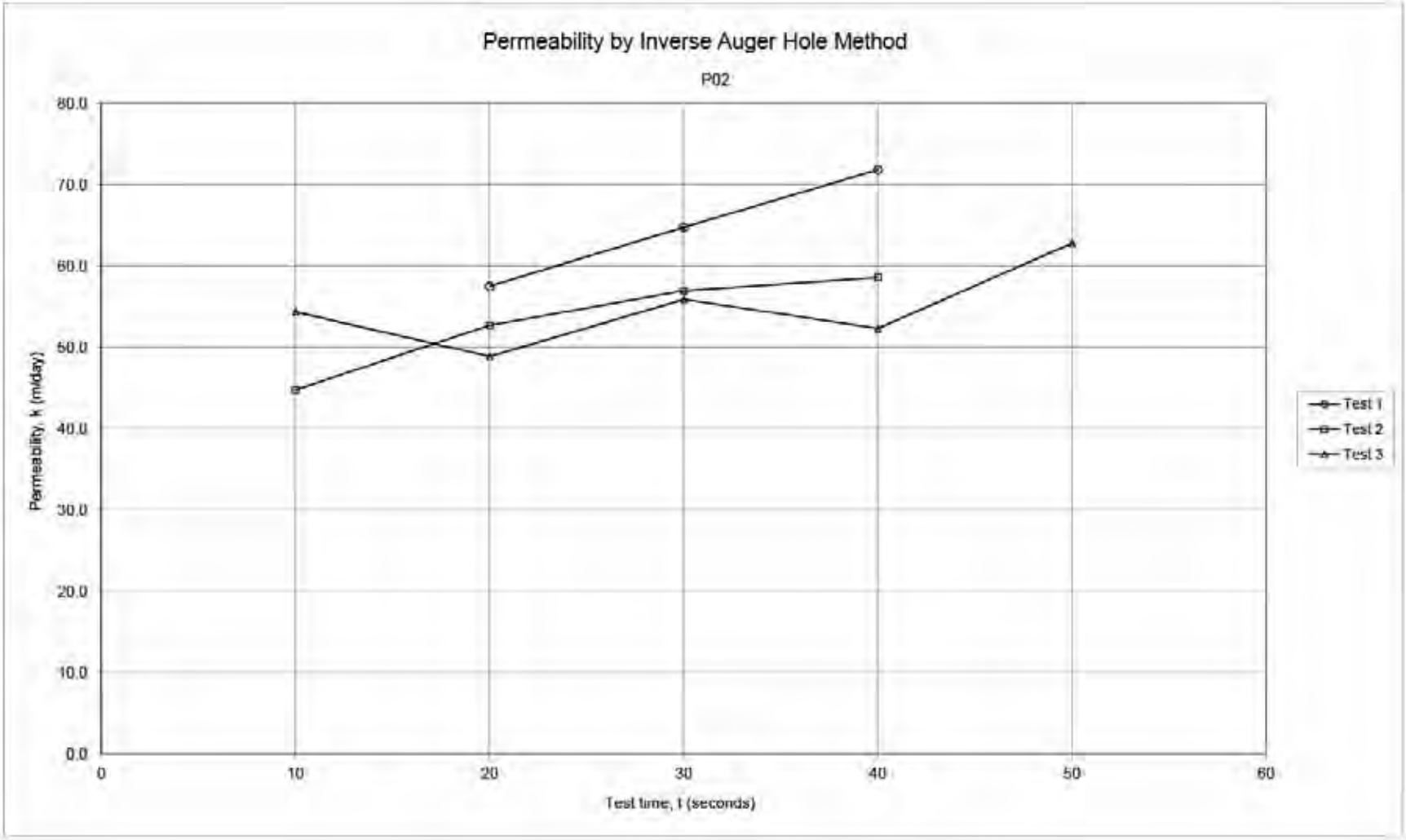
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.35		
20	0.43	0.17	6.7E-04	57.5
30	0.5	0.1	7.5E-04	64.8
40	0.55	0.05	8.3E-04	71.8
		AVERAGE	7.5E-04	64.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.27	0.33		
10	0.35	0.25	5.2E-04	44.8
20	0.43	0.17	6.1E-04	52.7
30	0.49	0.11	6.6E-04	57.0
40	0.53	0.07	6.8E-04	58.6
		AVERAGE	6.2E-04	53.3

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.35		
10	0.35	0.25	6.3E-04	54.4
20	0.41	0.19	5.7E-04	48.9
30	0.48	0.12	6.5E-04	55.9
40	0.51	0.09	6.1E-04	52.3
50	0.56	0.04	7.3E-04	62.8
		AVERAGE	6.4E-04	54.9


Permeability by Inverse Auger Hole Method
P02
Permeability, k (m/day)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

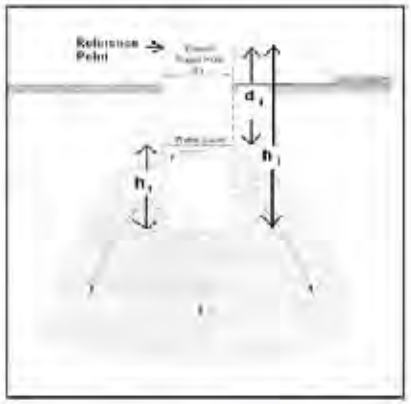
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woolcott Av
Calc by:	MW
BH Name:	P03
Test Depth:	0.6 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 Septembre 2007, pp101-114



Spreadsheet Legend

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

Parameter	Description	Value	Units
K	Permeability	X	m/s
r	radius of test hole	0.04	m
t	time since start of measurement	X	s
h_r	reference point height above base	0.6	m
d_t	depth from reference point to water at time t	X	m
h_t	Water column height at time t	X	m
h_0	h_t at t=0	X	m

Test 1

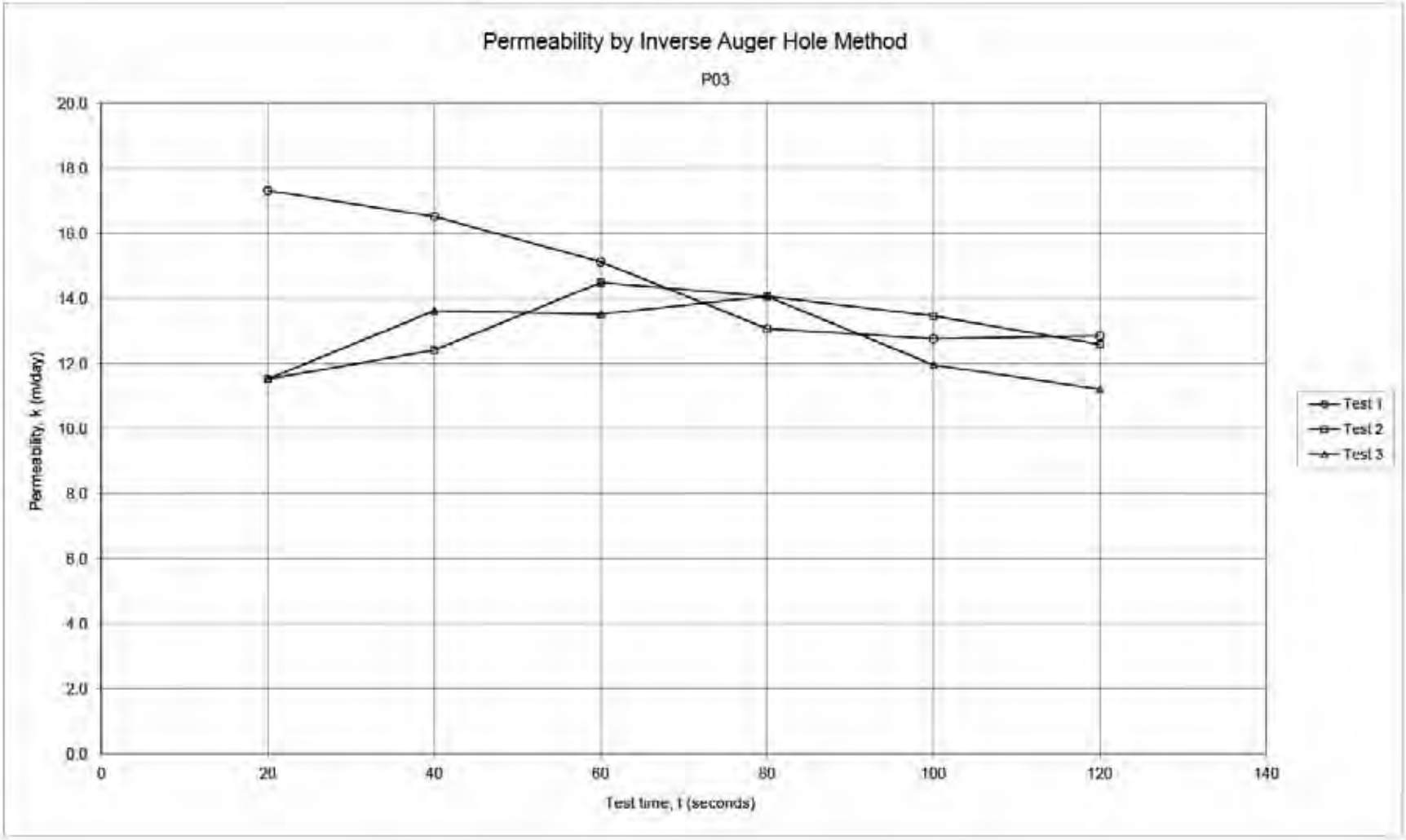
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.4	0.2	X	X
20	0.44	0.16	2.0E-04	17.3
40	0.47	0.13	1.9E-04	16.5
60	0.49	0.11	1.8E-04	15.1
80	0.5	0.1	1.5E-04	13.1
100	0.515	0.085	1.5E-04	12.8
120	0.53	0.07	1.5E-04	12.9
		AVERAGE	1.7E-04	14.6

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.38	0.22	X	X
20	0.41	0.19	1.3E-04	11.5
40	0.44	0.16	1.4E-04	12.4
60	0.475	0.125	1.7E-04	14.5
80	0.495	0.105	1.6E-04	14.1
100	0.51	0.09	1.6E-04	13.5
120	0.52	0.08	1.5E-04	12.6
		AVERAGE	1.5E-04	13.1

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.38	0.22	X	X
20	0.41	0.19	1.3E-04	11.5
40	0.445	0.155	1.6E-04	13.6
60	0.47	0.13	1.6E-04	13.5
80	0.495	0.105	1.6E-04	14.1
100	0.5	0.1	1.4E-04	12.0
120	0.51	0.09	1.3E-04	11.2
		AVERAGE	1.5E-04	12.7


Permeability by Inverse Auger Hole Method
P03
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
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

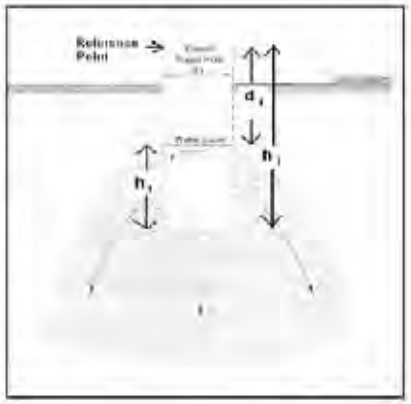
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P04
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 Septembre 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	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.85	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

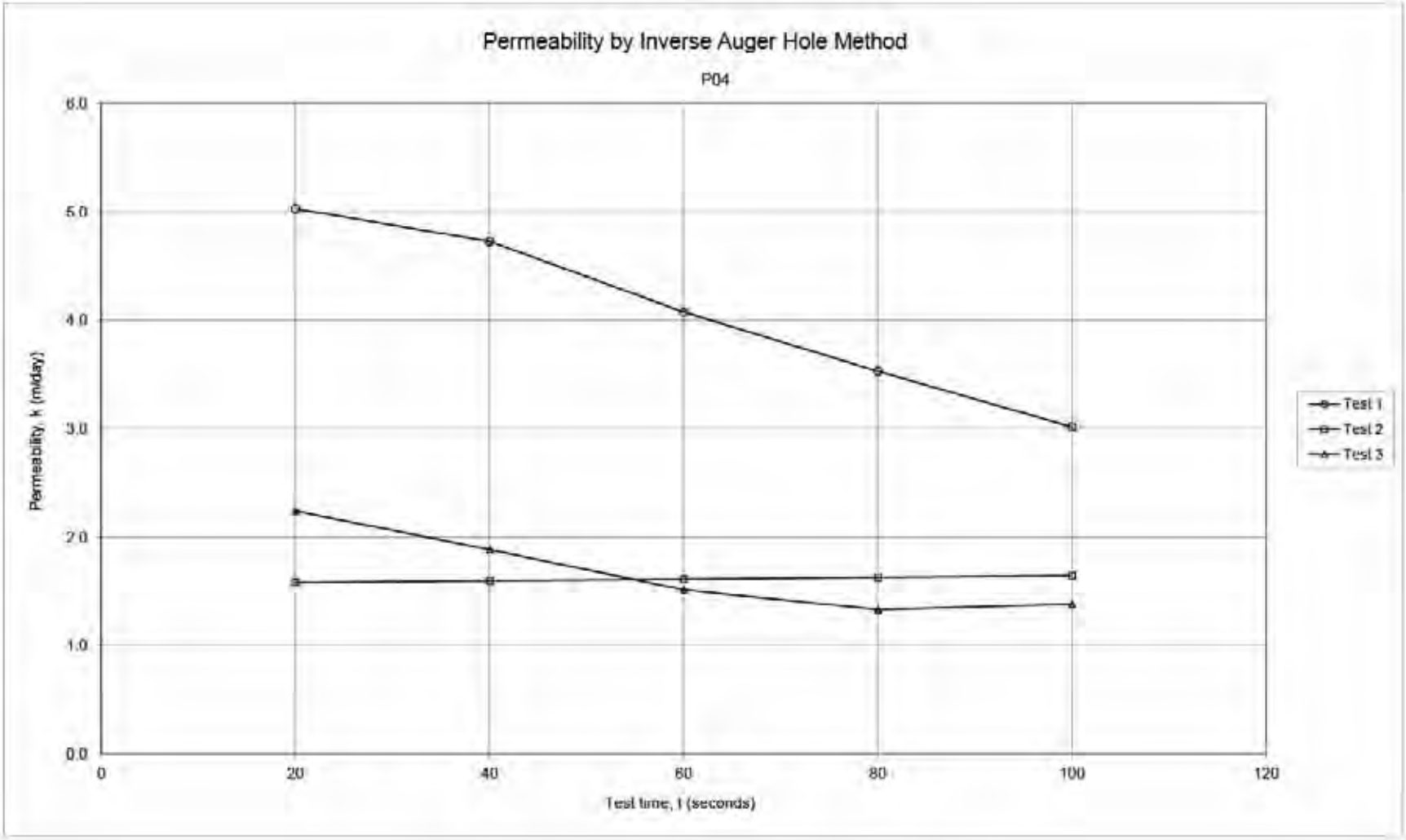
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.34	0.51		
20	0.37	0.48	5.8E-05	5.0
40	0.395	0.455	5.5E-05	4.7
60	0.41	0.44	4.7E-05	4.1
80	0.42	0.43	4.1E-05	3.5
100	0.425	0.425	3.5E-05	3.0
		AVERAGE	4.7E-05	4.1

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.32	0.53		
20	0.33	0.52	1.8E-05	1.6
40	0.34	0.51	1.8E-05	1.6
60	0.35	0.5	1.9E-05	1.6
80	0.36	0.49	1.9E-05	1.6
100	0.37	0.48	1.9E-05	1.6
		AVERAGE	1.9E-05	1.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.285	0.585		
20	0.3	0.55	2.6E-05	2.2
40	0.31	0.54	2.2E-05	1.9
60	0.315	0.535	1.8E-05	1.5
80	0.32	0.53	1.5E-05	1.3
100	0.33	0.52	1.6E-05	1.4
		AVERAGE	1.9E-05	1.7


Permeability by Inverse Auger Hole Method
P04
Permeability, k (m/day)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix F: Laboratory Test Results

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2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022 Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/736
Sample No:	P15/736
Issue Date:	19 February 2015

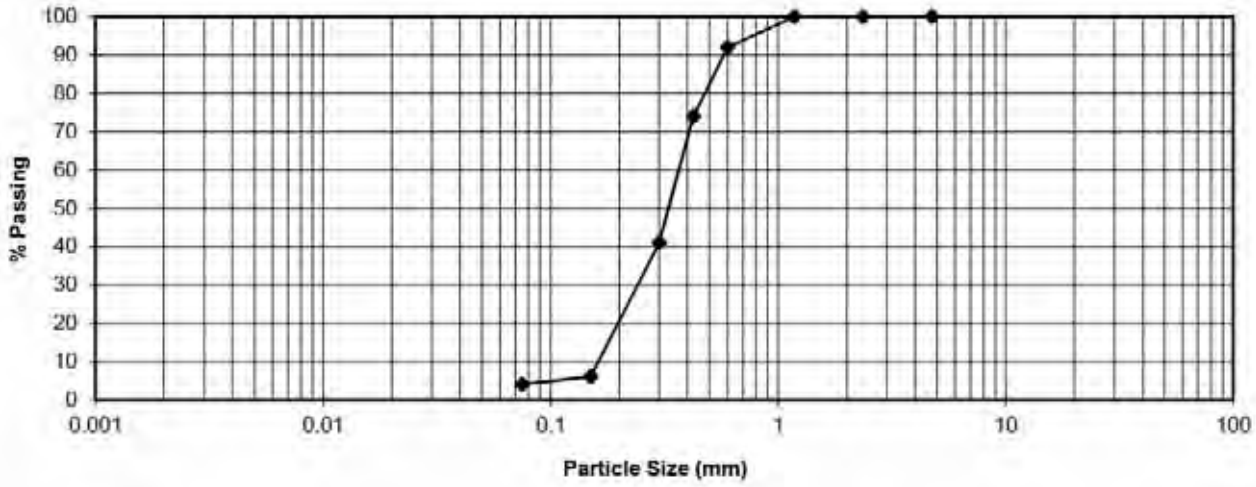
Client: Galt Geotechnics (J1501018)

Project: ABN Group

Location: DD SI, Brabham

Sample location: TP 05

Sample Depth (m): 0.9 - 1.1



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	92
0.425	74
0.300	41
0.150	6
0.075	4

Plasticity index tests

AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025

Accreditation No 15545

Approved signature

Matthew van Herk

AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022 Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/737
Sample No:	P15/737
Issue Date:	19 February 2015

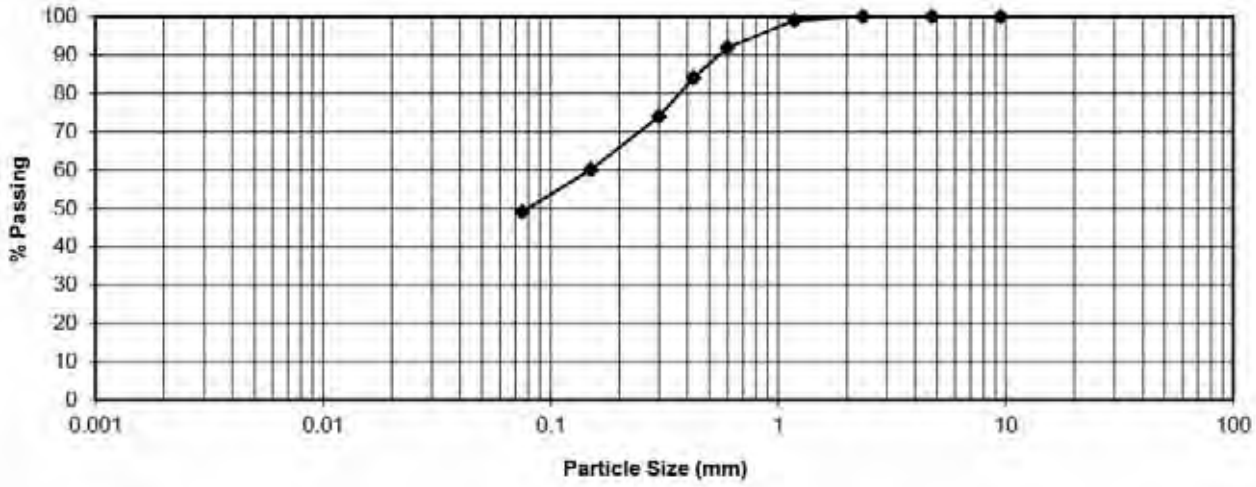
Client: Galt Geotechnics (J1501018)

Project: ABN Group

Location: DD SI, Brabham

Sample location: TP 07

Sample Depth (m): 0.0 - 0.15



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	99
0.600	92
0.425	84
0.300	74
0.150	60
0.075	49

Plasticity index tests

AS 1289

Liquid limit 3.1.1	29	%
Plastic limit 3.2.1	13	%
Plasticity index 3.3.1	16	%
Linear shrinkage 3.4.1	6.5	%

Cracked ☑

Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025

Accreditation No 15545

Approved signature

Matthew van Herk

AS PSDPI May 2009

Mining & Civil Geotest Pty Ltd

Ph (08) 9414 8022 Fax (08) 9414 8011

Email matt@mcgeotest.com.au

Unit 1/1 Pusey Road, JANDAKOT WA 6164

Organic content of Soils
ASTM: D 2974-07a
Test Method C

Job No: 60083

Report No: 60083-P15/736

Date of issue: 19 February 2015

Client: Gult Geotechnics (J1501018)

Project: ABN Group

Location: DD SL Brabham

Date tested: 12 February 2015

Tested by: P Culverston

Checked: K M Jones

Sample Number	Sample Identification & Depth (m)	Ash content %	Organic content %
P15/736	TP 05, 0.9 - 1.1	96.0	4.0

Tested as received | Furnace temperature 440^{oc}

Client address: 2/39 Flynn St, Wembley WA

Approved Signature Matthew van Herk

Appendix G: Understanding Your Report

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical 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 geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. 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 geotechnical problems 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 geotechnical 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 geotechnical engineering 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 design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical 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 as a consequence 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 geotechnical 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 as a result of anthropogenic events (such as construction 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 engineering 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 engineering judgement and opinion.

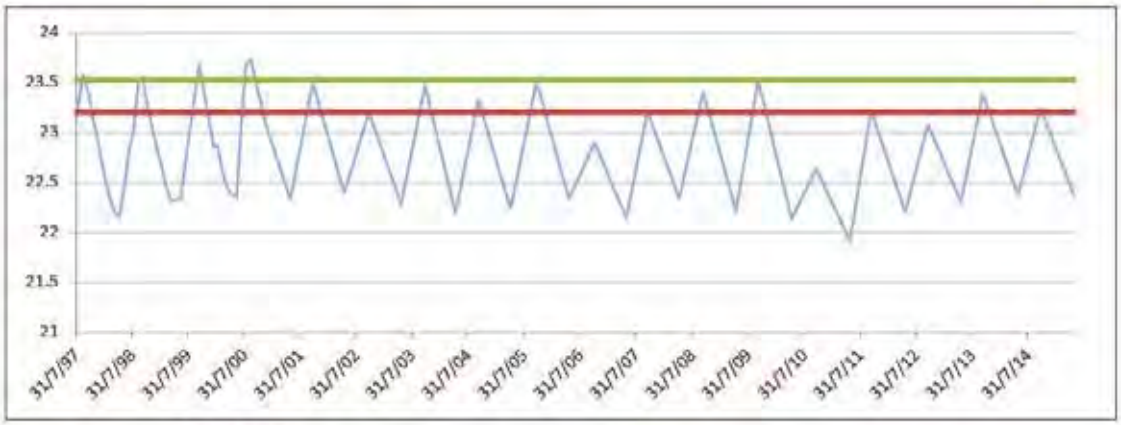
The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot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

7. ENVIRONMENTAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.

APPENDIX E: MAXIMUM GROUNDWATER LEVEL AND BORE LOGS

Maximum Groundwater Calculations



DoW Bore	MM71B
Win Site	14136052
Site Ref	61618444
Record Start	31/07/1997
Record End	26/05/2015

Year	Max GWL (mAHD)	Year	Max GWL (mAHD)
16/09/1997	23.58		
8/10/1998	23.56		
12/10/1999	23.89		
15/09/2000	23.73		
23/10/2001	23.50		
24/10/2002	23.20		
23/10/2003	23.47		
6/10/2004	23.33		
21/10/2005	23.51		
2/11/2006	22.90		
15/10/2007	23.21		
10/10/2008	23.40		
5/10/2009	23.52		
18/10/2010	22.64		
10/10/2011	23.22		
16/10/2012	23.08		
8/10/2013	23.38		
21/10/2014	23.24		
26/05/2015	22.37		

Maximum GWL (mAHD)	23.52
AAMGL (mAHD)	23.20

360 Environmental Measurement

Date	23/09/2015	Reading	23.07

Correction

Maximum GWL (m)	0.45
AAMGL (m)	0.13

360 Environmental Bores

Date

Bore	GWL	AAMGL	MaxGWL
PB01	25.45	25.58	25.90
PB02	24.45	24.57	24.90
PB03	26.48	26.61	26.93
PB04	25.54	25.67	25.99
PB05	26.70	26.82	27.14
PB06	26.15	26.27	26.60
PB07	28.26	28.39	28.71
PB08	27.50	27.63	27.95
PB09	28.32	28.45	28.77
PB10	28.07	28.19	28.51

Notes:

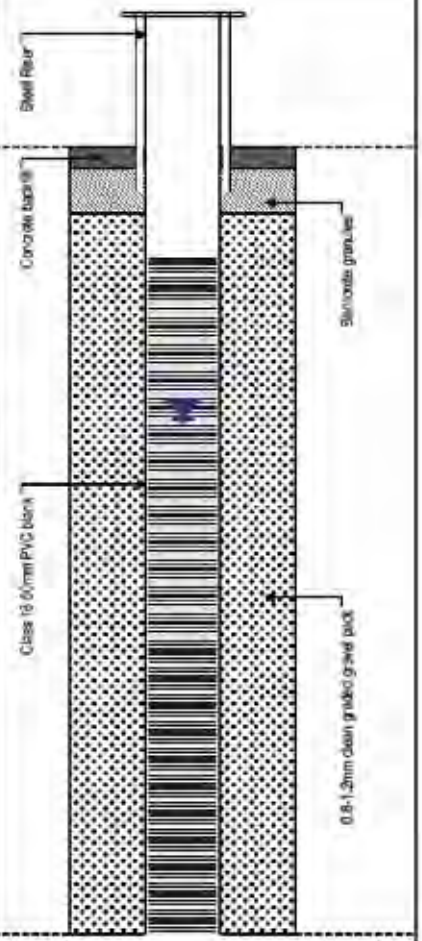
Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: South Left Corner

Borehole Number: PB01
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 043236
Northing: 6479031

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SP SAND, fine to medium grained, pale grey	M
				0.5			
				1.0			
							W
				1.5			
				2.0			
				2.5			
				3.0		SP SAND, fine to medium grained, pale grey to white	
				3.5		End of Log	



Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: South Left Corner

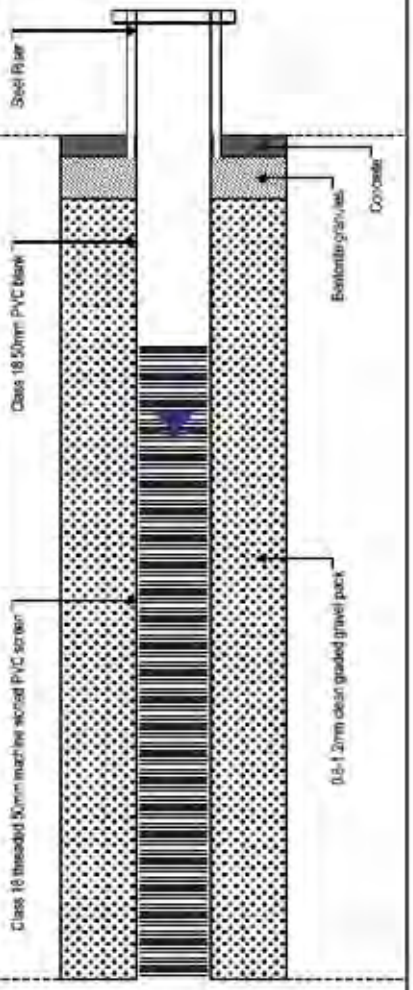
Borehole Number: PB02
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403252
Northing: 6478304

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SP SAND, fine to medium grained, grey	M
				1.5			W
						SP clayey SAND, fine to medium grained, low plasticity, brown, silt lines, "coffee rock"	
				2.5			
						SP clayey SAND, coarse grained, low plasticity, blue grey	
				3.5			
						CH CLAY, high plasticity, grey	
				4.0		End of Log	

Groundwater Bore Installation



Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1052
Borehole Location: South Right Corner

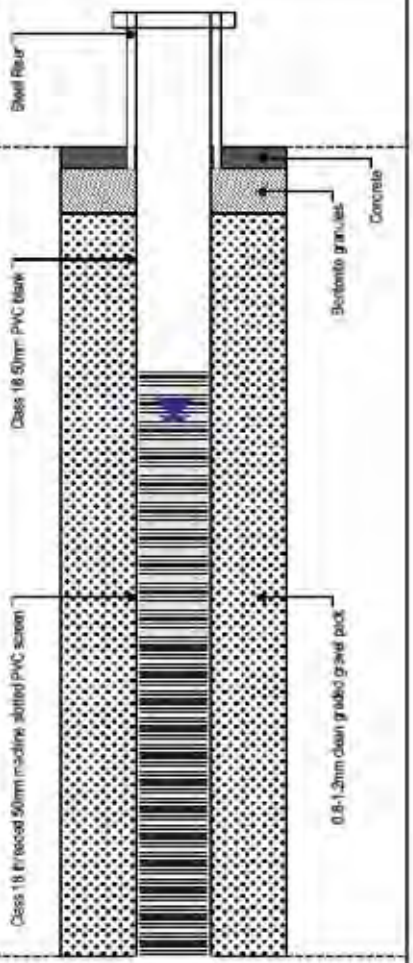
Borehole Number: PB03
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403056
Northing: 6478433

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SP SAND, fine to medium grained, yellow-brown	M
				0.5		SP SAND, coarse grained, pale grey-white	
				1.0			
				1.5			W
						SM SAND, fine to medium grained, moderately sorted, brown-grey	
				2.0		SP SAND, coarse grained, pale grey white	
				2.5			
				3.0			
				3.5			
						End of Log	

Groundwater Bore Installation



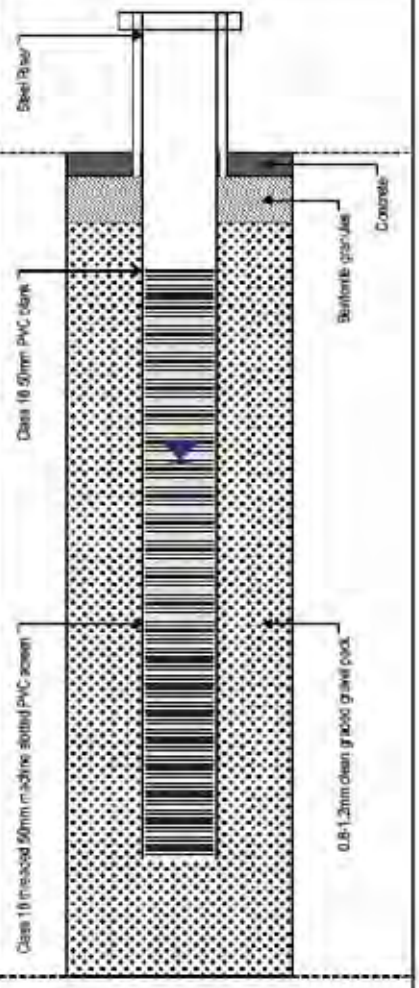
Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: Eastern Boundary

Borehole Number: PB04
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403236
Northing: 6478460

Drilling and Sampling					Material and Substance			
Penetration				Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Groundwater Bore Installation
1	2	3	4					
						Ground Surface		
				0.0		SM SAND, fine to medium grained, moderately sorted, brown	M	
				0.5		SP SAND, fine to medium grained, grey		
				1.0			W	
				1.5		SP SAND, coarse grained, silt lines, brown		
				2.0				
				2.5		SP SAND, coarse grained, silt, grey		
				3.0		SP SAND, coarse grained, brown grey		
				3.5		End of Log		



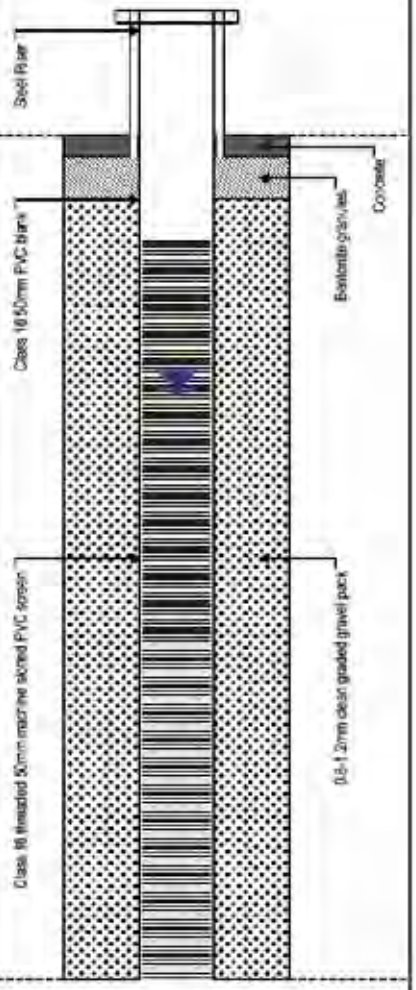
Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: Eastern Boundary

Borehole Number: PB05
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403112
Northing: 6478536

Drilling and Sampling				Material and Substance			
Penetration				Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
1	2	3	4				
				0.0		Ground Surface	
						SM SAND, fine to medium grained, dark grey	M
				0.5		SM SAND, coarse grained, pale grey	
				1.0		SM SAND, fine to medium grained, dark grey	W
				1.5			
				2.0			
				2.5		SM SAND, fine to medium grained, pale grey	
				3.0			
				3.5			
				4.0		End of Log	



Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: Eastern Boundary

Borehole Number: PB06
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403241
Northing: 6478556

Drilling and Sampling					Material and Substance			
Penetration				Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Groundwater Bore Installation
1	2	3	4					
						Ground Surface		Steel Riser
				0.0		SM SAND, fine to medium grained, pale grey	M	Concrete
				0.5				Bentonite granules
				1.0		SM SAND, fine to medium grained, moderately sorted, brown/grey	W	Class 16 50mm PVC blank
				1.5		SP SAND, fine to medium grained, grey		
				2.0				Class 16 machine slotted PVC screen
				2.5				0.8-1.2mm clean graded gravel pack
				3.0				
				3.5		End of Log		

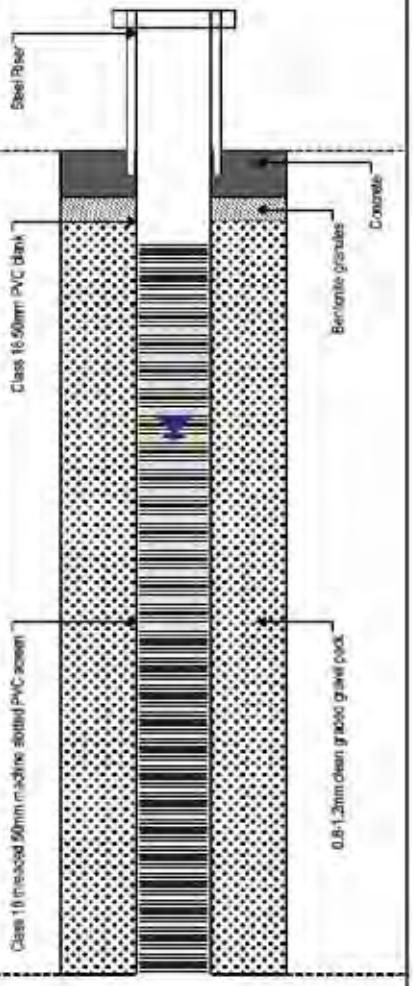
Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: Eastern Boundary

Borehole Number: PB07
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403048
Northing: 6478870

Drilling and Sampling				Material and Substance				
Penetration								
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition	Groundwater Bore Installation
				0.0		Ground Surface		
						SP SAND, fine to medium grained, grey	M	
				0.5		CL CLAY, low plasticity, yellow brown "coffee rock"		
						SP SAND, fine grained, white		
				1.0		SM SAND, fine to medium grained, yellow	W	
						SP SAND, coarse grained, white		
				1.5				
						SM SAND, fine to medium grained,brown		
				2.0				
				2.5				
				3.0		SM SAND, fine to medium grained, pale grey		
				3.5		End of Log		



360 environmental

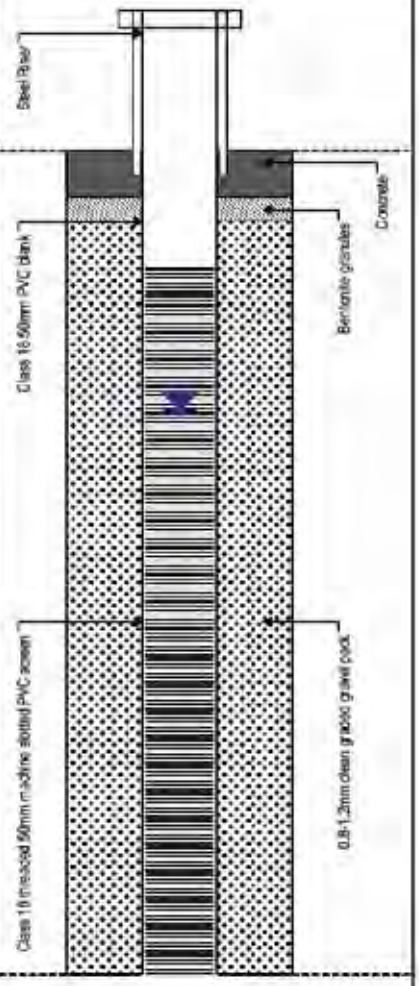
Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1062
Borehole Location: Eastern Boundary

Borehole Number: PB08
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403236
Northing: 6478807

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SP SAND, fine to medium grained, grey	M
				0.5		SP SAND, fine to medium grained, pale grey	
				1.0			W
				1.5		SM SAND, fine to medium grained, greySAND, fine to medium grained, yellow	
						SP SAND, fine to medium grained, pale grey	
				2.0		SP SAND, fine to medium grained, dark brown	
				2.5		SP SAND, fine to medium grained, grey	
				3.0			
				3.5		End of Log	



Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1052
Borehole Location: Northern Corner

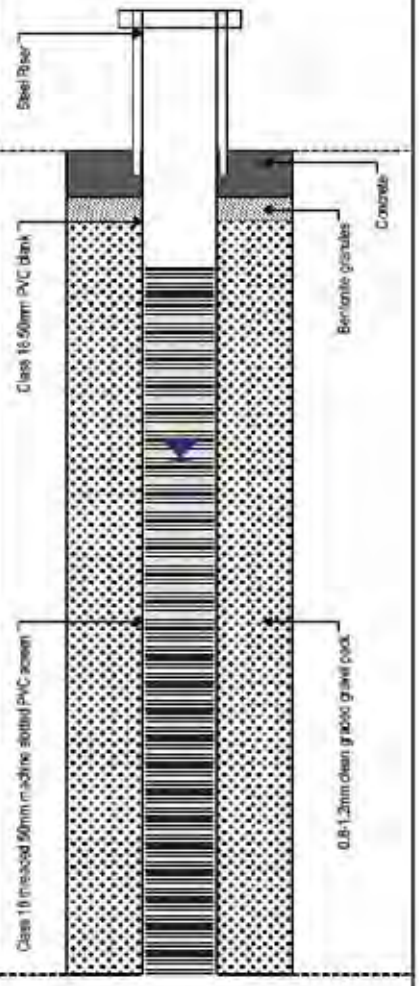
Borehole Number: PB09
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

Easting: 0403067
Northing: 6478927

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SM SAND, fine to medium grained, moderately sorted, brown	M
				0.5		**SC** Sandy CLAY, fine to medium grained, high plasticity, orange-brown, gravel inclusions "coffee rock"	
				1.0		**SM** SAND, coarse grained, yellow	W
				1.5			
						SW SAND, coarse grained, silt fines, grey brown	
				2.0			
				2.5			
				3.0		**SP** SAND, fine to medium grained, grey	
				3.5		End of Log	

Groundwater Bore Installation



Client: ABN Group
Project: Brabham LWMS
360 Job Number: 1052
Borehole Location: North East Corner

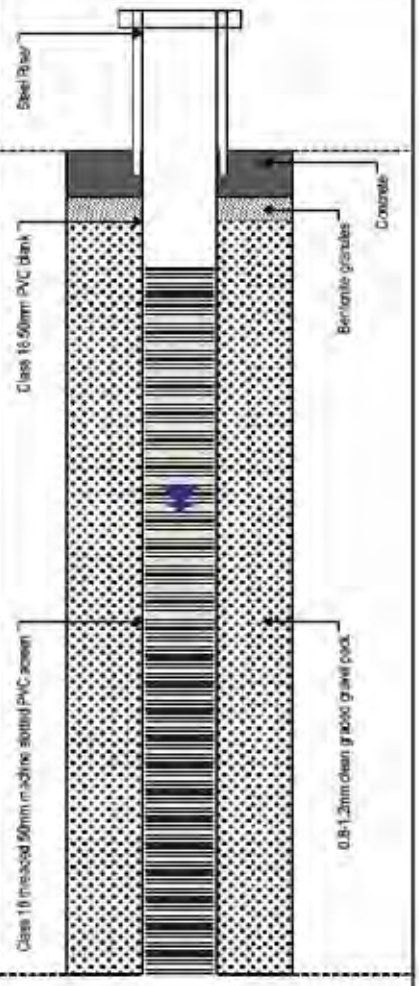
Borehole Number: PB10
Sheet: 1 of 1
Date: 21/05/2015
Logged By: SA

Drill Model: Direct Push Probing
Hole Diameter: 75mm

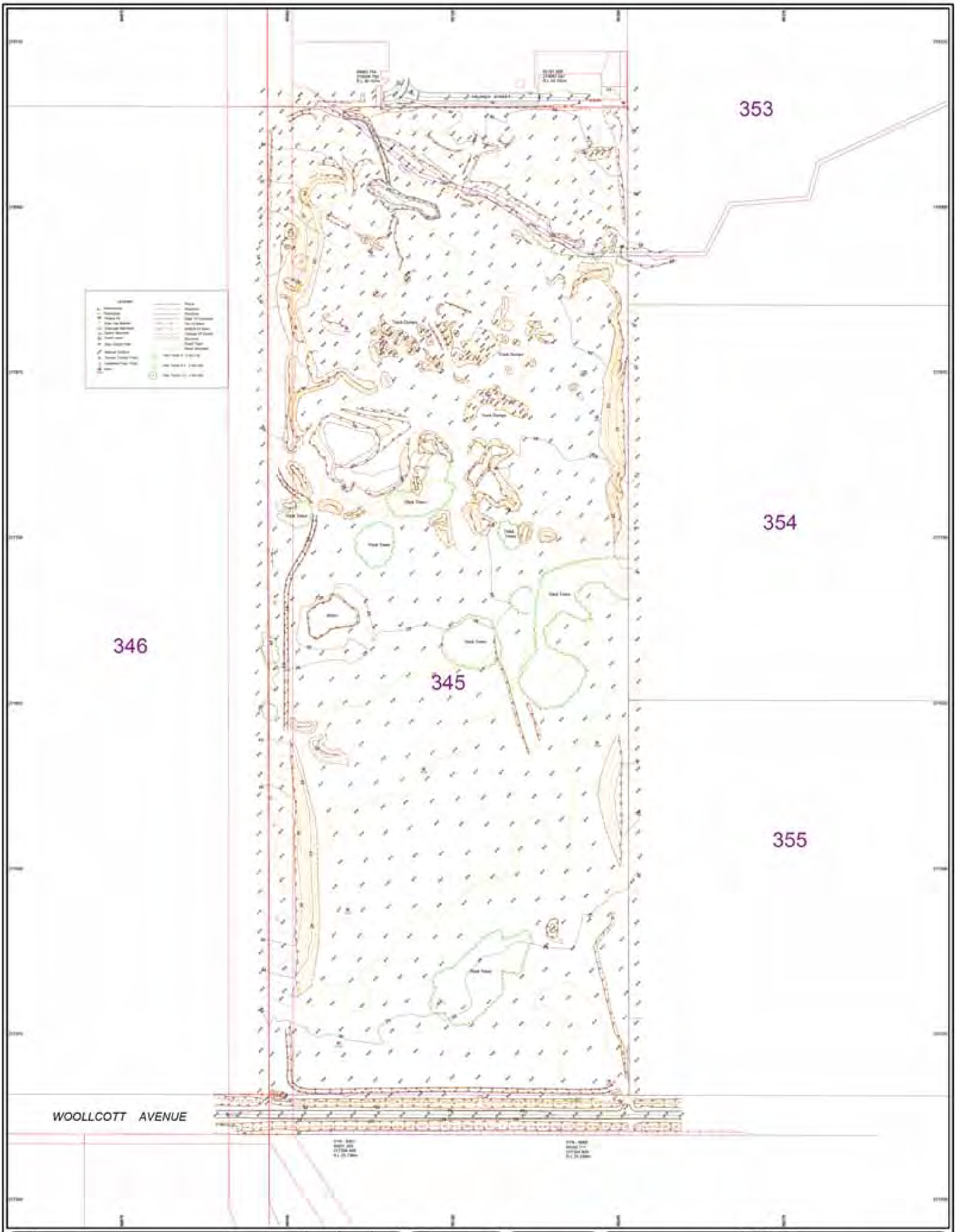
Easting: 0403236
Northing: 6479031

Drilling and Sampling				Material and Substance			
Penetration							
1	2	3	4	Depth (m)	Graphical Log	Lithologic Description	Moisture Condition
				0.0		Ground Surface	
						SP SAND, fine to medium grained, pale grey	M
				0.5			
				1.0			W
				1.5			
				2.0			
				2.3		SM SAND, fine to medium grained, moderately sorted, brown/black "coffee rock"	
				2.5			
				3.0		SP SAND, coarse grained, grey	
				3.5		End of Log	

Groundwater Bore Installation



APPENDIX F: DETAILED SITE SURVEY



Rev.	Description	Drawn	Date	Checked
B	Northern Creek Detail Updated			
A	Initial Issue			

BRABHAM
LOT 345 (#178) WOOLLCOTT AVENUE
DETAIL SURVEY

CLIENT: BRABHAM 2015 PTY LTD

ALL DISTANCES ARE IN METRES

MNG.

99276 - DE - 001 - B

APPENDIX G: FLORA AND FAUNA DATABASE SEARCH

NatureMap

NatureMap Species Report

Created By Guest user on 23/06/2015

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115°56' 35" E,31°49' 23" S
Buffer 1km
Group By Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	4	4
TOTAL	**4**	**4**

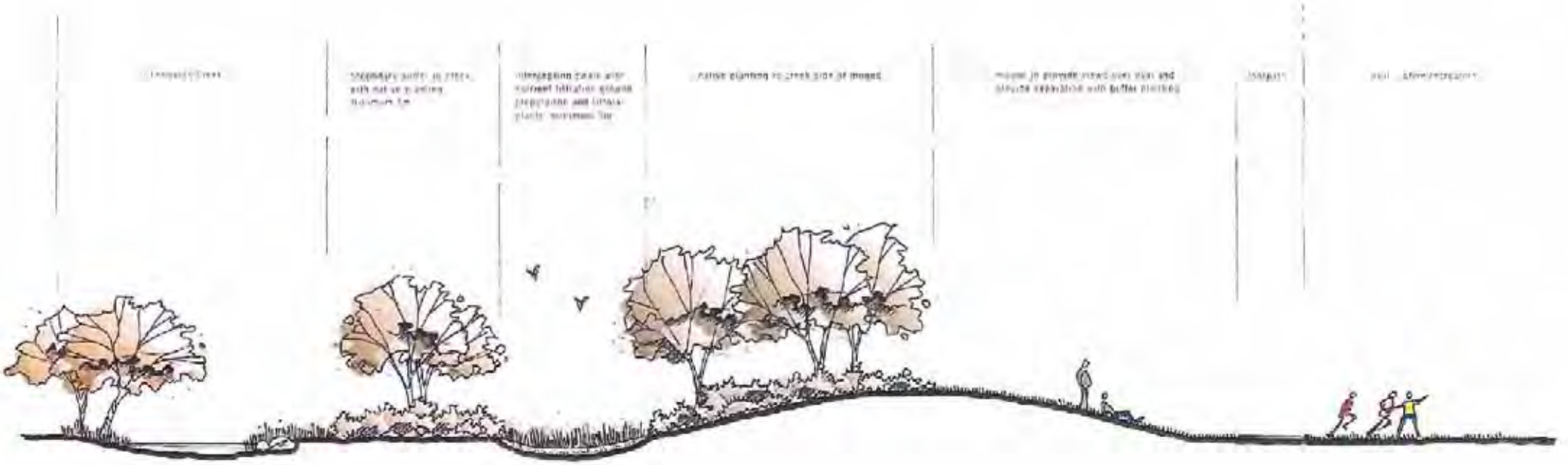
	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Non-conservation taxon					
1	1117	*Aphelia cyperoides*			
2	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
3	1190	*Juncus planifolius (Broadleaf Rush)*			
4		*Notiaspermus glaumfi*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX H: DSP ST LEONARDS CREEK CROSS SECTIONS

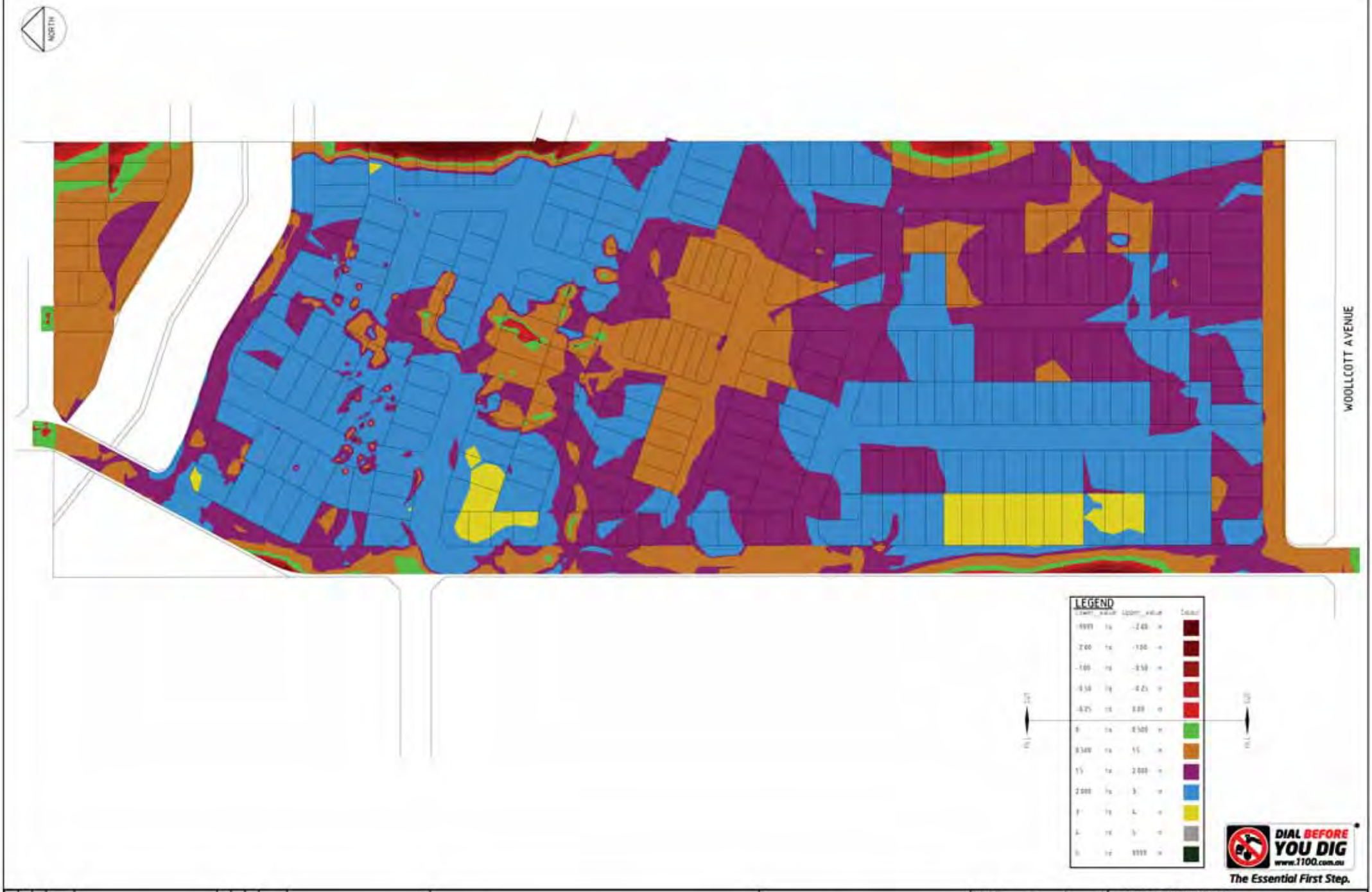
(JDA, 2008)



typical section of active open space and St Leonards Creek

APPENDIX I: PRELIMINARY EARTHWORK DESIGNS

(Pritchard Francis, 2016)



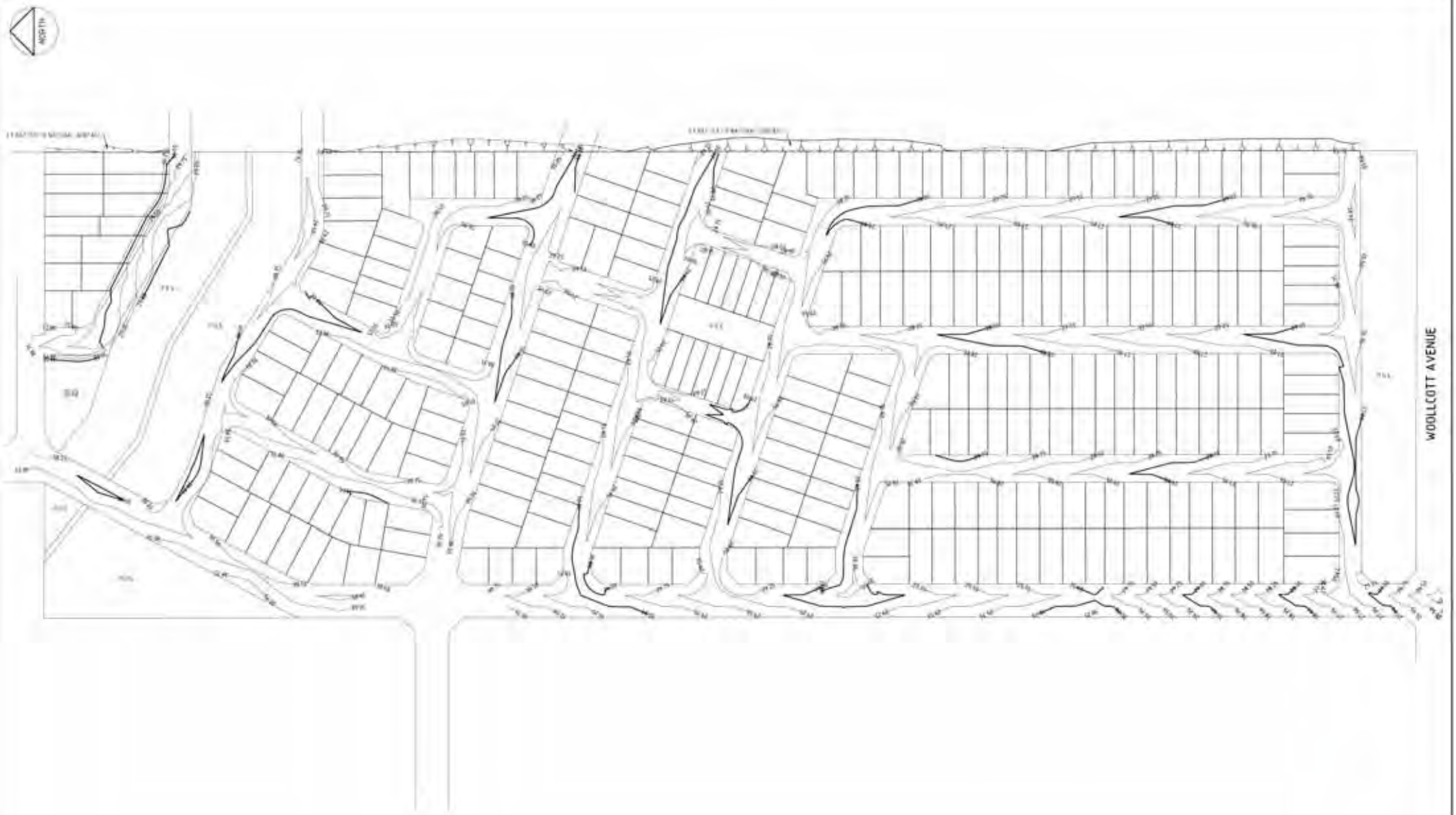
DIAL BEFORE YOU DIG
www.1100.com.au
The Essential First Step.

PRELIMINARY
NOT FOR CONSTRUCTION

pritchard francis

ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
CUT & FILL DEPTH LOCATION PLAN

A1 | 15006-C9-SK-04 | A



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PRELIMINARY
NOT FOR CONSTRUCTION

pritchard francis

ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
ROAD CONTOURS PLAN

A1 | 15006-C9-SK-08 | B

SITE PLAN

SECTION A

SECTION B

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The Essential First Step.

CONCEPT
FOR DISCUSSION ONLY

pritchard francis

ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
PROPOSED FORSHORE INTERFACE CONCEPT

A1 | 15006-C9-SK-14 | B

APPENDIX 3

Fire Management Plan - Natural Area Consulting

Natural Area
CONSULTING MANAGEMENT SERVICES

ABN Group

Fire Management Plan
Lot 345 Woollcott Ave, Brabham

05 August 2015

Natural Area Holdings Pty Ltd
99C Lord Street, Whiteman, WA, 6076
Ph: (08) 9209 2767
Fax: (08) 9209 2768
info@naturalarea.com.au
www.naturalarea.com.au

Disclaimer

Natural Area Holdings Pty Ltd, trading as Natural Area Consulting Management Services (Natural Area), has prepared this Fire Management Plan for use by:

- ABN Group
- City of Swan
- Purchasers of Lots in designated fire prone areas.

Natural Area has exercised due and customary care in the preparation of this document and has not, unless specifically stated, independently verified information provided by others. No other warranty, expressed or implied, is made in relation to the contents of this report. Therefore, Natural Area assumes no liability for any loss resulting from errors, omission or misrepresentations made by others. This document has been made at the request of the Client. Any recommendations, opinions or findings stated in this report are based on circumstances and facts as they existed at the time Natural Area performed the work. Any changes in such circumstances and facts upon which this document is based may adversely affect any recommendations, opinions or findings contained in this document.

Document Control

Document Title	2015 07 03 NAC ABN REPT Fire Management Plan, Lot 345 Woollcott Ave, Brabham				
Location	\\10.0.0.210\DropBox\Drop Box\Client Folders - NAC\ABN Group, Property Developers\Fire Management Plan - Brabham\				
Version No.	**Date**	**Changes**	**Prepared by**	**Approved by**	**Status**
1	05/08/2015	New Document	SB	LS	Final

Contents

1.0 Introduction

Natural Area Consulting (NAC), a division of Natural Area Holdings Pty Ltd, was commissioned by ABN Group to prepare a Fire Management Plan for Lot 345 Woollcott Ave, Brabham, within the City of Swan. The site is located approximately 25 km north east of the Perth Central Business District and is 20.12 ha. The lot is bounded by Woollcott Avenue to the south, and private land to the west, north and east (Figure 1). The majority of development site is vegetated with grassland and occasional areas of woodland.

Many Australian ecosystems require bushfire at regular intervals as part of their natural lifecycle. Vegetation within these ecosystems have developed characteristics which promote the spread of fire, such as flammable bark, dry coarse leaf litter and leaves which contain flammable oils (CSIRO, 2008). Accordingly, residential areas in proximity to remnant native vegetation are at risk from bushfire impacts such as smoke, ember attack and radiant heat. In knowing the risks, it is possible to identify varying mitigation strategies that allow urban development to occur in proximity to remnant bushland areas. Note that individual landowners will need to protect their property in line with this fire management plan, and that despite the management measurements outlined, fire appliances may not be available to protect each house during a fire event.

The Fire Management Plan has been prepared to support the City of Swan and Western Australian Planning Commission (WAPC) planning approvals processes. It provides fire risk mitigation options that will be applied as the subdivision proceeds. When preparing the Plan, Natural Area Consulting has considered the requirements outlined in the *Planning for Bushfire Protection Guidelines* prepared by the Western Australian Planning Commission, the Department of Planning and the Fire and Emergency Services Authority (2010), and *AS 3959 – 2009 Construction of Buildings in Bushfire Prone Areas*. Activities involved with the plan preparation process included:

- assessing the vegetation types present within and adjacent to the proposed development site using the second edition of Planning for Bush Fire Protection Guidelines (Western Australian Planning Commission, Department of Planning and Fire and Emergency Services Authority, 2010)
- assigning hazard ratings based on the vegetation types present
- determining projected BAL ratings and suggest likely management strategies that could be implemented based on current and projected site considerations
- preparation of the management plan.

Note that this Fire Management Plan will need to be reviewed periodically, with a minimum review period of five years. In addition, it is recognised that changes to Lot layout, site conditions, or other factors can result in changes to the fire management measures documented, and are discussed further in Section 6.9.2, and which may necessitate a review and update of this Fire Management Plan.

Figure 1
Location—Lot 345 Woollcott Avenue, Brabham

2.0 Management Plan Aim

The aim of the Fire Management Plan (FMP) is to outline the fire management methods and requirements that will be implemented within the proposed subdivision. Accordingly, broad aims include:

- reduce the threat of fire to the life and property of future residents and the environment
- allow easy access of fire-fighters if a fire does occur
- protect the landscape within Lot 345 Woollcott Avenue Brabham as far as is possible.

3.0 Management Plan Objectives

The objectives of this Fire Management Plan are to:

- define land use areas within the subdivision, including urban, areas of public open space, and areas of bushland to be retained
- define and rank fire hazard areas according to the vegetation type and fire fuels present
- outline the roles and responsibilities of individuals and organisations in relation to fire management within the subdivision
- propose fire management strategies for the subdivision, taking into consideration:
  - vegetation to be retained onsite and bushland areas in proximity to the site including those areas to the west, north and east
  - the need for building construction standards where vegetated areas interface with the urban development
  - identify access for fire-fighting operations and daily maintenance in an around vegetated areas and stages of development
- define an assessment procedure that will evaluate the effectiveness and impact of existing and proposed fire prevention activities and strategies
- document the performance criteria and acceptable solutions adopted for the site.

4.0 Description of the Area

4.1 General Context

Perth is located within the Swan Coastal Plain region of the Interim Biogeographical Regionalisation of Australia (IBRA). The Swan Coastal Plain comprises of two major divisions, namely Swan Coastal Plain 1 – Dandaragan Plateau and Swan Coastal Plain 2 – Perth Coastal Plain. The site is located in the Perth subregion, which is broadly characterised as including areas of Jarrah and Banksia woodlands on sandy soils in a series of sand dunes, along with wetland areas, often within the interdunal swales (Mitchell, Williams and Desmond, 2002). The site and surrounding areas include a range of social and cultural values to the local community, including recreational opportunities, bushland and parkland areas.

4.2 Climate

The climate experienced in the area is Mediterranean, with dry, hot summers and cool, wet winters. The Bureau of Meteorology (2014) describes the climate at the Perth Airport (Station 009021) as:

- average rainfall is 771.6 mm pa, with the majority falling between May and August
- average maximum temperature ranges from 17.9 °C in winter to 31.9 °C in summer, with the highest recorded maximum being 46.7 °C
- average minimum temperatures range from 8.0 °C in winter to 17.5 °C in summer, with the lowest recorded minimum being -1.3 °C
- predominant wind directions include morning easterlies followed by westerly sea breezes during summer months when the risk of fire is greatest (Figure 2). The average wind speed is 23.8 km/h with gusts of more than 100 km/h possible, particularly during storm events.

Note also that summer weather conditions also contribute to the fire threat through mid-level disturbances bringing unstable atmospheric conditions from the north or north-west that result in thunderstorms and the potential for lightning strike as a fire ignition source.

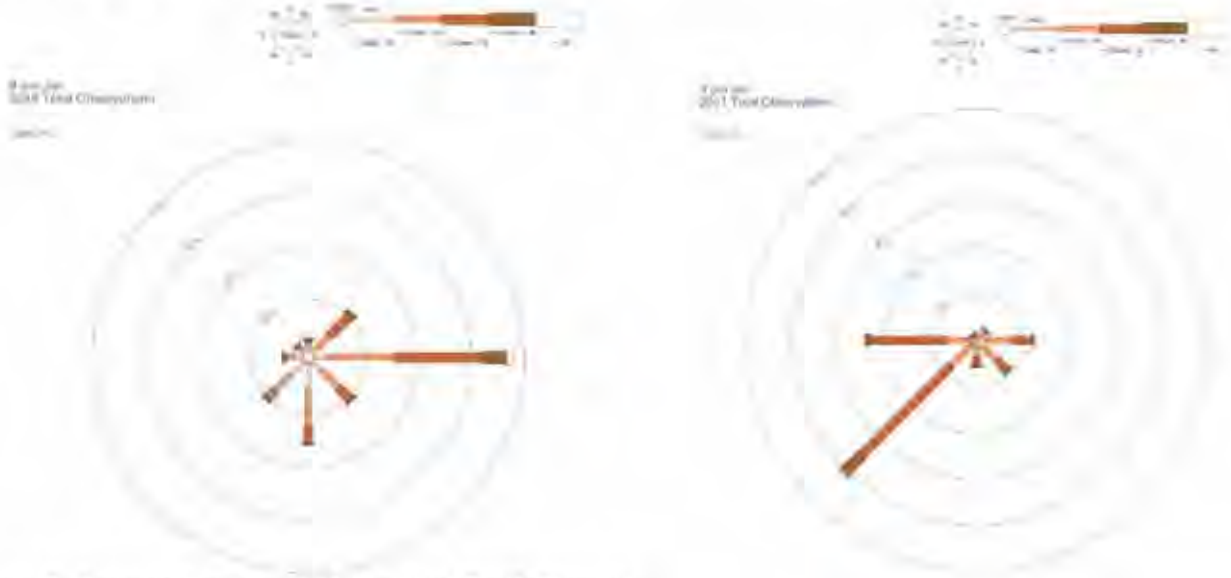


Figure 2: Average January wind direction, Perth Airport
Source: Bureau of Meteorology, 2015

4.3 Topography

The development area has a sloping topography from the south east to the north west, with site elevations ranging from 25 m AHD in the south rising to 32 m AHD in the north; elevations to 36 m are present in land to the west (Figure 3).

4.4 Bush Fire Fuels

The amount and type of vegetation and flora present at Lot 345 Woollcott Avenue directly contributes to the risks associated with fire, its spread, and impacts on property, the environment and people. The majority of the site is present as a sown pasture with areas of remnant vegetation characterised by both wetland and dryland vegetation types. Open areas of the site comprise an over storey of *Corymbia calophylla* and *Melaleuca preissiana*, sedge lands of *Juncus pallidus* are present towards the southern boundary of the site while those of *Lepidosperma longitudinale* are present towards the creek line in the north. The understorey is sparsely vegetated and dominated by introduced grasses such as African Love Grass (*Eragrostis curvula*). It is intended that some of the vegetation in the vicinity of the creek line west will be retained, while other areas will be cleared during the subdivision process.

4.4.1 Offsite Vegetation

Vegetation off site also needs to be considered due to the potential for fire spread into or out of these areas, as conditions allow (Figure 4). The major vegetated areas outside of the development will be an area of remnant bushland in the Cedar Woods land to the west. While offsite vegetation to the east in the Department of Housing land is sparse, there are a number of stands that are approximately 0.5 ha, and thus need to be considered from a fire management perspective.

4.4.4 Landscaping and Revegetation

Some vegetation will be retained in a 30 m buffer either side of St Leonards Creek in the north. A landscaped area that includes the occasional tree will be retained as an entry statement along Woollcott Avenue. Any changes to the plans will require a reassessment of the fire management implications at the site, and potentially an adjustment to this plan with additional Lots requiring a BAL-rating.

4.5 Land Use

Lot 435 Woollcott Ave is owned by the ABN Group. It is currently vacant and is vegetated with an over storey of trees and a weedy understorey. There is evidence of degradation with 4WD activities in and around the site, along with the presence of rubbish and fire debris.

4.6 Assets

As the site is vegetated, there are currently no assets or infrastructure present on site. Development is progressing to the north, with areas to the south, west and east is largely cleared land with pockets of remnant bushland (Figure 1).

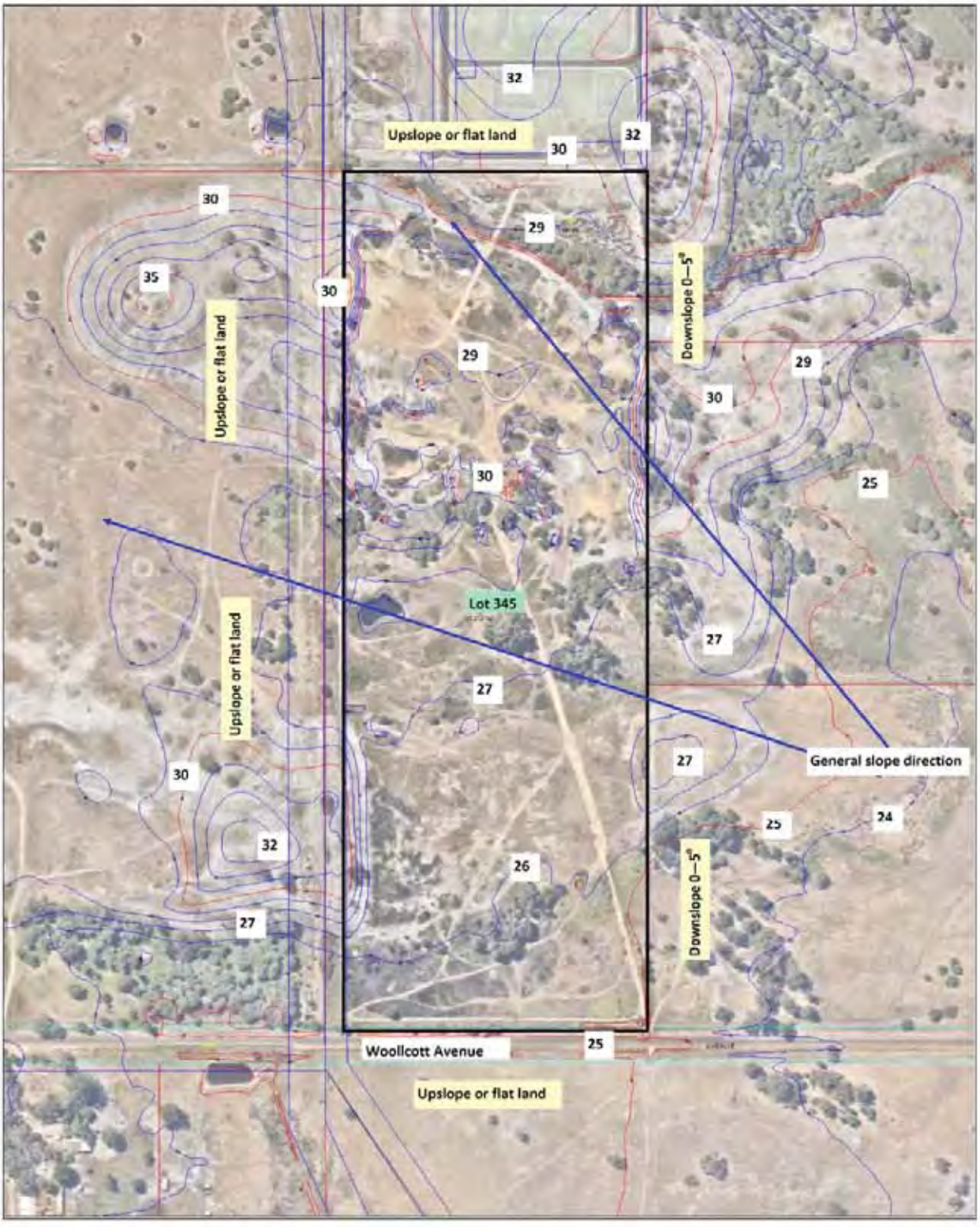


Figure 3
Contours—Lot 345 Woollcott Avenue, Brabham

4.7 Access

At present, there is no formal access to the site in the form of a driveway or other access road. However, there are a number of informal tracks indicating off-road vehicle access has occurred and is possible from Woollcott Avenue, through neighbouring properties and the development site to the north.

As the development progresses, access will be formalised through the creation of roads. The current design of the subdivision application site indicates a major north-south entry road from Woollcott Avenue that connects with the development site to the north, along with a series of east-west roads within the subdivision (Figures 10, 11). Development is currently occurring in land owned by Cedar Woods to the west, with the Lot 345 east-west road network designed as a continuation of those planned for the Cedar Woods site.

The Department of Housing owns the land to the east of Lot 345, with development planned at some future point in time. The road network on that site will connect with that created within Lot 345. In the short term, an emergency access way will be constructed on the Department of Housing land with their approval to ensure Lots in the north-east portion of Lot 345 will have an alternative egress option in the event of a fire.

4.8 Water Supply

As the subdivision proceeds, the site will be connected to scheme water with fire hydrants required approximately every 200 m within the built up area. Clearance on the placement of hydrants will be required from the Department of Fire and Emergency Services (DFES), the Water Corporation and the City of Swan. Hydrants will need to be clearly identifiable, with markings installed by the developer prior to sign off. Hydrants will be marked via the following:

- a blue 'cats eye' reflective indicator to the left of the centre line of the road
- a small blue 'H' painted on the curbing
- a white and red stripe around the power pole nearest to the hydrant.

Note that contractors or others carrying out building or other works at the site must not cover hydrants and/or the markings indicating their location. In the event activities occur that do result in hydrants or markings being covered, damaged, or removed, it will be the responsibility of the relevant contractor to rectify the situation.

5.0 Fire Problem

In order to identify the potential fire risks and mitigation strategies, it is necessary to describe the fire problem associated with the site. The assessment takes into consideration the:

- type and classification of vegetation present at the site (Table 1, Figure 4)
- distance between the dominant vegetation classification and the walls of existing or proposed buildings across from the classified vegetation
- the topography and slope of the land between proposed buildings and the classified vegetation
- land use.

5.1 Fire History

A review of historical aerial imagery held by Landgate for Lot 345 Woollcott Avenue suggests there have been no fires within at least the past 10 years. While aerial imagery is available dating back to 1953, between then and the year 2000, there would often be a number of years between imagery dates. Fire has occurred in nearby Whiteman Park (approximately 1.5 km west of the site), in March 2010, December 2006, January 2014 and December 2014.

5.2 Bushfire Risk

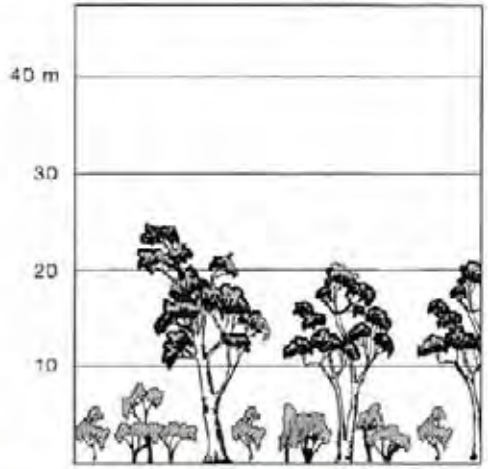
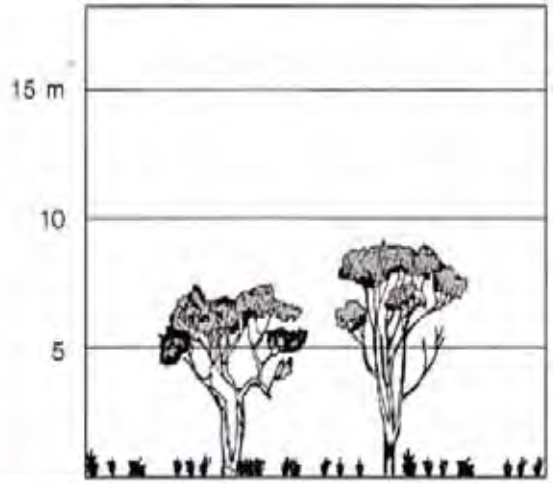
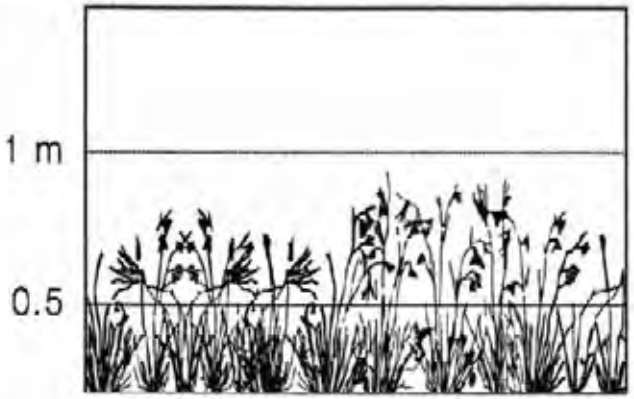
Risk relates to the likelihood of a negative or detrimental consequence arising out the interaction between hazards, community and the environment. The *Planning for Bush Fire Protection Guidelines* (Western Australian Planning Commission, Department of Planning, and Fire and Emergency Services Authority, 2010), describes three hazard levels relating to bush fire risks. These are:

- **Low** – primarily areas of no standing native vegetation, pasture or cropping areas with limited vegetation or suburban areas with maintained gardens and < 0.25 ha of standing vegetation
- **Moderate** – open woodlands and shrublands, low shrubs with slopes < 10° or flat land, suburban areas with some native tree cover, pasture or cropped areas with slopes > 10°
- **Extreme** – forests, woodlands and/or tall shrubs.

At Lot 345 Woollcott Ave, the nature of the vegetation and the slope in some locations mean that the following pre-subdivision hazard ratings have been determined:

- low to the grassland area,
- moderate in some remnant bushland pockets across the centre of the site
- extreme ratings to the bushland in the vicinity of St Leonards Creek and the vegetation in neighbouring Lot to the east (Figure 5).

Table 1: Vegetation types as per AS 3959 - 2009

Woodland (B5)	Low Woodland (B7)	Tussock Grassland (G22)
		
		

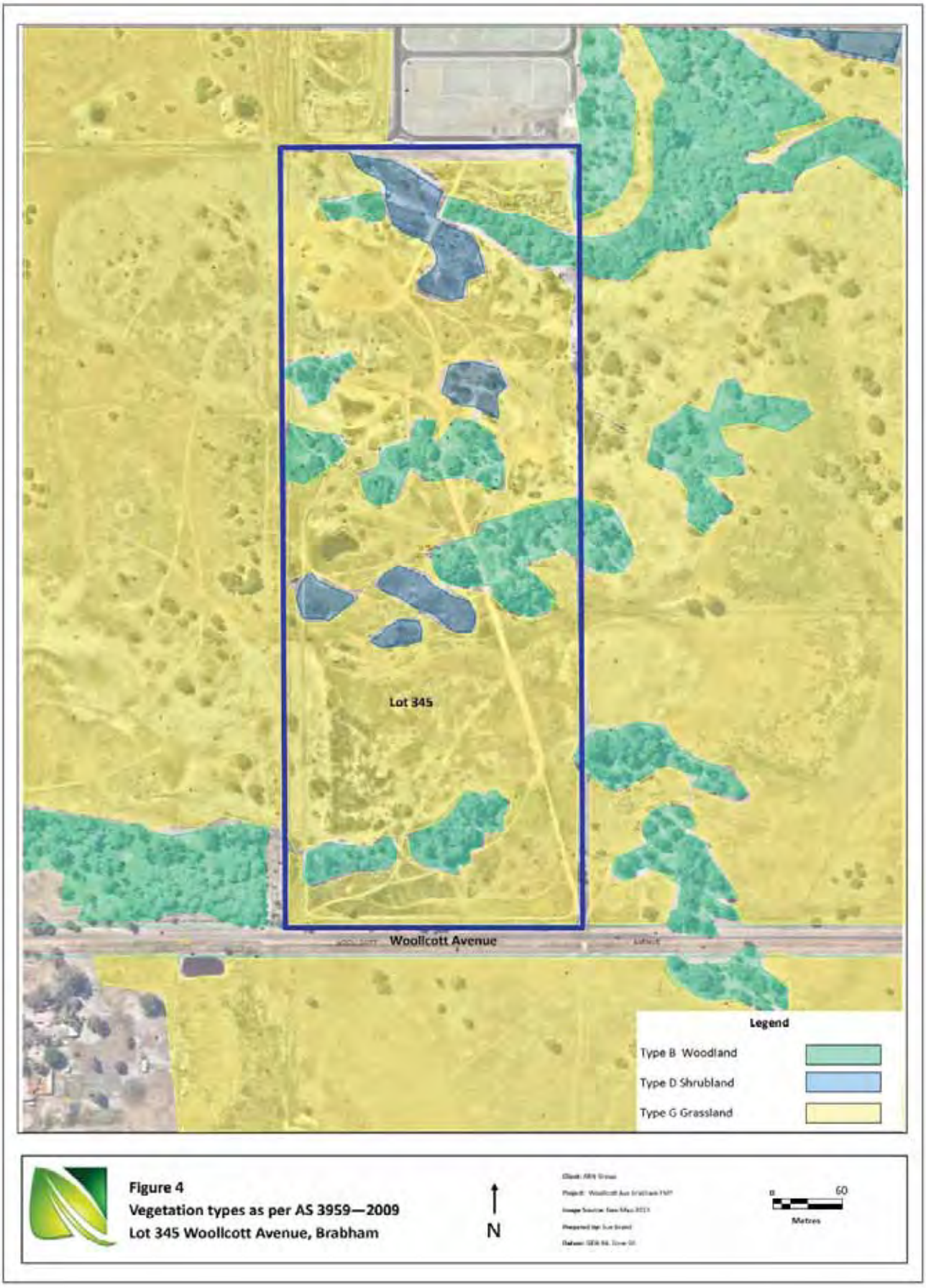


Figure 4
Vegetation types as per AS 3959—2009
Lot 345 Woollcott Avenue, Brabham

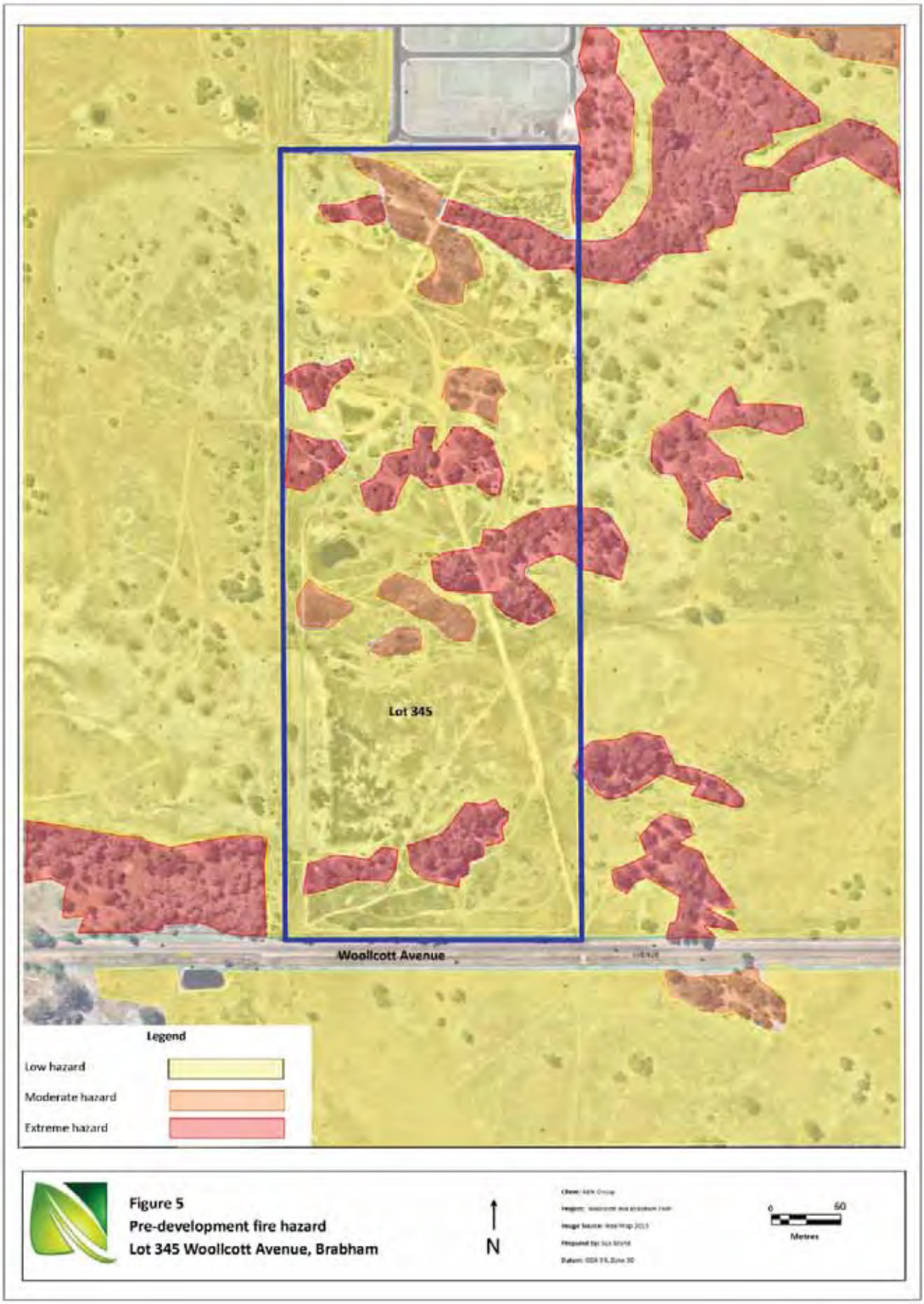


Figure 5
Pre-development fire hazard
Lot 345 Woollcott Avenue, Brabham

5.3 Bushfire Hazard

Bushfire hazard assessments considers existing site conditions (Table 2) including:

- topography, in particular, the slope or gradient of the land
- vegetation cover and associated fuel loads
- relationship to surrounding development.

Lot 345 Woollcott Avenue is located within an area that has a gentle rise towards the north and the west. Accordingly, land is upslope or flat land to the north, south and west, and downslope 0 – 5° to the east (Figure 3). The nature of the vegetation and slope mean that pre-subdivision hazard ratings of low have been applied to grassland areas and moderate to extreme to all other vegetation on site (Figure 5). As the development proceeds and clearing of the vegetation on site occurs, the risk associated with the onsite vegetation will decrease. Indicative post-development hazard assessments are provided in Figures 6 and 7, which takes into consideration vegetation to be cleared for housing Lots, roads, areas of on-site and offsite vegetation to the west that will be retained within public open space (POS), and vegetation that is expected to be cleared at some future point in the Department of Housing land to the east.

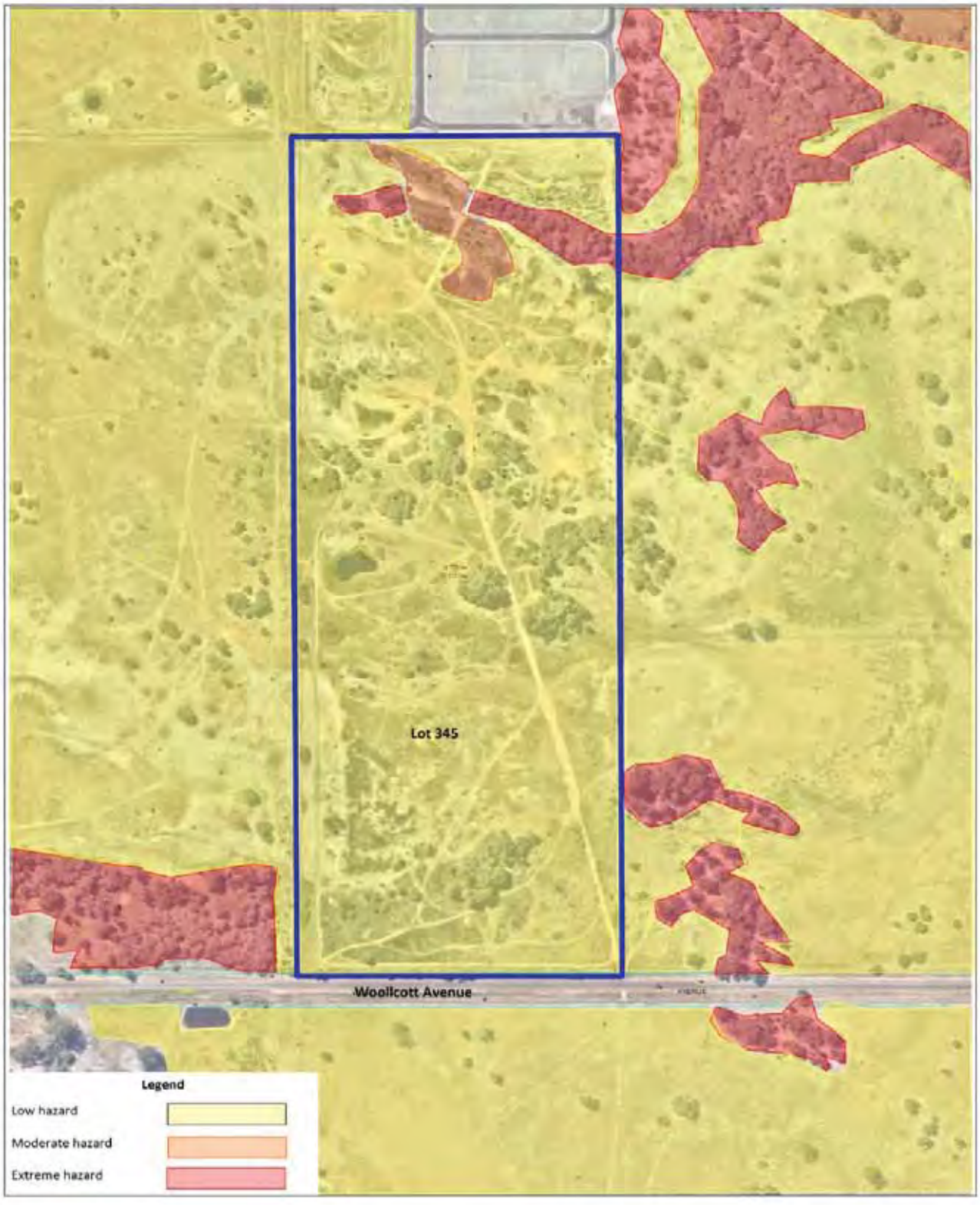


Figure 6
Post-development fire hazard
Lot 345 Woollcott Avenue, Brabham
(No clearing in Department of Housing Land)

Figure 7
Post-development fire hazard
Lot 345 Woollcott Avenue, Brabham
(Clearing in Department of Housing Land)

5.3.1 BAL Assessment

For buildings within fire prone areas, an ideal hazard separation zone of at least 100 m between vegetation and building walls that includes a 20 m building protection zone is preferred (Figure 8). Where that is not possible, the requirements of AS 3959-2009 *Construction of Buildings in Bushfire Prone Areas* can be applied as an acceptable solution, as is the case for buildings proposed within the vicinity of the vegetated areas on and off site at Lot 345 Woollcott Avenue Brabham.

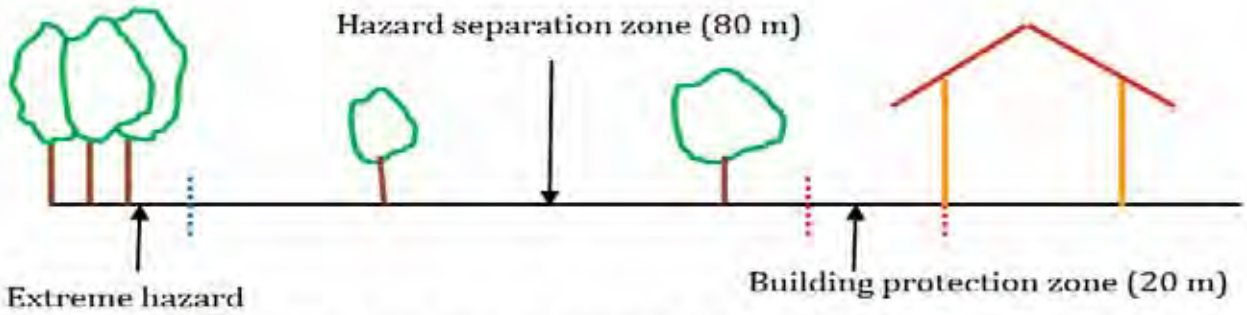


Figure 8: Ideal hazard separation zone between vegetation and buildings

The Lot 345 site has been designed to provide appropriate hazard separation and building protection zones between the vegetation in the public open space areas and offsite vegetation and building walls that incorporate the assigned BALs determined in accordance with Amendment 2 of AS 3959 – 2009 (February, 2011) (Figure 9), and provide a minimum 20 m building protection zone.

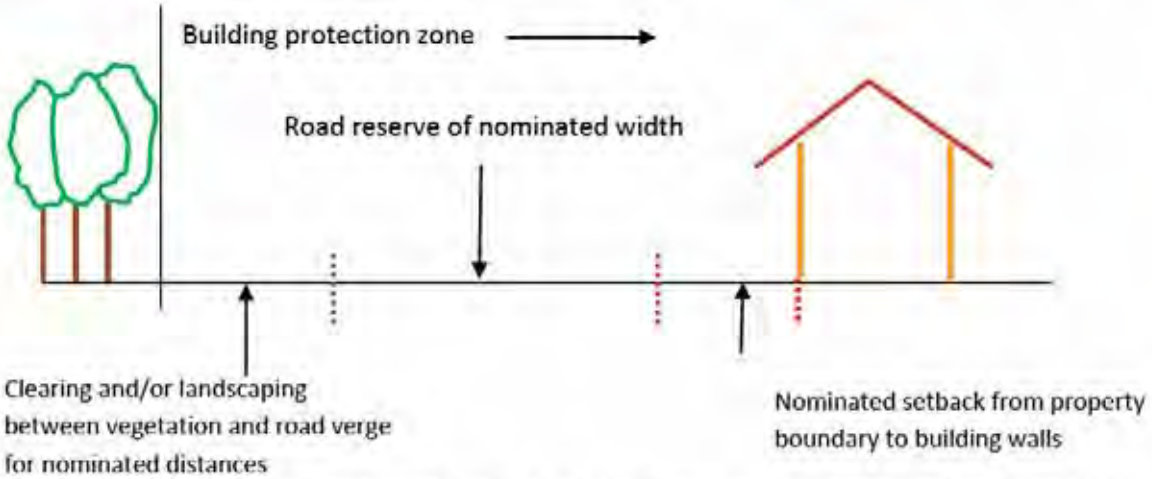


Figure 9: Reduced Hazard Separation Zone and Building Protection Zone in accordance with AS 3959 - 2009

The BAL assessment for all Lots within 100 m of classified vegetation at Lot 345 Woollcott Avenue, Brabham takes into consideration:

- the current Lot layout for the subdivision application site
- projected fill requirements required to provide an even surface to build on
- recommended clearing and preliminary landscaping design with fire mitigation strategies taken into consideration
- projected location of vegetation to be retained in public open space areas (POS).

Outcomes of the BAL assessment are discussed below for each area within the subdivision based on whether or not clearing occurs in the Department of Housing land to the east (Figures 10 and 11). Note that BAL ratings are valid for three months, and will need to be reviewed as development proceeds. The City of Swan will become responsible for ongoing management of the landscaped and vegetated POS areas.

Area 1 – Lots to the North of St Leonards Creek

Area 1 includes 14 single dwelling Lots, with those fronting the vegetated area within the St Leonards Creek requiring a BAL-29 rating and a minimum setback of 4 m from the front Lot boundary in addition to the road reserve to provide adequate separation from the vegetation. The seven Lots to north will require a BAL-12.5 rating.

A grouped housing site is planned for an area abutting the vegetated area, and a BAL-rating will be determined when further design work is carried out. A minimum separation distance of 14 m will be required between the vegetation and buildings for a BAL-29 rating, and which may be achieved through ensuring car park and hardstand areas are concentrated towards the rear of the Lot. Landscaping and some clearing within St Leonards Creek may also contribute to separation distances between buildings and vegetation.

Area 2 – Lots to the South of St Leonards Creek

Fourteen Lots that front the vegetated buffer associated with St Leonards Creek will require a 4 m setback from the Lot boundary in addition to the road reserve to achieve a minimum separation distance from the vegetation for a BAL-29 rating. All other Lots within 100 m of that vegetation will require a BAL-12.5 rating.

Area 3 – Vegetation to be Retained in Cedar Woods Land to the East

A larger stand of woodland vegetation is to be retained within the Cedar Woods development to the east. The presence of the Parmelia gas pipeline easement and the main north-south road into Lot 345 mean a minimum separation distance of 43 m between the vegetated areas and Lots, thus a BAL-12.5 rating will apply to Lots within 100 m.

Area 4 – Vegetation to the East in Department of Housing Land

Area 4 comprises eight Lots some 58 m from a patch of woodland vegetation within the Department of Housing land to the east. This land will be developed at some future point in time, and which will result in the clearing of this stand of vegetation. If development within Lot 345 Woollcott Avenue proceeds ahead of that in the Lot to the east, vegetation in that Lot will need to be considered from a fire management perspective. For Area 4, it will mean a BAL-rating of 12.5 for those Lots within 100 m of that vegetation. BAL-ratings for this area are shown on Figure 10, along with those that will occur if this vegetation is cleared (Figure 11).

Area 5 – Vegetation to the East in Department of Housing Land

There are two vegetation stands to the south west of the Department of Housing land, one of which is immediately adjacent to the eastern boundary of Lot 345. As a result, there are seven Lots that cannot achieve an adequate separation distance unless this vegetation is cleared. Other Lots within 100 m of this vegetation are developable if a BAL-rating is assigned as a fire protection mechanism, with the majority being a BAL-12.5. The appropriate BAL-ratings for the two Lots immediately to the north and south of those

that cannot achieve a suitable separation distance will be determined when the style of house and location within the Lots is known, with the likely rating being a BAL-19. BAL-ratings for this area are shown in Figure 10 if clearing does not occur in the Department of Housing Land, and Figure 11 indicates that no Lots in this area will require a BAL-rating if the land is cleared.

It is the developer's intent that those Lots immediately adjacent to the vegetation in the Department of Housing land will not be developed until such time as that vegetation is cleared and the fire risk in that area reduced accordingly.

5.4 Bush Fire Threat

At present, the vegetated nature of the site means the threat of bush fire is moderate - high. However, as the site is developed and the majority of the vegetation cleared, the threat will diminish. The presence of the to the west and the retained vegetation in the northern portion of the site will mean a moderate – high bush fire threat, with a low threat around the rest of the site.

5.5 Summary of Bushfire Potential Issues

The potential bushfire issues that are present at the site will include the presence of bushland vegetation that will be retained within nominated public open space area and in vegetation in the Lot to the west (Figure 10). Vegetation is also present in the Department of Housing land to the east, and this will remain an issue until that site is developed. Fire in any of these locations has the potential to result in smoke, ember attack and/or heat from flames.

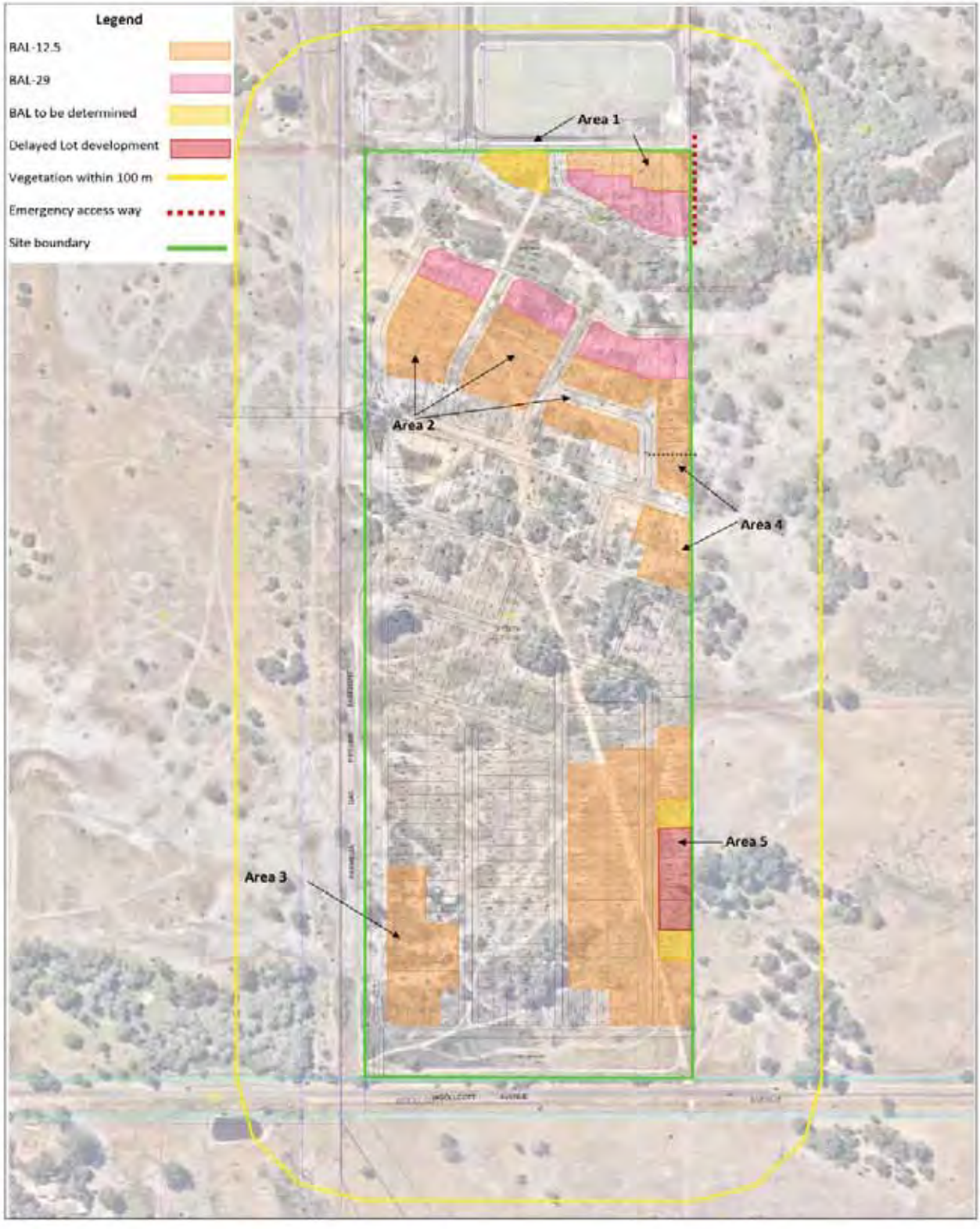


Figure 10
Indicative BAL-rated areas
Lot 345 Woollcott Avenue, Brabham
(No clearing in Department of Housing Land)

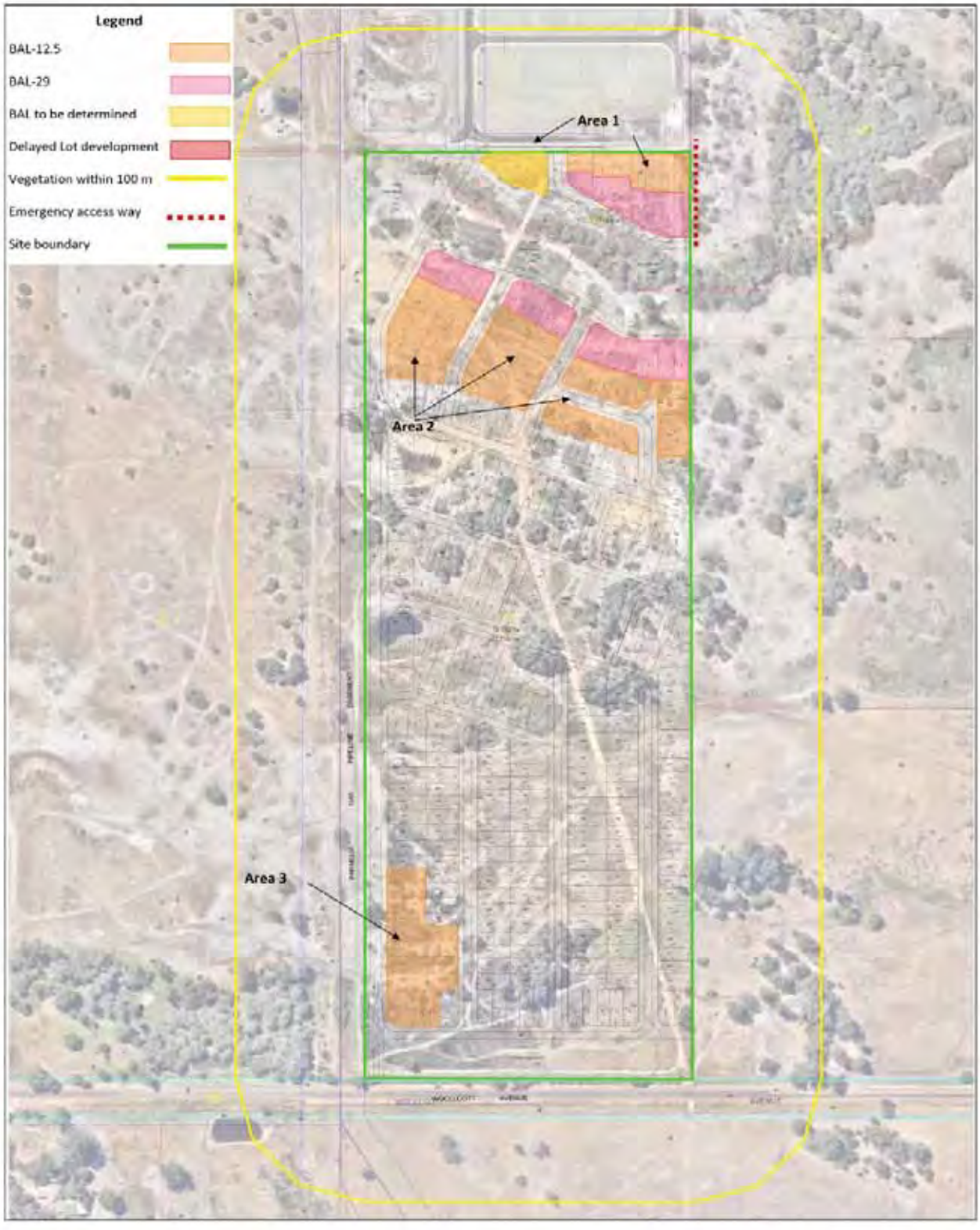


Figure 11
Indicative BAL-rated areas
Lot 345 Woollcott Avenue, Brabham
(Clearing in Department of Housing Land)

6.0 Fire Mitigation Strategies

As development proceeds, all sites within 100 m of bushland areas will need to meet the criteria associated with an extreme bushfire hazard rating through the adoption of performance criteria and acceptable solutions as described in the bushfire protection guidelines. However, the site will also need to be managed during the staging of development activities.

6.1 Hazard Management

The proposed development site will largely be cleared to facilitate the clearing of urban residential Lots. During the development process, vegetation to be retained with POS areas will be maintained below 5 – 8 tonnes per hectare to reduce the potential for fire spread. This will occur through a combination of landscaping, weed control and parkland maintenance activities. Weed control measures, such as chemical control and/or slashing of long grass to a maximum height of 50 mm (5 cm) is required in areas where understorey species are largely absent. Works will be carried out during the development process and subject to inspection by the City of Swan on an as required basis. In the longer term, the City of Swan will assume responsibility for the ongoing management of POS areas, as outlined in Section 6.9.

Dwellings to be constructed within 100 m of classified vegetation will have a BAL-rating assigned that nominates higher building construction requirements as defined in AS 3959 – 2009 Construction of Buildings in Bushfire Prone Areas. Roads, building setbacks and parkland cleared areas will contribute to low fuel building protection and hazard separation zones. All other Lots will be more than 100 m from classified vegetation, meeting minimum hazard separation requirements from classified vegetation.

6.2 Bushfire Risk Management

The urban residential nature of the development site will require landowners and occupiers to comply with City of Swan fire emergency information and fire advice issued by DFES. This will include but not be limited to complying with any firebreak notices, restricted and prohibited burning times, and fire danger notices such as restrictions on the use of vehicles and/or machinery in fire prone areas on very high fire danger days. Vegetation within POS areas will be maintained below 5 – 8 tonnes per hectare on an ongoing basis. This will occur through a combination of landscaping, irrigation, weed control and parkland maintenance activities.

6.3 Future Development

Fire prone areas within the development have been nominated, as have Lots that require construction in accordance with relevant sections of AS 3959 – 2009 Construction of Buildings in Fire Prone Areas. Each Lot within the development will be urban residential with little retention of native vegetation, and which will ensure the future low risk is maintained. Lot 345 Woollcott Avenue Brabham is in an area where development is occurring in surrounding areas, with the longer term expectation that they will also be developed.

While the fire management plan has the aim of ensuring the proposed development is designed with due consideration to the potential for ignition of fires and their spread, the Developer also needs to ensure the protection of property and the environment during the various stages of construction. Each stage will incorporate a series of fire protection requirements until the subdivision is completed, including:

- a 6 m strategic trafficable firebreak on the outside of the development on the alignment of the internal road of the next stage. Note that it may be necessary to lay road base or similar to accommodate access for larger fire appliances
- a 94 m low fuel area is to be established between the last lots in each stage to be sold and the 6 m strategic firebreak, ensuring a 100 m hazard separation zone is maintained. The low fuel area will consist of a 30 m building protection zone, with vegetation in the residual 64 m low fuel area to be slashed and maintained at a maximum of 100 mm in height
- vegetation within the building protection zone is to be slashed and maintained below 50 mm.

6.4 Access

Access to the site will be via the urban road network, which has been designed to connect to planned developments to the west, north and east. Development is well advanced to the north, and is in progress in the Cedar Woods land to the west. It is uncertain when the Department of Housing will develop the land in the lot immediately east of Lot 345 Woollcott Avenue. This means that the seven Lots that will front the northern portion of St Leonards Creek (Area 1, Figures 10 and 11) have only one access/egress option, which is inconsistent with Element 2 – Vehicular Access in the *Planning for Bushfire Protection Guidelines* (WAPC *et al*, 2010), which indicates two different vehicle access routes must be available that connect to the public road network.

This will be addressed through the construction of a temporary emergency access route in the Department of Housing land to the east that will provide a second connection from the road within the subdivision that connects to the road network within the development that is currently progressing to the north. The construction of the emergency access way has been agreed to by the Department of Housing, with the actual configuration and where it joins the road network to be determined when the Lots in this area are being developed.

6.5 Firebreaks

The residential zoning of Lot 345 as urban mean that the need for firebreaks within each of the proposed Lots is not required. Firebreaks will continue to be required in adjacent, undeveloped land in other ownership, such as the Cedar Woods land to the west and the Department of Housing land to the east, in accordance with City of Swan requirements.

6.6 Public Education and Community Awareness

Owners of Lots in fire prone areas need to be aware of information provided by the following:

- the City of Swan, such as the annual firebreak notice and local emergency management arrangements
- various educational materials available on the DFES website, including those relating to fire preparedness and survival, and evaporative air conditioners
- community bushfire ready action groups.

Housing in close proximity to the vegetated areas will always be subject to some risk from the effects of a fire, particularly smoke, radiant embers and potentially spot fires. It is recommended that Lot owners within

1 km of the vegetation, particularly those where a BAL rating has been determined, are made aware of the potential risks from fire and what to do in the event a fire is noticed, such as:

- ringing 000 as soon as a fire is noticed
- if installed, turning off evaporative air conditioners, or if possible to do so, continue running water through the unit with the fan turned off
- if evaporative air conditioners haven't been used prior to smoke being detected, it is advisable to wet the filter pads with a garden hose or run the unit to wet the filter pads, then turn it off when smoke appears overhead
- ensuring accessibility is maintained to enable easy movement of emergency vehicles.

It is also recommended that they are made aware of the current edition of the FESA publication 'Survive – The Home Owner's Bush Fire Survival Manual' (2008) which is available on the DFES website.

6.7 Fire Safer Areas

Fire safer areas are not required for the proposed development.

6.8 Assessment of Fire Management Strategies

The development of the area will significantly reduce the potential for and risks associated with bushfire in and around the proposed subdivision. Areas of bushland vegetation to be retained around St Leonards Creek to the north and in the Lot to the east will have some possibility of spreading to surrounding areas. Accordingly, the fire management strategies proposed for the site will result in social and financial benefits associated with the reduced fire potential. Environmental benefits are associated with the retention of bushland vegetation.

6.9 Implementation

Implementation of this Plan will commence immediately and will be the responsibility of the Developer, the Department of Housing, until such time as relevant portions of the site are formerly handed over to the City of Swan or the new owners of the Lots. When installed, maintenance of any fencing, gates and access points will be the responsibility of the developer until handover to the City, at which time ongoing maintenance requirements will need to be incorporated into annual budgetary processes. Activities that will be involved with the implementation of this plan are described in Table 3.

Table 3: Implementation Schedule

Activity	Responsibility	Maintenance	Responsibility
Ensuring bushfire protection of land and property during the various stages of the development	Developer	Checking and maintaining firebreaks, low fuel zones and other protection mechanisms during staging activities	Developer
Installation of emergency access way that will allow egress from the northern Lots in Area 1 to the north in the event of a fire	Developer	Annually	Developer until hand over to City of Swan or completion of road network to east

Activity	Responsibility	Maintenance	Responsibility
Assessing fire fuel loading in area of vegetation to be retained	Developer	Annually	Developer until hand over of POS areas to City of Swan
Undertake slashing of long grass to 50 mm and other weed control to reduce fuel load	Developer	Annual, prior to summer, in accordance with information issued to ratepayers by the City of Swan	Developer, until sale of individual lots or hand over of POS and conservation area to the City of Swan
Assess fire management implications of proposed revegetation plans	Developer	As required, during revegetation design phase	Developer
Education	Developer and City of Swan	Updating materials and information to reflect current policies, plans, knowledge, or accepted practice	Developer – during sale process City – during normal administrative activities to residents and rate payers
FMP review	Developer in consultation with City of Swan	Ensure continued suitability of FMP by reviewing contents in conjunction with current site conditions	Developer

6.9.1 Responsibilities

Responsibilities for bushfire preparedness and response within the development area at Lot 345 Woollcott Avenue Brabham are shared by the City of Swan, the Developer, DFES, and building owners.

Developer Responsibilities

The Developer is responsible for implementing key portions of this Fire Management Plan, including:

- reviewing bushfire hazards and risks associated with the landscape protection areas during the subdivision design process, and ensuring the risks are as low as required to meet the requirements of this FMP and AS 3959 - 2009
- implementing requirements associated with installation and maintenance of the emergency access way until hand over to the city of Swan or completion of the road network to the east, as appropriate

- installation and maintenance of signage associated with the emergency access way until hand over to the city of Swan or completion of the road network to the east, as appropriate
- maintaining any firebreak areas or similar in accordance with City of Swan requirements and guidelines until the land is no longer the responsibility of the developer, such as when the POS area is ceded to the City of Swan for ongoing management
- providing appropriate information, including a copy of this fire management plan, to potential purchasers and owners of lots within the development that have a BAL of 12.5 or greater to inform them of the bushfire risks and minimum building construction requirements
- arrange for the Section 70A notification on the titles of lots subject to the requirements of this Fire Management Plan.

City of Swan Responsibilities

The City of Swan has the responsibility and powers under the Town Planning Scheme and the *Bush Fires Act 1954* to ensure that this Fire Management Plan, City of Swan annual fire break notice and any special orders issued under the *Bush Fires Act 1954* are complied with. The City of Swan will be responsible for:

- maintaining District Fire Fighting Facilities
- maintaining any City equipment and apparatus for fire fighting purposes in good condition
- providing appropriate advice in relation to City requirements for firebreaks, hazard reduction, and similar to the Developer and property owners as required
- ensuring appropriate information is included on titles of lots with a BAL of 12.5 or greater.

DFES Responsibilities

DFES will be responsible for:

- maintaining fire fighting equipment in good condition and repair
- responding to fires within vegetated areas within the Woollcott Avenue site in a timely manner in an effort to minimise the spread of fire and damage to nearby housing from ember attack.

Owner Responsibilities

It is the responsibility of individual property owners building houses within near the vegetated areas to comply with the requirements of this Fire Management Plan. They also have the responsibility of responding to advice from the City of Swan, DFES, or the Developer in relation to maintaining properties in a manner that will reduce potential damage from ember attack. In addition, it is recommended that Lot owners include ember shields on evaporative air conditioners and inform DFES or the local fire brigade as soon as practicable after a fire is noticed within bushland within the subdivision boundary.

6.9.2 Plan Review

This fire management plan has been developed based on current conditions at the site, but recognises that changes can occur over time and may be subject to review based on detailed design processes. It is recommended that this plan also be reviewed twelve months after initial endorsement and implementation to ensure its continued suitability, and in the event any of the following occur:

- a fire occurs within the site boundary or a neighbouring property that spreads to the site
- during detailed design phases, particularly if expected fill levels change, resulting in altered slopes (both upward and downward slopes)

- any revegetation activities are likely to result in areas of classified vegetation greater than 0.25 ha (as defined by AS 3959-2009)
- if the vegetation to be retained on site is altered, and will or is likely to result in an area of classified vegetation greater than 0.25 ha
- on finalisation of the development when the POS areas are handed over to the City of Swan.

7.0 Appendices

7.1 Maps

Maps are included in relevant sections of this document.

7.2 Works Program

The nature of the proposed subdivision mean a works program identifying tasks to be performed is not required.

7.3 Guidelines, Specifications and Minimum Standards

7.3.1 AS 3959 – 2009 Construction in Bushfire Prone Areas

The assigning of a BAL rating to Lots within a subdivision is an acceptable management strategy with the aim of providing an increased level of protection against radiant heat that could otherwise damage flammable portions of buildings in the event of a bushfire. Increased protection comes through increased construction standards and the setting of minimum distance requirements between building walls and vegetation in accordance with Australian Standard AS 3959 - 2009. Note that the assigning of a BAL rating does not guarantee the protection of homes from fire impacts; rather, it decreases the likelihood of impacts.

A BAL- low requires no additional building construction requirements and is the preferred rating, and applies to building Lots 100 m or more from classified vegetation. For those properties within 100 m of the classified vegetation, a BAL rating of 12.5 or higher will apply according to the vegetation type, slope and distance (Table 4). For those Lots within the Lot 345 Woollcott Avenue site, up to four BAL ratings will apply, namely BAL low, BAL-12.5, BAL-19 and BAL-29. Hazard separation distances for each BAL rating and slope class are calculated from the edge of the classified vegetation to building walls based on the projected area of vegetation to be retained within POS areas.

Table 4: BAL description – AS 3959 – 2009

BAL rating	Risk Level	Description	Applicable AS 3959 – 2009 Sections
Low	Very low	Insufficient risk to warrant any specific construction requirements but there is still some risk	4
12.5	Low	• risk of ember attack • exposure to radiant heat	3 and 5
19	Moderate	• risk of ember attack • burning debris ignited by wind embers • likelihood of exposure to radiant heat	3 and 6
29	High	• increased risk of ember attack • increased risk of burning debris ignited by windborne embers • likelihood of exposure to a high level of radiant heat	3 and 7

Table 5 indicates the minimum distance from the hazard (vegetation) to building walls for BAL-rated Lots. Those Lots requiring construction that meets building requirements detailed in AS 3959 – 2009 *Construction*

of Buildings in Bushfire Prone Areas (Standards Australia, 2009) could expect to add a minimum of 4 – 10% additional costs for housing, with the actual depending on the assigned BAL, materials chosen and the builder engaged to carry out the work. Potential owners of these Lots will be advised that there are additional building requirements to be met during the sales process.

The above have been considered when determining BAL ratings for Lot 345 Woollcott Avenue Brabham, noting that ratings apply to an entire Lot, not a part thereof. Minimum distances for the vegetation type and gradient for the site are provided in Table 5; these ratings assume that the expected fill requirements are applied to relevant portions of the site.

Table 5: Minimum distance (metres) to vegetation for BAL ratings – Type B Woodland

BAL Rating	Upslope or flat land	Downslope 0 – 5°
BAL 12.5	29 – <100	35 – <100
BAL 19	20 – <29	25 – <35
BAL 29	14 – <20	17 – <25

BAL ratings have been provided for those Lots within 100 m of vegetation to be retained, with Lots having a BAL- rating shown on Figure xxxx, and Figure cccc if development proceeds in the shorter term in the Department of Housing land to the east. Some Lots will need to have their final BAL-rating assessed at a later stage of the development process, when design phases and the location and amount of vegetation to be retained in POS areas is known. Other Lots in the development area will not require a BAL rating.

Note that AS 3959 – 2009 indicates that construction requirements for the next lower BAL than that determined for a particular site may be applied where a particular elevation on a building is not exposed to the source of the bushfire attack because other portions of the building act as shielding (Figure 12). Thus, for buildings located in an area determined to be BAL 29, walls not immediately facing the fire threat can be constructed in accordance with BAL 19. Note that no lessening of construction standards can occur in areas assessed as BAL 12.5.

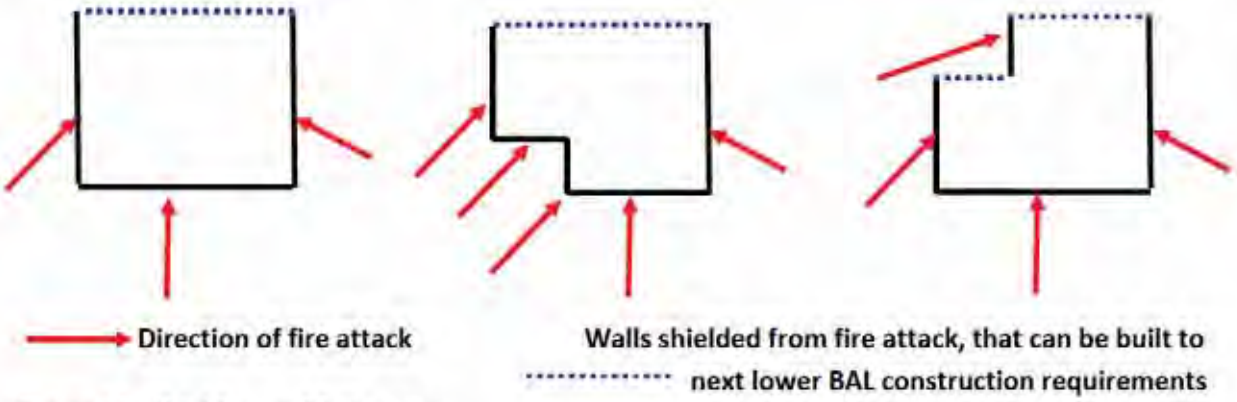


Figure 12: Shielding and BAL rating

7.3.2 Planning for Bush Fire Protection Guidelines (Edition 2, 2010)

7.3.2.1 Emergency Access Way

Construction of the emergency access way from Area 1 through to the road network in the northern development area will be constructed in accordance with the requirements described in A2.6 of the *Planning for Bush Fire Protection Guidelines* (WAPC et al, 2010), namely:

- minimum trafficable surface: 6 metres
- horizontal clearance: 6 metres
- vertical clearance: 4 metres
- maximum grades: 1 in 8
- maximum grade over <50 metres: 1 in 5
- maximum average grade: 1 in 7
- minimum weight capacity: 15 tonnes
- maximum crossfall: 1 in 33
- curves minimum inner radius: 12 metres
- must be signposted.

7.3.2.2 Signage – Emergency Access Way

Signage is required to be installed where the emergency access way where it adjoins the public road network, and must comply with the following requirements:

- minimum height above ground: 0.9 metres
- design and construction: to be approved by the City of Swan
- lettering height: 100 millimetres
- to display the following wording: 'Emergency Access Only'.

7.3.2.3 Firebreak Construction

Firebreaks will be constructed and maintained in accordance with information provided in the City of Swan annual firebreak notice. The FESA (undated) publication *Firebreak Location, Construction and Maintenance Guidelines* available on the DFES website contains a range of useful information for land owners and managers.

7.4 Glossary

AHD	Australian Height Datum
AS	Australian Standard
BAL	Bushfire Attack Level
Building protection zone	Low fuel area immediately surrounding buildings (20 m wide)
°C	Degrees Celsius
CoS	City of Swan
DFES	Department of Fire and Emergency Services (previously FESA)
DoP	Department of Planning
FESA	Fire and Emergency Services Authority (now DFES)
FMP	Fire Management Plan
FZ	Fire zone, or area where property or similar is under threat from flames
ha	Hectare
Hazard separation zone	Area around buildings, including outbuildings, that has a reduced fire fuel loading as a means of reducing potential damage from bushfire, ideally 100 m from buildings to vegetation
km	Kilometres
kmh	Kilometres per hour
m	Metres
mm	Millimetres
pa	Per annum
POS	Public open space
WAPC	Western Australian Planning Commission

7.5 References

AS 3959 – 2009 *Construction of Buildings in Bushfire-Prone Areas*. Standards Australia. NSW.

AS 3959 – 2009 *Construction of Buildings in Bushfire-Prone Areas* (Amendment 2 – February 2011).Standards Australia. NSW.

Bureau of Meteorology (2015). *Climate and Weather Statistics*. Retrieved from http://www.bom.gov.au/climate/data/.

Fire and Emergency Services Authority (FESA), (2008, 5th Edn), *Survive – the Homeowner's Bush Fire Survival* Manual, Government of Western Australia, Perth, Western Australia; also available at: http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireManualsandGuides/FESA_Bushfire-Homeowners_Survival_Manual.pdf.

Fire and Emergency Services Authority (FESA), (Undated), *Firebreak Location, Construction and Maintenance Guidelines*, Retrieved from: http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireProtectionPlanningPublications/FESA%20Firebreak%20Guidelines_std.pdf.

Geoscience Australia. (2013). *What Causes Bushfires*. Retrieved from http://www.ga.gov.au/hazards/bushfire/bushfire-basics/causes.html.

Mitchell, Williams and Desmond, (2002) *Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion)*, Department of Conservation and Land Management available World Wide Web URL: http://www.dec.wa.gov.au/pdf/science/bio_audit/swan_coastal_plain02_p606-623.pdf, accessed June 2012.

Western Australian Planning Commission, Department of Planning and Fire and Emergency Services Authority. (2010). *Planning for Bushfire Protection Guidelines* (Edition 2). Government of Western Australia. Perth. Western Australia.

7.6 Compliance Criteria for Performance Criteria and Acceptable Solutions

Element		Compliance						Report Section(s)	Response (if required)
		If 'no' to any element or sub-element, explain in writing how the proposal satisfactorily complies with the performance criterion P1 for this area of non-compliance and provide with this checklist							
Compliance with Element 1: Location									
The subdivision/development is located in an area where the bush fire hazard is manageable									
A1.1	The subdivision/development is located on land that is not subject to either an extreme bush fire hazard land classification or requires construction standards to BAL-40 for BAL-FZ	Yes		No	✓	N/A		5.3	
Compliance with Element 2: Vehicular access									
The internal layout design and construction of public and private vehicular access in the subdivision/development allows emergency and other vehicles to move through it easily and safely at all times									
A2.1	Two access routes – two different vehicular access routes, both of which connect to the public road network, are available to all residents/the public at all times	Yes	✓	No		N/A		4.7, 6.4	
A2.2	Public roads must meet minimum requirements	Yes	✓	No		N/A			
A2.3	Cul-de-Sacs must meet minimum requirements	Yes		No		N/A	✓		No cul-de-sacs planned
A2.4	Battle axes must meet minimum requirements	Yes		No		N/A	✓		No battle-axe blocks planned
A2.5	Private driveways must meet minimum requirements	Yes		No		N/A	✓		No private driveways expected
A2.6	Emergency access ways must meet minimum requirements	Yes	✓	No		N/A		6.4, 7.3.2	
A2.7	Fire service access routes must meet minimum requirements	Yes		No		N/A	✓		Access will be via gazetted roads within subdivision
A2.8	Gates must meet minimum requirements	Yes		No		N/A	✓		
A2.9	Firebreak widths must meet minimum requirements	Yes		No		N/A	✓		
A2.10	Signs must meet minimum requirements	Yes	✓	No		N/A		7.3.2	
Compliance with Element 3: Water									

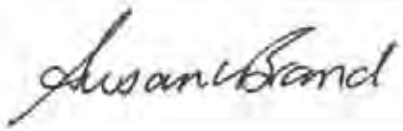
The development is provided with a permanent and secure water supply that is sufficient for fire fighting purposes									
A3.1	Reticulated areas – the development is provided with a reticulated water supply, with fire hydrants in accordance with the specifications of the relevant water supply authority and FESA	Yes	✓	No		N/A		4.8	Subdivision will be connected to scheme water
A3.2	Non reticulated areas – water tanks with a hydrant or standpipe are provided and meet minimum requirements	Yes		No		N/A	✓		
A3.3	A dam or dams with permanent water all year is provided and meets minimum requirements	Yes		No		N/A	✓		
Compliance with Element 4: Siting of Development									
The siting (including paths and landscaping) of the development minimises the bush fire risk to life and property									
A4.1	Hazard separation – moderate to extreme – Every building is sited a minimum of 100 m from any classified vegetation or has its construction standard increased to align with the appropriate bush fire attack level for that location as per AS3959	Yes	✓	No		N/A		5.3	Construction standards as per AS 3959 – 2009 will apply to nominated areas
A4.2	Hazard separation – low bush fire hazard level – every building is a minimum of 20 m from any classified vegetation	Yes	✓	No		N/A		5.3	As above
A4.3	Building protection zone – every building is surrounded by a building protection zone that meets minimum requirements	Yes	✓	No		N/A		5.3	As above
A4.4	Hazard separation zone – every building and its contiguous building protection zone is surrounded by a hazard separation zone that meets minimum requirements	Yes	✓	No		N/A		5.3	As above
A4.5	Shielding – a reduction in the bush fire attack level due to shielding from direct flame contact or radiant heat via a stand-alone non-combustible structure shall be given consideration when meeting nominated conditions	Yes	✓	No		N/A		7.3.1	

Compliance with Element 5: Design of Development									
The design of the development is appropriate to the level of bush fire hazard that applies to the development site									
A5.1	Compliant development – development that complies with acceptable solutions A4.1, A4.2, A4.3, and A4.4 require no further special design requirements	Yes	✓	No		N/A		5.3	Construction standards as per AS 3959 – 2009 will apply to nominated areas
A5.2	Non-compliant development – for development that does not comply with acceptable solutions there is no acceptable solution and must be assessed under performance criterion P5	Yes		No		N/A	✓	5.3.1	Lots that cannot achieve minimum separation distances from vegetation will not be developed until land to the east is cleared for development

Applicant Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Full name: Susan Catherine Brand

Applicant signature: 

Date: 05 August 2015

APPENDIX 4

Pipeline Risk Management Plan and Protection Plan (Qualitative Risk Assessment) - Worley Parsons

WorleyParsons Consulting

EcoNomics

BIRCH FALLS

Lot 345 Woollcott Avenue Brabham

Pipeline Risk Management Plan and Protection Plan

401012-02213 – 401012-02213-00-SR-RP-001

18 May 2015

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250 St Georges Terrace Perth WA 6000
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Disclaimer

PROJECT 401012-02213 - LOT 345 WOOLLCOTT AVENUE BRABHAM

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	W S Woo	M Karyagina	N/A	18-May-15	N/A	
B	Issued for Client Review	W S Woo	M Karyagina	M Karyagina	18-May-15		

CONTENTS

Appendices

1 INTRODUCTION

Birch Falls are currently in the process of developing Lot 345 Woollcott Avenue (the Brabham residential area). This area is planned as a residential site and will include general infrastructure upgrades.

The APA Parmelia pipeline corridor is located on the development site while the Dampier-Bunbury Pipeline (DBP) and Dampier-Bunbury Loop line are on the adjacent block, Lot 346. All three of these pipelines contain high pressure (HP) natural gas.

In preparation for the proposed development a pipeline risk assessment was undertaken. This risk assessment was conducted on 13th May 2015 in the WorleyParsons office at 235 St Georges Tce, facilitated by WorleyParsons. The full workshop minutes and actions are included in Appendix 4 and Appendix 5 respectively.

1.1 Requirement

The WA Planning Commission (WAPC) requires that any land development in the vicinity of high pressure gas transmission pipelines maintains certain setback distances [Ref. 1]. These distances vary depending on the area of the metropolitan Perth traversed by the pipeline.

For developments within the setback distances, a pipeline risk management plan (PRMP) is required by the Planning Bulletin 87 (PB 87) [Ref. 1] as part of the application for planning approval. Preparation of the PRMP requires a pipeline risk assessment to be undertaken. There are two documents that set the guidelines for pipeline risk assessments:

- Australian Standard 2885 Pipelines – Gas and Liquid Petroleum (AS 2885.1) [Ref. 2], which uses qualitative risk assessment.
- PB 87 – High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region [Ref. 1], which includes quantitative guidelines.

This document covers the requirements for both standards and specifically covers the requirements of the following:

- Safety management study (SMS) – required to be carried out for high pressure gas pipelines if new threats to the pipeline are introduced, as per AS 2885.1 section 2.2.4 [Ref. 2].
- Pipeline risk management plan (PRMP) to demonstrate that the risk from the pipeline is within acceptable risk levels as per PB 87. Due to the commonality of the AS 2885.1 SMS and the PB 87 PRMP, these are presented as a single assessment and referred to as PRMP.
- Pipeline protection plan (PPP) to detail the precautions taken and processes used to implement risk management plan mitigation measures and construction works as per PB 87 [Ref. 1].

1.2 Study Objectives

The objectives of this PRMP and PPP are to identify:

- Threats to pipeline integrity in the area of the development.
- Existing controls and processes which will protect the pipelines during both construction of the works and lifetime of the development (including implementation of risk management plan mitigation measures).
- Further mitigation measures needed to achieve negligible, low or as low as reasonably practicable (ALARP) risk levels to the populations adjacent to HP gas pipelines within the scope of this study.
- Timing and responsibility for the installation of mitigation measures.
- Any on-going management measures.

1.3 Study Scope

This report considers the sections of the DBNGP Main, DBNGP Loop and Parmelia pipelines bordering the western boundary of the proposed Birch Falls development site.

Threats to the pipeline from the development during and after construction are the focus of the risk assessment workshop. The scope of the risk assessment work includes:

- The relevant section of the buried natural gas pipelines.
- Roads, crossings and drainage near the Parmelia pipeline.
- Civil construction works near the Parmelia pipeline.
- Future maintenance of services and infrastructure crossing the Parmelia pipeline.

The setback distance in this area is driven by the Parmelia pipeline, so the main focus of the risk assessment is the Parmelia pipeline, although risks to DBNGP/Loop are also covered. Risks to DBP were addresses as part of the Lot 346 PRMP and it is assumed that the risk mitigation measures identified therein will be fully implemented.

Any additional pipeline threats which become apparent due to changes in the scope of the development works must be reassessed.

1.4 Abbreviations

ALARP	As Low As Reasonably Practicable
APA	APA Group
AS	Australian Standard
CIC	Common Infrastructure Corridor

CP	Cathodic Protection
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DBYD	Dial Before You Dig
DCVG	Direct Current Voltage Gradient
DMP	Department of Minerals and Petroleum
DOC	Depth of Cover
EIP	External Interference Protection
EPA	Environmental Protection Authority
EPR	Earth Potential Rise
HDD	Horizontal Directional Drilling
HP	High Pressure
ILI	Inline Inspection
LFI	Low Frequency Induction
MAOP	Maximum Allowable Operating Pressure
NLST	Non Location Specific Threat (applies along the entire pipeline)
PB 87	Planning Bulletin 87
PPP	Pipeline Protection Plan
PRMP	Pipeline Risk Management Plan
ROW	Right of Way
SMS	Safety Management Study
WAPC	Western Australian Planning Commission
WT	Wall Thickness

2 FACILITIES DESCRIPTION

2.1 Development Proposal

The APA Parmelia pipeline corridor is located on the development site while the Dampier-Bunbury Pipeline (DBP) and Dampier-Bunbury Loop line are on the adjacent block, Lot 346.

2.2 Pipeline Specifications

The pipeline details in Table 2-1 were presented and agreed at the start of the workshop.

Table 2-1 Pipeline Details

	DBNGP Main	DBNGP Loop	Parmelia
Design Code	AS 2885	AS 2885	AS 2885
Diameter (OD), mm	660	660	355.6
Pipe Wall Thickness, mm	12.7	14.6	5.16
Maximum Allowable Operating Pressure (MAOP), MPag	8.48	8.48	7.48
Pipe Grade	API 5L X65 DSAW	API 5L X70 ERW	API 5L X52
Design Factor	0.5	0.5	0.72
Pipe Coating	MobiloxD1003		Yellow Jacket
Corrosion Prevention System	DC Impressed Current	DC Impressed Current	DC Impressed Current
Depth of Cover (DOC, min nominal), mm	1000 to 1520	1500 to 1800	~1000
Distance to 4.7 kW/m^2 (Measurement Length), m	660	660	320

2.3 Location Class

The location classes are defined in Sections 4.34 and 4.35 of AS 2885.1 [Ref. 2]. These classes describe what the predominant land use will be and what physical and procedural controls are required for each class.

With the advent of this development the primary location class of the land has changed to "Residential (T1)"[1]. Residential land is defined as land that has been developed for community living and applies where multiple dwellings exist in proximity to each other or in areas served by common public utilities.

A secondary location class of "Common Infrastructure Corridor (CIC)" is also applied as the function of the land results in multiple infrastructure development within a common easement.

As a result of the Birch Falls development, the primary location class is Residential (T1) with a secondary location class of Common Infrastructure Corridor (CIC).

2.4 Setback Distances

Setback distances are based on the type of land use or development, generic quantitative risk assessment and individual fatality risk values set in EPA guidance for different land use. The setback distance mandated in PB 87 [Ref. 2] for a residential area in the vicinity of the DBNGP corridor and Parmelia pipeline easement when adjoining between Muchea and Baldivis is 75 m from the edge of the pipeline easement. This distance corresponds with a fatality risk level of one in a million per year or less.

The development plan shown in Appendix 2 indicates the closest residential land is within the residential setback distance of 75 m, with a separation distance of approximately 18 m from the Parmelia pipeline easement.

[1] DBNGP and Loop line were designed to meet T1 requirements in this area, whereas Parmelia pipeline was designed for "Rural (R1)" location class.

3 RISK ASSESSMENT

A qualitative pipeline risk assessment in accordance with AS 2885.1 was conducted on the 13th of May 2015 for the sections of the DBNGP Main, DBNGP Loop and Parmelia pipelines adjacent to the site of the Birch Falls development at Lot 345 Woollcott Avenue, Brabham.

3.1 Team Composition

The pipeline risk assessment group included representatives from the developer (Birch Falls), pipeline operators (APA and DBP), construction contractor (PACT Construction) and design engineer for the development (Pritchard Francis).

The workshop was facilitated by a facilitator from WorleyParsons.

The attendance sheet for the workshop can be found in Appendix 1.

3.2 Methodology

The risk assessments followed the following process:

- A PowerPoint presentation covering the meeting agenda, highlighting the potential for harm from high pressure gas pipelines, and introducing the risk based AS 2885.1 process [Ref. 2].
- The Birch Falls representative responsible for the Brabham development described the proposed works. The plot plan (Appendix 2) was used to assist with the attendees' understanding of the potential issues/threats.
- PRMP: The AS 2885.1 [Ref. 2] risk methodology was used to brainstorm and document operational (post construction) related threats and the associated risks to the pipelines. The risk matrix from AS 2885.1 [Ref. 2] was used and ALARP documented if required. Actions were also logged as necessary. The risk matrix is included in Appendix 3.
- PPP: The AS 2885.1 [Ref. 2] risk methodology was used to brainstorm and document construction related threats and the associated risks to the pipelines. The risk matrix from AS 2885.1 [Ref. 2] was used to risk assess each credible threat. ALARP was documented and actions logged as necessary.

3.3 Workshop Results

The AS 2885 risk assessment of the construction and post-construction phases determined threats to the DBNGP Main, DBNGP Loop and Parmelia pipelines resulting from the proposed development and threats to the occupants who are adjacent to the pipeline.

Threats to the pipelines included the following:

- Pipeline joint corrosion.

- Heavy vehicles on the northern road crossing and on the Parmelia pipeline easement.
- Installation and maintenance activities of 3rd party services – power / communications cables, water and sewerage.
- Construction and maintenance activities of the northern road crossing.
- Installation of fences and signage posts.
- Vegetation over the Parmelia pipeline easement
- Vibrating machinery.

Where appropriate the existing and required risk mitigation measures were discussed and documented.

Minutes from the AS 2885 pipeline risk assessment for construction and post-construction phases are attached in Appendix 4.

Thirteen (13) actions were raised and are presented in Appendix 5. Implementation of these actions will ensure that risks to the integrity of the pipelines and therefore to adjacent populations remain ALARP.

4 RISK MITIGATION MEASURES AND RESPONSIBILITIES

The risk mitigation measures in Table 4-1 to be implemented during the development of the site have been agreed between the land developer and pipeline operators.

Table 4-1 Summary of Risk Mitigation Measures

Mitigation Measures	Responsibility	Project Phase
Increased signage may be required (if not already installed as part of Lot 346).	Birch Falls / ABN	Design
Crossing design to comply with AS 2885.1 and APA requirements (slab, minimum DOC requirement, minimum separation between 3rd party services, etc.).	Birch Falls / ABN	Design
Bollards to prevent vehicle access to pipeline easement (but ensuring pipeline operator has access to it).	Birch Falls / ABN	Design
Ground cover in pipeline easement to comply with APA requirements.	Birch Falls / ABN	Design
Temporary fence restricting access to the pipeline. Points of note: • Provide access gates / keys to the pipeline operator. • Non-excavation installation method is preferred for the fence sections that cross the pipeline.	Birch Falls / ABN	Construction
Approved machinery and construction method to ensure no loading over the pipeline / vibration risk.	Birch Falls / ABN	Construction
Installation of services in the road crossing should be post crossing construction (i.e. slab is in place).	Birch Falls / ABN	Construction
Liaison with APA (and where appropriate with DBP) to ensure appropriate supervision during high risk activities (crossing construction, sewerage line horizontal direction drilling (HDD), etc.)	Birch Falls / ABN	Construction
Weld joints will be inspected as part of Lot 346 development for entire length of development.	APA	N/A
Existing controls as required by AS 2885.3 and APA / DBP safety cases commensurate with the T1 location class.	APA, DBP	Ongoing

5 CONCLUSIONS

The proposed Birch Falls development at Lot 345 Woollcott Avenue, Brabham poses potentially ongoing threats to the DBNGP Main line, DBNGP Loop line and Parmelia pipeline. These threats were evaluated using the AS2885.1 methodology.

The results of the AS2885 risk assessment for construction and post-construction phases can be seen in Appendix 4.

Thirteen (13) actions were raised and responsibilities assigned – it remains the responsibility of the actionees to actively and expeditiously progress the actions to a suitable conclusion in order to bring the various pipeline threats to ALARP risk levels.

Correspondence and active liaison between the pipeline operators and the land developer will occur on an ongoing basis to progress the proposed development. The actions raised also reflect this.

6 REFERENCES

1. High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region. Planning Bulletin 87, Western Australian Planning Commission, October 2007.
2. AS2885.1: Australian Standard: Pipelines – Gas and Liquid Petroleum, Part 1 Design and Construction, 2012.

Appendix 1 Workshop Attendance Record

WorleyParsons

Meeting Attendance Record

Date 13 May 2015
Meeting topic 345 Woollcott Avenue Brabham Risk Assessment
Held by WorleyParsons
Venue Level 2, 235 St Georges Terrace, Avon Conference Room

NAME	SIGNATURE	POSITION	COMPANY
Marina KARYAGINA	[signature]	Facilitator	WorleyParsons
Sebastian Montoya	[signature]	Site Manager	DACT contracting
Chathna Doran	[signature]	Engineer	Pritchard Francis
Mark Riddell	[signature]	Civil Engineer	Pritchard Francis
Wai Sum WOO	[signature]	Scribe	WorleyParsons
Adam Crichton	[signature]	Pipeline Engineer	APA Group
Kathy Chick	[signature]	Lands Officer	DBP
Bill Ivory	[signature]	Land Agent	APA
Jeremy Cordina	[signature]	ABN Land Development	ABN

DISTRIBUTION

☐ Personnel Manager ☐ Other (please specify)
☐ Other (please specify)

Appendix 2 Development Plan

LAND USE SCHEDULE	
TOTAL SITE	20.29
DEDUCTIONS.	
PIPELINE EASE'T	1.34
1:1 yr DRAINAGE	0.1
NET SUBDIVISIBLE	18.85ha

P.O.S. PROVIDED	2.35ha = 12.5%

TOTAL SITE AREA (NDA)	= 11.35 ha.

LOT YIELD	
SINGLE LOTS	325
G.H. LOTS.	1
TOTAL.	326 LOTS

CONCEPT PLAN

Lot 345 Woollcott Avenue, Brabham
City of Swan

plan no: 3403-03A-01
scale: 1:2500 @ A3
date: 06.03.2015

Appendix 3 AS 2885 Pipeline Risk Assessment – Matrix

AS2885.1 2012 - Risk Matrix

			Typical Severity Classes	Catastrophic	Major	Severe	Minor	Trivial
CONSEQUENCES			People	Multiple fatalities result	Few fatalities, or several people with life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health & safety
			Supply	Long term interruption of supply	Prolonged interruption; long term restriction of supply	Short term interruption; prolonged restriction of supply	Short term interruption; restriction of supply but shortfall met from other sources	No impact; no restriction of pipeline supply
			Environment NOTE: Significant environmental consequences may occur in locations which are relatively small & isolated	Effects widespread; viability of ecosystems or species affected; permanent major changes	Major off-site impact; long term severe effects; rectification difficult.	Localised (<1 ha) & short-term (<2 yr) effects, easily rectified.	Effect very localised (<0.1 ha) and very short term (weeks), minimal rectification	No effect; minor on-site effects rectified rapidly with negligible residual effect
FREQUENCY	Frequent	Expected to occur once per year or more		Extreme	Extreme	High	Intermediate	Low
	Occasional	May occur occasionally in the life of the pipeline		Extreme	High	Intermediate	Low	Low
	Unlikely	Unlikely to occur within the life of the pipeline, but possible.		High	High	Intermediate	Low	Negligible
	Remote	Not anticipated for this pipeline at this location.		High	Intermediate	Low	Negligible	Negligible
	Hypothetical	Theoretically possible, but has never occurred on a similar pipeline		Intermediate	Low	Negligible	Negligible	Negligible

Risk Management Actions	
Extreme:	Modify the threat, the frequency or the consequences so that the risk rank is reduced to 'intermediate' or lower. For an in-service pipeline the risk shall be reduced immediately.
High:	Modify the threat, the frequency or the consequences so that the risk rank is reduced to intermediate or lower. For an in service pipeline the risk shall be reduced as soon as is possible, typically within a timescale of not more than a few weeks.
Intermediate:	Repeat threat identification and risk evaluation processes to verify and, where possible, quantify the risk estimation; determine the accuracy and uncertainty of the estimation. Where the risk rank is confirmed to be 'intermediate', if possible modify the threat, the frequency or the consequence to reduce the risk rank to 'low' or 'negligible'. Where the risk rank can not be reduced to 'low' or 'negligible', action shall be taken to: (a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable; and (b) demonstrate ALARP. For an in-service pipeline the reduction to 'low' or 'negligible' or demonstration of ALARP shall be completed as soon as possible, typically within a timescale of not more than a few months.
Low:	Determine the management plan for the threat to prevent occurrence and to monitor changes that could affect the classification.
Negligible:	Review at the next review interval.

Appendix 4 AS 2885 Risk Assessment Minutes

Threats and Safeguards

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
NLST	1.1.1. Corrosion	1.1.1.1 Potential for joint corrosion of Parmelia pipeline	APA	T1, CIC	Yes	No			Inline inspection (ILI) Direct current voltage gradient (DCVG) surveys Cathodic protection (CP) Weld joints will be inspected as part of Lot 346 development for entire length of development	Yes	No		Yes	
		1.1.1.2 Potential for joint corrosion of DBNGP	DBP	T1, CIC	Yes	No			ILI DCVG surveys (5 yearly) Cathodic protection (CP)	Yes	No		Yes	
	1.1.2. Natural Event	1.1.2.1 No additional credible threats identified due to development	DBP, APA	T1, CIC										Existing creek will be widened and walls stabilised to reduce risk of flooding
	1.1.3. Electrical Effect	1.1.3.1 Electrical cables (LV and HV) installed on east side of road reserve have potential to impact Parmelia pipeline's CP system	APA	T1, CIC						No		1. Developer to provide Earth Potential Rise (EPR) and Low Frequency Induction (LFI) studies for APA approval	No	
	1.1.4. Operations and maintenance activities (pipeline operator)	1.1.4.1 No additional credible threats identified due to development	DBP	T1, CIC										
	1.1.5. Construction defects	1.1.5.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.6. Design defects	1.1.6.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.7. Material defects	1.1.7.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.8. Intentional damage	1.1.8.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.9. Other - Seismic and blasting	1.1.9.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.10. Inundation area	1.1.10.1 Flotation of pipeline	APA	T1, CIC	No	No			Subject to APA investigation Screw anchors					Ground water table is close to surface in this area and will be rectified as part of development to comply with building code
Birch Falls	1.2.1. New road crossing over pipelines	1.2.1.1 Vehicle loading over pipeline leading to increased pipe stress	DBP, APA	T1, CIC	Yes	No			> 1200 mm DOC required at road crossing Load calculations API RP 1102	No		2. Submit northern crossing design for approval by APA	No	
		1.2.1.2 Road maintenance by the City of Swan to a maximum depth of ~ 300 mm for resealing	APA	T1, CIC	Yes	Yes	Burial, minimum DOC > 1200 mm (as per approved road crossing design) Slab will be installed as part of approved road crossing design	Dial before you dig (DBYD) Third party liaison Signage Patrolling, aerial		No		2. Submit northern crossing design for approval by APA	No	EIP controls assume crossing design as per API RP 1102
		1.2.1.3 Road maintenance by the shire to a maximum depth of ~ 300 mm for resealing	DBP	T1, CIC	Yes	Yes	Burial, minimum DOC > 1200 mm Wall thickness	DBYD Third party liaison Signage Patrolling, aerial		No			No	This crossing is outside of the development. It is assumed that it will have typical controls required by DBP.
		1.2.1.4 Installation of future underground services (i.e. casing)	DBP, APA	T1, CIC	Yes	Yes	Burial, minimum DOC >1000 mm	DBYD		Yes	Yes	3. Obtain standard third party services crossing drawing	Yes	

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
		trenchless techniques)					Additional protection (e.g. slab), will be provided as agreed with APA	Third party liaison Signage Patrolling, aerial				from APA and design crossing as per standard API RP 1102		
	1.2.1.5. Use of vibrating equipment for compaction of road leading to damaged coating and potential long term corrosion failure		DBP, APA	T1, CIC	Yes	No			ILI DCVG surveys Third party liaison Patrolling, aerial	No			No	No additional requirements on developer for post-construction phase
	1.2.2. Residential development adjacent to pipeline easement	1.2.2.1. Vehicle access onto pipeline easement opposite residential housing resulting in decreased DOC over time	APA	T1, CIC	Yes	No		Third party liaison Signage Patrolling, aerial	Bollards to prevent vehicle access onto easement Battered bank in some areas	No		4. Install bollards in road reserve as per City of Swan regulations to restrict access to pipeline easement 5. Obtain details of access points for pipeline easement from APA	No	
	1.2.3. Maintenance of third party utilities installed in road reserve	1.2.3.1. HDD to reconnect services between two developments may impact pipelines	DBP, APA	T1, CIC	Yes	Yes	None	DBYD Third party awareness Signage Patrolling, aerial		Yes			Yes	
	1.2.4. Installation and repair of street lights	1.2.4.1. Street lights installed in road reserve - not a credible threat to pipeline	APA	T1, CIC										
	1.2.5. Vegetation in pipeline easement	1.2.5.1. Coating damage from roots	APA	T1, CIC	Yes	No			Mulch and plant ground cover with root penetration not exceeding 100 mm across entire span of easement	No		6. Provide details of landscaping plan for pipeline easement to APA for approval	No	
	1.2.6. Installation of signage in pipeline easement	1.2.6.1. Coating damage of pipeline by signs supports if installed deep enough (typical 600 mm posts)	APA	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm	Patrolling, aerial Signage Third party awareness		No		7. Ensure no advertising signs are installed in pipeline easement	No	
	1.2.7. Failure of high pressure sewerage line	1.2.7.1. HP sewerage line crosses Parmelia pipeline on southern part of development, release from HP sewerage line may result in the wash out of soil from underneath pipeline leading to unacceptable stresses	APA	T1, CIC	Yes	No			No controls	No		8. Provide information on pump station shut down philosophy in event of leak or breakage	No	Gravity type sewerage line will not have this issue
Existing fences(s) south of development	1.3.1. Fence	1.3.1.1. Fence post hole digging	APA	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm Wall thickness, sufficient to protect from post hole digger	Landowner liaison Marker tape Signage (might not be as per T1 location class)		No		9. Check if signage in pipeline corridor, at road crossings and at any fences is as per new location class and if not, increase signage	No	Sensitive class signage spacing will be implemented as part of Cedar Woods development on northern side of development
		1.3.1.2. Fence post hole digging	DBP	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm Wall thickness, sufficient to protect from post hole digger	Landowner liaison Marker tape Signage as per T1 location class		No			No	
Existing	1.4.1. Minor watercourse	1.4.1.1. Cleaning silt using backhoe or excavator to depth 300 mm silt. Overall depth of drain is unaffected. Not a credible threat to pipeline as watercourse does not cross pipelines in the development	DBP, APA	T1, CIC	No									
	1.4.2. Overhead power line	1.4.2.1. Maintenance, replacement of power pole	DBP, APA	T1, CIC	No									There is no overhead power line on the development. There is a power line along Woolcott Avenue. No power poles on

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
														assessment

Phase: Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
	1.1.1. Road construction	1.1.1.1. Vehicle load on pipeline.	DBP, APA	T1, CIC	No	No			Calculations performed to determine allowable vehicles	No		10. Obtain vehicle load analysis form from APA and utilise construction vehicles as determined by the calculation.	No	
		1.1.1.2. Excavation works may impact pipeline	DBP	T1, CIC	Yes	Yes	Slab will be installed as part of approved road crossing design	DBYD DBP permit to work APA supervisor No digging within 1 m of pipeline - APA requirement				11. Developer to provide method statement for road crossing construction for APA approval. 12. Liaise with Cedar Woods in regards to pipeline slabbing over road crossing, to ensure it complies with requirements of action 4.	Yes	Cedar Woods is slabbing pipeline with protective slab in the area of road crossing
		1.1.1.3. Use of vibratory equipment leading to coating damage and weld joint stresses	APA	T1, CIC	Yes	No			Vibratory equipment cannot be used within 10 m of Parmelia pipeline APA permit to work.	No			No	
	1.1.2. Construction works	1.1.2.1. Storage of materials over pipeline leading to erosion of cover over pipeline and/or unacceptable stresses	APA	T1, CIC	Yes	No			Fence will be installed at commencement of construction in road reserve preventing access to pipeline	No			No	Operator will need to have access gate installed (and be provided with keys)
	1.1.3. Installation of fence	1.1.3.1. Sections of fence may be installed over pipeline. May impact pipeline by auger	APA	T1, CIC			DOC approximately 1 m	APA supervision		Yes		13. Ensure no excavation over pipeline for fence installation (water barrier or above ground fence in this section).	No	Post workshop note: Threat was not progressed to risk assessment because the proposed mitigation measure will eliminate the threat.
	1.1.4. Installation of sewerage line at southern end of development	1.1.4.1. Impact to pipeline from installation of sewerage line	DBP, APA	T1, CIC	Yes	Yes	Separation between Parmelia pipeline, sewerage line and DBNGP will be maintained during installation of sewerage line	APA supervision DBP supervision		Yes			Yes	
	1.1.5. Installation of buried services at northern crossing	1.1.5.1. Excavation works crossing pipeline	APA	T1, CIC	Yes	Yes	Slab will be installed as part of approved road crossing design	DBYD APA permit to work		No			No	

Appendix 5 Actions List

Action ID	Action	Responsibility	Place(s) Used
1	Developer to provide Earth Potential Rise (EPR) and Low Frequency Induction (LFI) studies for APA approval.	Birch Falls / ABN	Threats: 1.1.1.3.1
2	Submit northern crossing design for approval by APA.	Birch Falls / ABN	Threats: 1.1.2.1.1, 1.1.2.1.2
3	Obtain standard third party services crossing drawing from APA and design crossing as per standard API RP 1102.	Birch Falls / ABN	Threats: 1.1.2.1.4
4	Install bollards in road reserve as per City of Swan regulations to restrict access to pipeline easement.	Birch Falls / ABN	Threats: 1.1.2.2.1
5	Obtain details of access points for pipeline easement from APA.	Birch Falls / ABN	Threats: 1.1.2.2.1
6	Provide details of landscaping plan for pipeline easement to APA for approval.	Birch Falls / ABN	Threats: 1.1.2.5.1
7	Ensure no advertising signs are installed in pipeline easement.	Birch Falls / ABN	Threats: 1.1.2.6.1
8	Provide information on pump station shut down philosophy in event of leak or breakage.	Birch Falls / ABN	Threats: 1.1.2.7.1
9	Check if signage in pipeline corridor, at road crossings and at any fences is as per new location class and if not, increase signage.	APA	Threats: 1.1.3.1.1
10	Obtain vehicle load analysis form from APA and utilise construction vehicles as determined by the calculation.	Birch Falls / ABN	Threats: 2.1.1.1.1
11	Developer to provide method statement for road crossing construction for APA approval.	Birch Falls / ABN	Threats: 2.1.1.1.2
12	Liaise with Cedar Woods in regards to pipeline slabbing over road crossing, to ensure it complies with requirements of action 4.	Birch Falls / ABN	Threats: 2.1.1.1.2
13	Ensure no excavation over pipeline for fence installation (water barrier or above ground fence in this section).	Birch Falls / ABN	Threats: 2.1.1.3.1

APPENDIX 5

Service Infrastructure and Earthworks Strategy - Pritchard Francis

Lot 345 Woollcoot Avenue, Brabham
Engineering Servicing Report

pritchard francis

providing the right solution

pritchard francis

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Subiaco WA 6904

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15-006

Engineering Servicing Report

for

ABN Group

On

Lot 345 Woollcott Avenue, Brabham

Revision	Description	Date
0	Issued to Client for Review	9 Feb 2015
1	Issued for Structure Planning	17 Aug 2015
2	Updated Staging	25 Aug 2015

Contents

Appendices

1 Introduction

Pritchard Francis has been engaged by Jeremy Cordina of ABN Group to carry out engineering due diligence for the non-building related infrastructure associated with the development of Lot 345 Woollcott Avenue, Brabham. Lot 345 Woollcott Avenue (the site) is located approximately 1km east of Whiteman Park in the City of Swan, as highlighted in Figure 1 below. Due to the large gas pipelines and easements in the area, and the groundwater protection zoning of Priority 3 over a portion of the site, the area is zoned as Special Use Zone 10 under the City of Swan's Local Planning Scheme No. 17. The zone objectives are to:

a) Provide for specific uses or combination of uses in circumstances where the uses have particular locational and development requirements for which a generic zoning is unsuitable;

b) Facilitate the development of strategically important facilities that cannot be satisfactorily provided for within any of the generic zones, and to ensure compatibility with adjacent development.

Figure 1: Site Location

The site falls within the Albion District Structure Plan (DSP), prepared by Chappell Lambert Everett (CLE) in 2010. The DSP shows the site to be on the fringe of the '800m Walkable Catchment to Town Centre' radius and the majority of the site to be within the '400m Walkable Catchment to Local Centre' radius.

The proposed site plan, prepared by CLE in May 2015, contained in Appendix One, proposes to construct approximately 330 lots, varying in size from 200m² to 600m², and a larger group housing lot to the north. This plan shows the Parmelia Gas Pipeline easement at 18.3m and no setback distance from the pipeline easement has been included as a result from a Risk Assessment carried out by Worley Parsons in May 2015, in which APA, DBP (Dampier-Bunbury Pipeline) ABN, Pritchard Francis and Pact Contracting were involved in. This is discussed further in Section 2.4.

This report considers the engineering servicing constraints and opportunities for the proposed residential development. The report does not comment on sustainability measures, planning requirements and environmental management, as these have been addressed in other documents at this stage, and will be considered in greater detail in the engineering design at a later date.

Service information within this report is based upon preliminary discussions with respective consultants, major service providers and contractors working in the vicinity.

2 Site Conditions

The site was previously quarried for sand and shows the effects with groundwater currently ponding at surface level. The site currently sits at elevations of 25.3m AHD in the south east corner to 35m AHD on top of a small mound along the western boundary. The site is predominantly fine to medium grained Bassendean sand. The Topography and Geology figure, contained in Appendix Two, extracted from the Swan Urban Growth Corridor Drainage and Water Management Plan (Swan WMP), prepared in 2009 for the Department of Water, indicates that there is a possibility of peaty clay in the southern portion of the site. However, the geotechnical investigation carried out on site by Galt Geotechnics in February 2015, contained in Appendix Four, found no trace of peat or clay. Sand was found to cover the entire site to the investigation depth of 0.8m – 1.9m, and minor pockets of 'coffee rock' noted from depths of 0.9m to 2.1m in 6 of the 15 test pits.

The site is dissected in the north east corner by St Leonard Creek, listed as Lot 33 and zoned Regional Reserve. The creek has been integrated into the proposed site layout with a buffer either side of it to accommodate large storm flows.

2.1 Ground Water

Based on the Department of Water Groundwater Atlas, the Swan WMP, geotechnical investigations and ground water monitoring data on the site and neighbouring lots, the groundwater on site seasonally fluctuates approximately 2m. The Annual Average Maximum Groundwater Level (AAMGL) sits roughly between 29m in the north-west portion of the site, to approximately 24.5m in the south east portion the site. The high groundwater table will necessitate dewatering during construction of the sewer network, filling of the site by 1m - 2m to gain separation from the groundwater, and sub-soil drainage in areas where a minimum of 1.5m separation from the Maximum Groundwater Level (MGL) may not be achievable.

The northern and western portion of the site are located within the Gnangara underground water pollution control area and is classified as a Priority 3 (P3) area, as shown in Figure 2 below. This will not affect residential development, with the only potential influence being restrictions on storage and use of chemicals in this area, limiting the extent of chemical nutrients being added to POS in the vicinity.

Figure 2: Extract from DOW Geographic Data Atlas – Protection area - P3

2.2 Surface Water

A natural water course, St Leonard's Creek, dissects the northern portion of the site, running east and eventually discharging to the Swan River. The seasonal creek is protected under the Swan and Canning Rivers Trust Management Act 2006 and is in a degraded state at present. During the drafting of the Swan WMP in 2009 the area was modelled for flooding and Table 6-2 of the report summarises peak flows, levels and indicative floodway widths at critical locations for water courses in the study area. Below is an extract from the table.

Swan urban growth corridor drainage and water management plan

Table 6-2 Flows, levels and floodway widths at critical locations

Location	peak flows (m3/s)		peak levels (m AHD)		indicative floodway width (m)
Number(Fig. A-8) and description	5 Year ARI	100 Year ARI	5 Year ARI	100 Year ARI	100 Year ARI
1. Albion - Inflow to St Leonards Creek at Park St	0.5	1.1	30.8	30.9	16
2. Albion - St Leonards Creek at Murray Rd	0.5	1.5	23.4	23.4	50-100
3. Albion - St Leonards Creek at Woolcott Ave / Murray Rd	0.1	0.3	22.0	22.1	50

Figure 3: Extract from Table 6-2 of Swan Urban Growth Corridor Drainage and Water Management Plan, 2009

With increased development in the area impermeable space will increase, making this creek an integral piece of drainage infrastructure. During major storm events runoff from the northern portion of this site will discharge into the creek. Flood modelling in the area has been undertaken by 360 Environmental as part of the Local Water Management Strategy (LWMS), and the use of the creek for stormwater management is discussed in more detail in that report. The water course will require reconstruction along degraded sections, and vegetating the buffer zone during site development to improve stability of the verges.

There is a drain running east along Woollcott Avenue at present with its longitudinal section listed in the Swan WMP as Albion Central, discharging to St Leonards Creek at Murray Road. There is little information available for this drain and it is yet to be deciphered what upgrading works will be required when upgrading Woollcott Avenue.

2.3 Wetlands

There is one wetland, Wetland 13396, mapped over half the site. The wetland is labelled a Multiple Use palusplain wetland, meaning a wetland that is seasonally waterlogged and scores poorly on both natural and human use attributes. During an environmental investigation for neighbouring Lots 346 and 347, Aurora Environmental deemed the wetland to be in a highly degraded condition with native vegetation absent across much of its extent.

Based on this, the omission of the wetland from the Albion DSP, and provisional approval to develop over it on neighbouring Lots 346 and 347, it is anticipated that the wetland will not hinder development

Wetland UFI 8805 to the west and south west of the site, shown as the light green patch in Figure 4 below, is classified as a Resource Enhancement sumpland. Environmental reporting for Lots 346 and 347 states that this wetland is in good condition in those lots, however the portion south of Woollcott Avenue appeared to be devoid of native vegetation. A large portion of this wetland is likely to remain and the opportunity to replenish the wetland with stormwater from our site should be investigated through discussions with the council and neighbouring land owner in order to minimalize on-site stormwater detention.

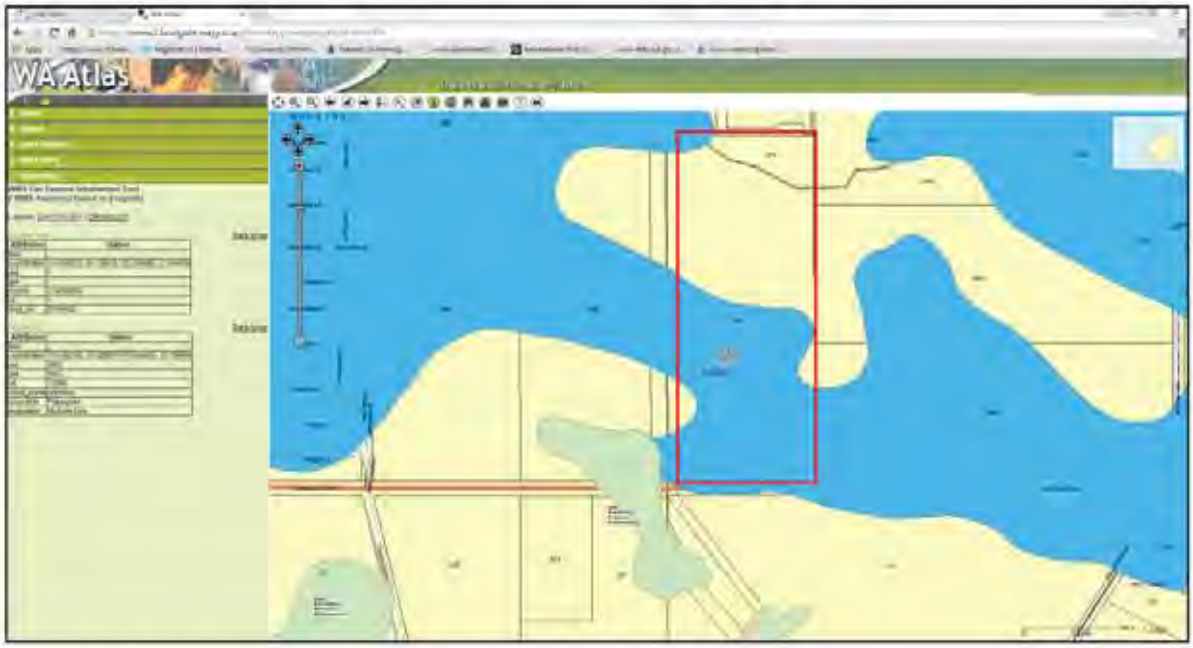


Figure 4: Wetland mapping of Brabham area

2.4 APA Gas Pipeline

As shown on the proposed site plan, the site encompasses the APA Parmelia Gas Pipeline, running north-south along the western boundary. To the west of the Parmelia gas line runs the Dampier to Bunbury Natural Gas Pipeline (DBNGP). The DBNGP has no effect on this site however the proposed sewer connection discussed in Section 3.2 will cross both pipelines and will require discussions with, and approvals from, all asset owners.

An easement of 18.3m has been allocated over the Parmelia pipeline, in which it is not permitted to construct structures of any kind. Further to this, APA specify a standard setback distance from the edge of the easement of 75m. A risk assessment was carried out by Worley Parsons, with the involvement of APA, DBP, ABN, Pritchard Francis and Pact Construction on 13 May 2015, where proposed land use and risk mitigation measures were discussed, and actions put in place, which has permitted the removal of the setback to the easement for this site. The Worley Parson report is contained in Appendix Five.

Any proposed road or pipeline crossings over the gas pipelines will need the approval of APA, and where relevant the DBP, prior to construction. The pipeline owners will inspect the area in question and the pipeline will require suitable protection during construction.

Any construction within 320m of the pipeline will require notification and liaison with APA.

2.5 Site Preparation and Earthworks

In order to develop the site a large quantity of clean sand fill is required to gain adequate separation to the groundwater. A minimum separation of 1.5m is required from finished lot level to the MGL or the controlled groundwater level (CGL) through the use of sub-soil drainage. Initial earthwork designs have calculated the fill requirements for the site in the order of 290,000m³. This quantity includes allowance for removal of debris and unsuitable material from site, and 'cut to fill' of the localised mounds within the site.

Acid Sulphate Soil (ASS) Risk mapping, contained in Appendix Two, show the southern portion of the site having a high to moderate ASS disturbance risk at less than 3m from the surface. RJ Vincent & Co Pty Ltd who have worked on a site further west along Woollcott Avenue have encountered ASS at their site, however the geotechnical investigation conducted on this site did not encounter any soil type that indicated possible ASS being present.

The site preparation and earthworks may have to include protection and retention of significant trees. However this aspect has not been included in the preliminary design as a vegetation survey of the site has yet to be conducted to establish the extent of significant trees and vegetation.

The preliminary Cut/Fill plan are shown in Figure 5 and Appendix Three. The pipeline easement has been omitted from the plan as no movement of material will occur over the pipeline easement.

The development is anticipated to be completed in 10 stages, starting along Woollcott Avenue and moving north through the site. The sequence of the staging may vary in order to construct the site services in a more efficient manner, and to tie into neighbouring developments as required. The staging plan is shown in Figure 6 and contained in Appendix Three.

Figure 5: Site Bulk Earthworks and Cut/Fill area plans

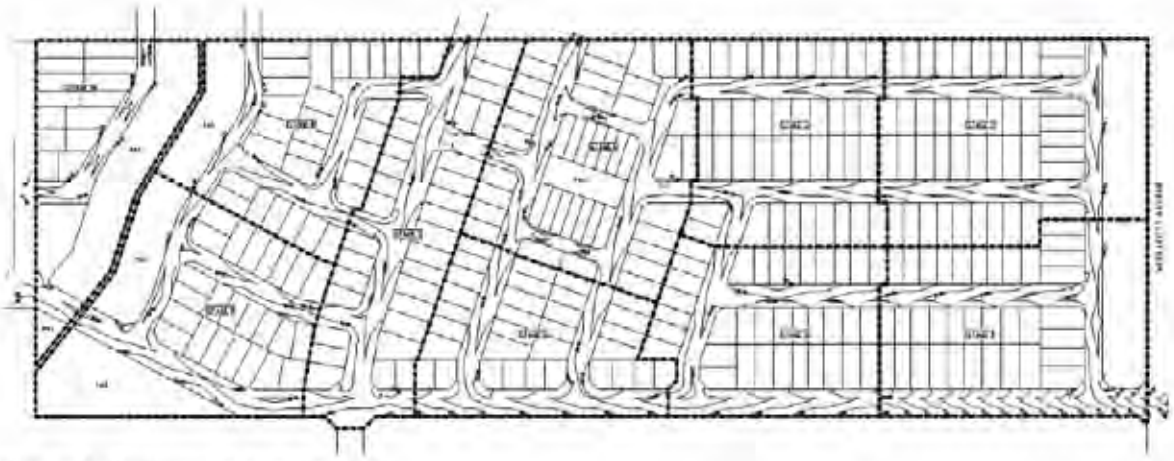


Figure 6: Preliminary Staging Plan

3 Infrastructure

3.1 Stormwater Management

An LWMS for the site has been prepared by 360 Environmental, detailing the Stormwater Management Objectives and the intent to construct swales and utilise POS area for stormwater detention and infiltration where appropriate, with POS sections and proposed vegetation detailed in the Landscaping Concept Plan prepared by LD Total, August 2015. The preliminary catchment areas, corresponding to the preliminary site levels, are shown in Figure 7.

The stormwater system involves the construction of a pit and pipe system for collecting run-off from the roads, constructed swales where appropriate, and lot connection pits for lots smaller than 300m^2 and/or with insufficient clearance to the MGL for infiltration. Stormwater will be conveyed to either St Leonards Creek in the northern portion of the site, to the POS in the south portion of the site, or to the detention swale along the west.

Figure 7: Proposed Site Catchment Plan

3.2 Sewerage Reticulation

Brabham is experiencing an increase in residential development, changing a previously rural area into an urban hub. Due to the infancy of the urban area, sewer infrastructure is still in planning stages and being dealt with locally through interim pump stations.

Water Corporation have advised that there is a current proposal to construct an interim Type 90 Wastewater Pump Station (WWPS) along Youle-Dean road, just west of the Dampier to Bunbury gas pipeline easement, which will allow for the grading out of smaller WWPSs in the area. Unfortunately the levels at this site and surrounding sewer infrastructure are not conducive to installing a gravity sewer through existing road reserves to the proposed Type 90 WWPS, as the sewer would end up too deep to be feasibly constructed.

In order to service the site, it is proposed to construct a Water Corporation Type 10 interim waste water pump station (WWPS) and rising main, connecting the site, and northern Lot 9203's gravity sewer system to the gravity main at Partridge Street, 560m west of the site along Woollcott Avenue, to service the lots temporarily, until a gravity main is constructed to service the surrounding sites.

The intent is to construct the sewer network, tying into Lot 9203 to the north, in order to grade out the temporary Type 10 pump station in use there, run the sewer south through this site to Woollcott Avenue and install a Type 10 WWPS at the southern point of the site to pump west connecting into the gravity sewer at Woollcott and Partridge Street.

The proposed sewer will be at depths ranging from 1.5m to in excess of 6m BGL, meaning dewatering will be required. As the main north-south run of the sewer has to connect into manhole AD0398 north of the site at I.L. 25.02m. Boring the 225mm dia sewer main is being advised to minimalize dewatering cost, water storage from de-watering, possible ASS management cost and lime dosing facilities, etc. associated with trenching 6m+ in this area. The intent is to bore the deep sewer approximately 0.8km from manhole AD0398 to the Type 10 WWPS, while constructing the site's local sewer network at depths of 1m - 3m BGL. The local sewer network will connect into the deep sewer at manholes, and the installation of the manholes will still require dewatering, but to a manageable scale over the 2.9km of proposed internal 100mm and 150mm diameter sewer.

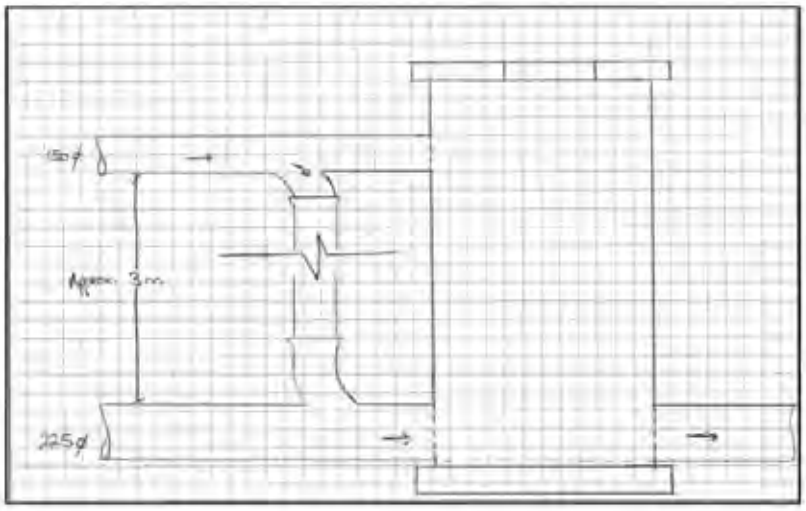


Figure 8: Example of a Dual Sewer connection

This proposed sewer arrangement has been done previously along Coogee Road, Munster in the City of Cockburn, but will still require discussions with, and approval from, the Water Corporation.

Water Corporation have stated that an interim Type 10 WWPS will only be accepted as a last resort, when all other options have been exhausted. Due to the cost of installation, the temporary nature of the WWPS and Water Corporations' advice, all gravity sewer options are being looked into to eliminate the need for a pump station on the site. The possibility of running a gravity sewer south, through southern neighbouring lots, is being looked into, however, this is at its preliminary stages and no plan or agreements have been put in place regarding this.

3.3 Water Reticulation

The proposed development will likely be serviced by extending the existing 250mm water reticulation main, which terminating at the site's northern boundary, into the site. Water Corporation have commented that there shouldn't be an issue with extending this main, however they will confirm this once a more detailed plan is provided to them.

The intent is to construct a 200mm dia water main route through the site, which will have 100mm dia mains coming off it to service the majority of the lots. Generally, service utilities prefer to have service mains

extended to form rings in order to enable greater distribution of flows and pressures and increasing security of supply by providing alternative flow directions.

3.4 Gas Supply

There is a proposed 160PE gas main planned for installation in Lot 9203, which terminates at the northern boundary of Lot 345. Gas supply mains are often installed in common trenches, following other hydraulic services, which in this case would be the water main, being extended from the same location on the northern boundary south into the site. Discussions with ATCO Gas regarding reticulating gas through the site will commence once a development plan is in place, a water reticulation route is chosen and a possible demand on their network is known. Once a water main design is established, ATCO Gas can review it and decide whether to follow the water or service the site through a preferred route. Gas servicing for the development is not expected to create major issues and would be seen to be a necessary service for development of this scale and nature.

3.5 Roadworks

The road reserves vary from 12m – 18m widths, as per the proposed structure plan. The major road layout for the development, guided by the DSP, has an 18m reserves with 7.2m roads, semi mountable kerbing and 2m dual use path along one verge, bollards and a swale along the other, running north-south through the site. The secondary roads in the development are 15m reserves where there are lots on both sides, and 12m reserves along POS areas. Both will have standard 6m roads with semi mountable kerbing and 2m wide footpaths along one side. It has been assumed the makeup of all road types will consist of a 200mm limestone base, 40mm high fatigue asphalt and 25mm wearing course.

Woollcott Avenue, and the servicing infrastructure within the road reserve, are likely to be upgraded over the coming years to accommodate the rapid development in the area. Coordination with neighbouring developers and the City of Swan will occur to ensure the proposed upgrade of the road fronting the site is consistent with previous upgrade works.

3.6 Electrical and Communications Supply

Electrical and communication servicing for the site is based on preliminary advice from electrical consultants that have vast experience with sub-division of land.

Advice from the electrical consultant regarding Western Power capacity in the area is that both Beechboro Zone substation, approximately 10km south west of the site and Ellenbrook Zone Substation on Gnangara Road, about 2.5km north of the site have less than 5MVA of remaining capacity with the current equipment, but they can be expanded providing a network capacity that is much higher.

It was recommended that a Design Information Package (DIP) request should be submitted to reserve available capacity as soon as feasible.

Bringing power to the site is likely to involve extending the HV lines to the north-west and partial upgrade of the HV aerial lines to reinforce the underground network.

With respect to communications infrastructure, Telstra and NBN are the communication services required.

3.7 Headworks

As part of servicing the site, headworks and additional charges from authorities relating to constructing and servicing these lots will be applicable. This will include elements such as water, sewer, gas and power service charges. For subdivisional works, the developer is required to pay for relevant headworks charges to enable clearance of titles relevant to the subdivided lots.

Water Corporation have assigned a surcharge on the standard infrastructure contribution in the area they refer to as North-East Corridor. Infrastructure contributions are to be paid for all new lots created with sewer and water. The surcharge on these contributions are meant to reflect the higher cost of operating and maintaining their infrastructure in a remote area. A copy of the Water Corporation Information Sheet 24 is included in Appendix Six.

The Brabham (Albion) Development Contribution Plan, DCA – 1, developed for the City of Swan details the method for calculating the contribution to be paid to the city by the developer, to go towards infrastructure expansion and upgrading in the region. Based on DCA - 1 and Consumer Price Index percentage changes, a contribution of $3.2 million for developing Lot 345 is payable to City of Swan.

Department of Education and Training Contribution Fee, to contribute to the schools being built in the area, has been equated to $1,870 per dwelling.

It has been estimated that the Western Power energisation fees will be approximately $2,880 per dwelling.

4 Conclusion

Lot 345 Woollcott Avenue, Brabham, has high groundwater issue due to its previous use as a sand quarry, however preliminary earthwork calculations and groundwater monitoring data indicate that adequate clearance from the groundwater can be achieved with the importation of approximately 290,000m^3 of fill.

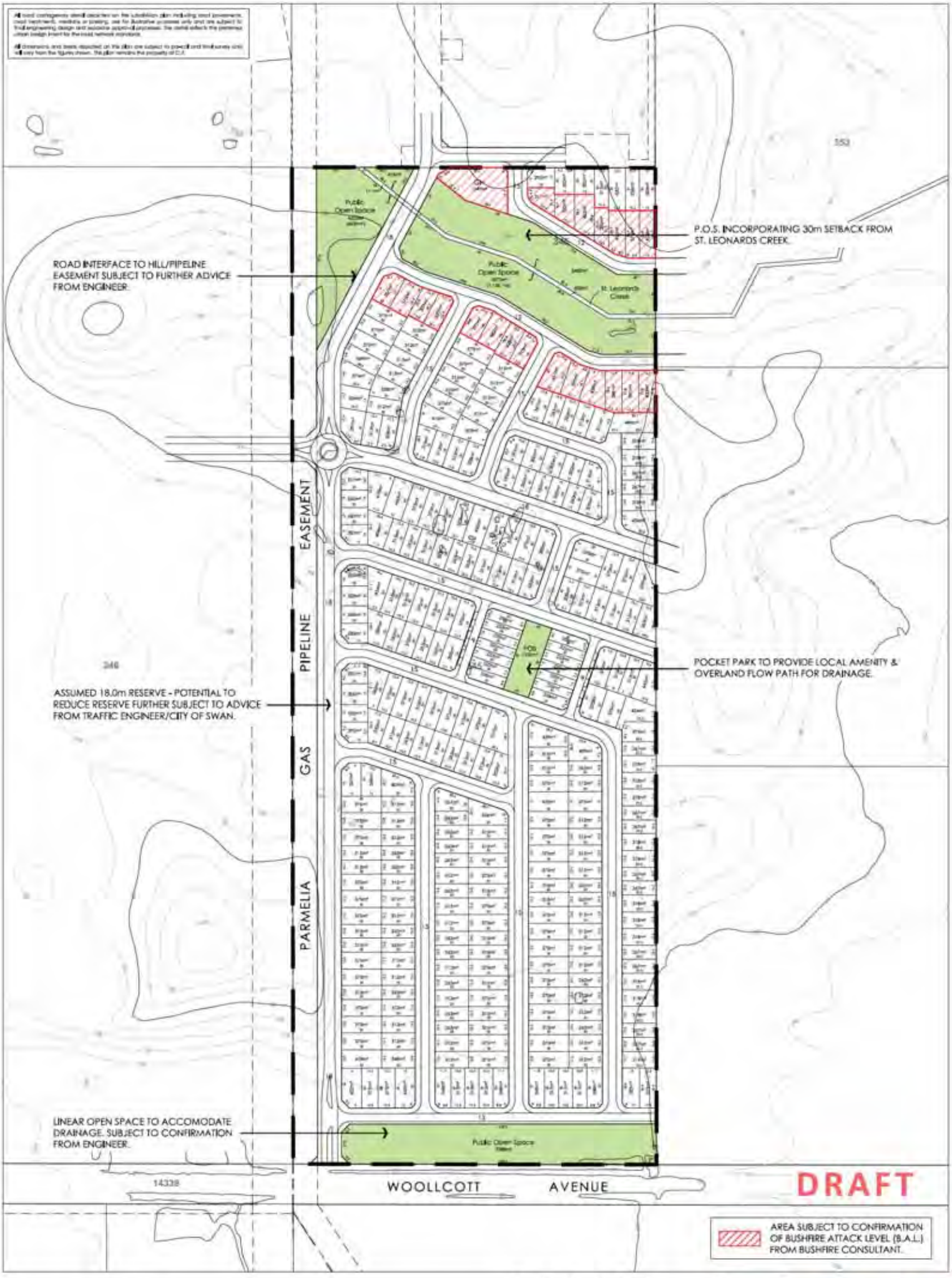
Geotechnical investigations carried out by Galt Geotechnics in early 2015 indicate that acid sulphate soil shouldn't be an issue on this site, however further ASS testing will be required in the relevant areas for the proposed deep sewer.

With the removal of a setback distance from the Parmelia pipeline easement, the site can be developed to its full potential and make use of land that would otherwise have been left barren. There will be close coordination with APA throughout the works to ensure they are confident with work procedures on site, especially where road construction and sewer installation occur over their pipeline, and where relevant there will coordination with DBP and neighbouring developers.

Appendices

Appendix One	*Proposed Structure Plan*
Appendix Two	*Extract from Swan Urban Growth Corridor Drainage and Water Management Plan*
	Acid Sulphate Soil Mapping
	Topography and Geology Mapping
Appendix Three	*Stormwater Catchment Plan*
	Road Contours Plan
	Cut and Fill Depth Location Plan
	Proposed Staging Plan
Appendix Four	*Galt Geotechnics Geotechnical Study of Lot 345 Woollcott Avenue*
Appendix Five	*Worley Parsons Pipeline Risk Management Plan and Protection Plan*
Appendix Six	*Water Corporation Information Sheet 24 – Non-Standard North-East Corridor Contributions*

Appendix One *Proposed Structure Plan*



CONCEPT PLAN

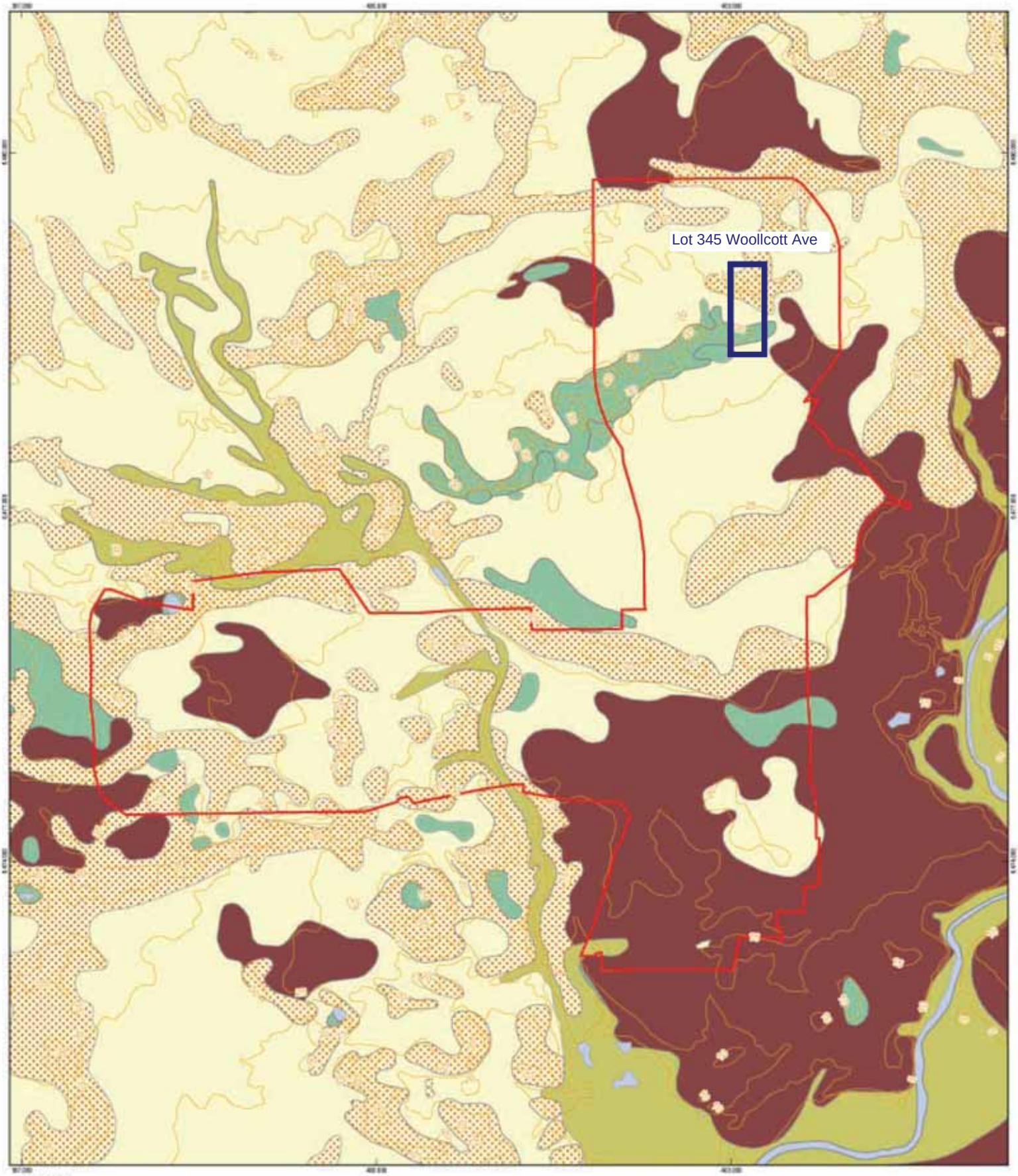
Lot 345 Woollcott Avenue, Brabham
City of Swan

plan no: 3403-09A-01
scale: 1:2500@A3, 1:1250@A1
date: 29.05.2015

Appendix Two — *Extract from Swan Urban Growth Corridor Drainage and Water Management Plan*

Acid Sulphate Soil Mapping

Topography and Geology Mapping



LEGEND

Swan Urban Growth Corridor DWMP Study Area - GHD-20082212

1:50000k Geology Map Sheet of Perth - DOIR 2007

Qpb - Bassendean Sand

QptnQa - Bassendean sand over alluvium

Qpe - Peaty Clay

Mga1 - Pebbly Silt

Mc1 - Clayey silt

Water

5m Contours - DLI - 20071005

For more information, see Perth Metropolitan Region 1:50,000 Environmental and Urban Geology Series map sheet for Perth

1:30,000

0 150 300 600 900 1,200

Metres (at A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

GHD

Government of Western Australia
Department of Water

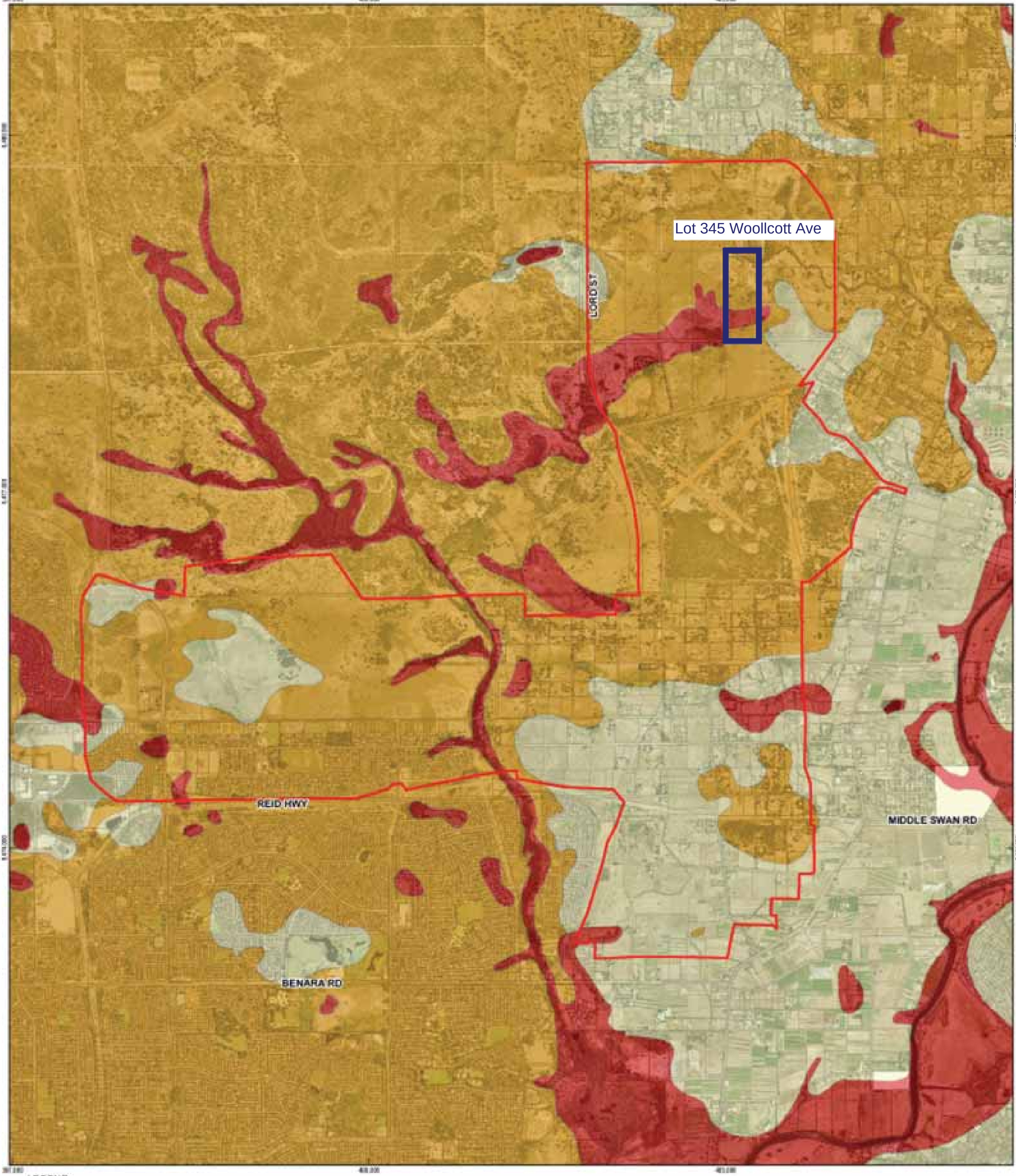
Department of Water
Swan Urban Growth Corridor -
Drainage and Water Management Plan

Topography & Geology

Job Number 6121416
Revision 1
Date 2 September 2008

Figure 10.2

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



LEGEND

Acid Sulfate Soil Risk - DEC - 2007

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)
- No known ASS disturbance risk (<3m from surface)
- Swan Urban Growth Corridor DWMP Study Area - GHD-20080212
- Cadastre - DLI 2007

1:30,000

0 150 300 600 900 1,200

Metres (at A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

Government of Western Australia
Department of Water

Department of Water
Swan Urban Growth Corridor -
Drainage and Water Management Plan

Acid Sulfate Soil Risk

Job Number 6121416
Revision 1
Date 2 September 2008

Figure 10.3

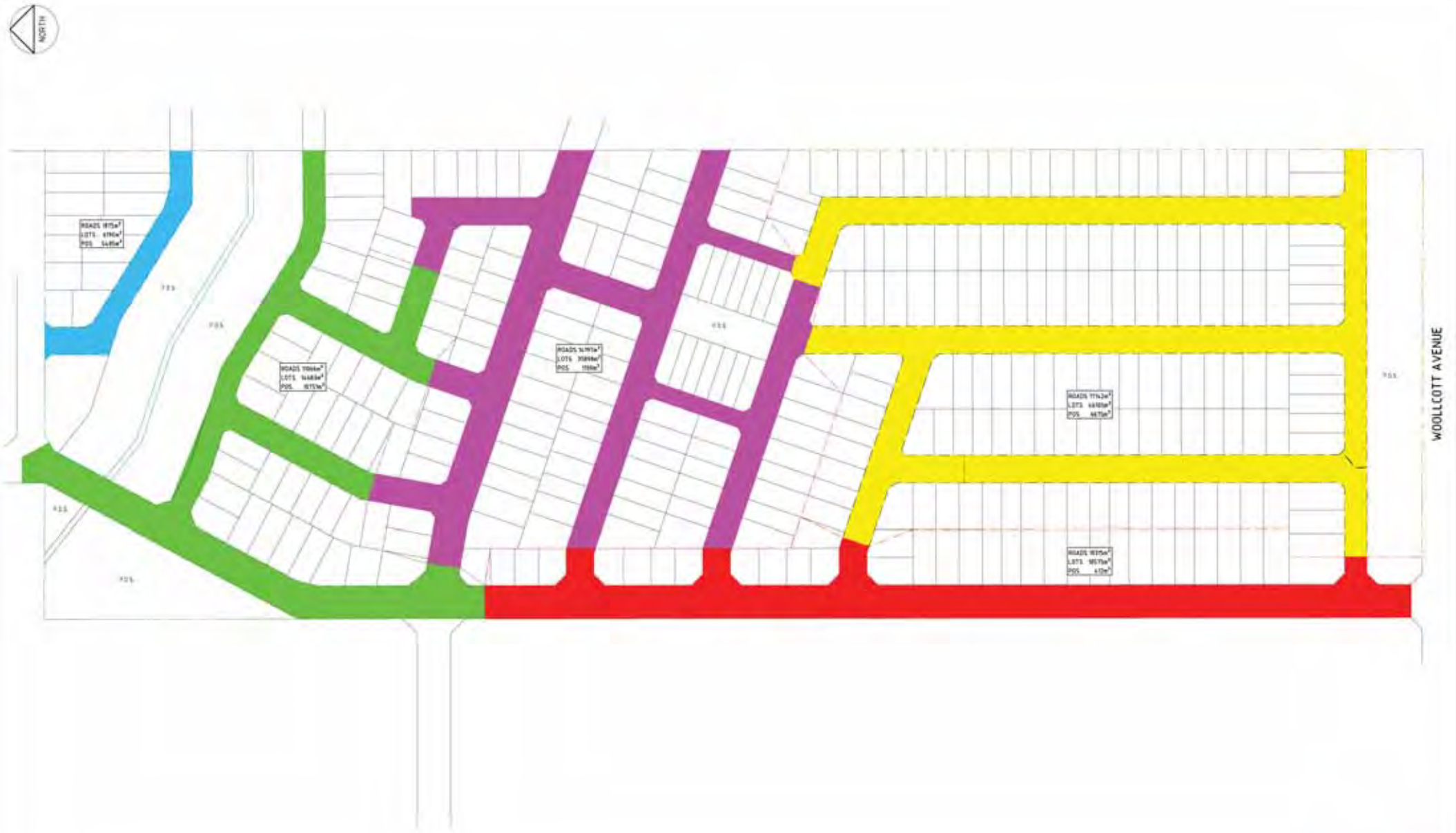
239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Appendix Three ***Stormwater Catchment Plan***

Road Contours Plan

Cut and Fill Depth Location Plan

Proposed Staging Plan



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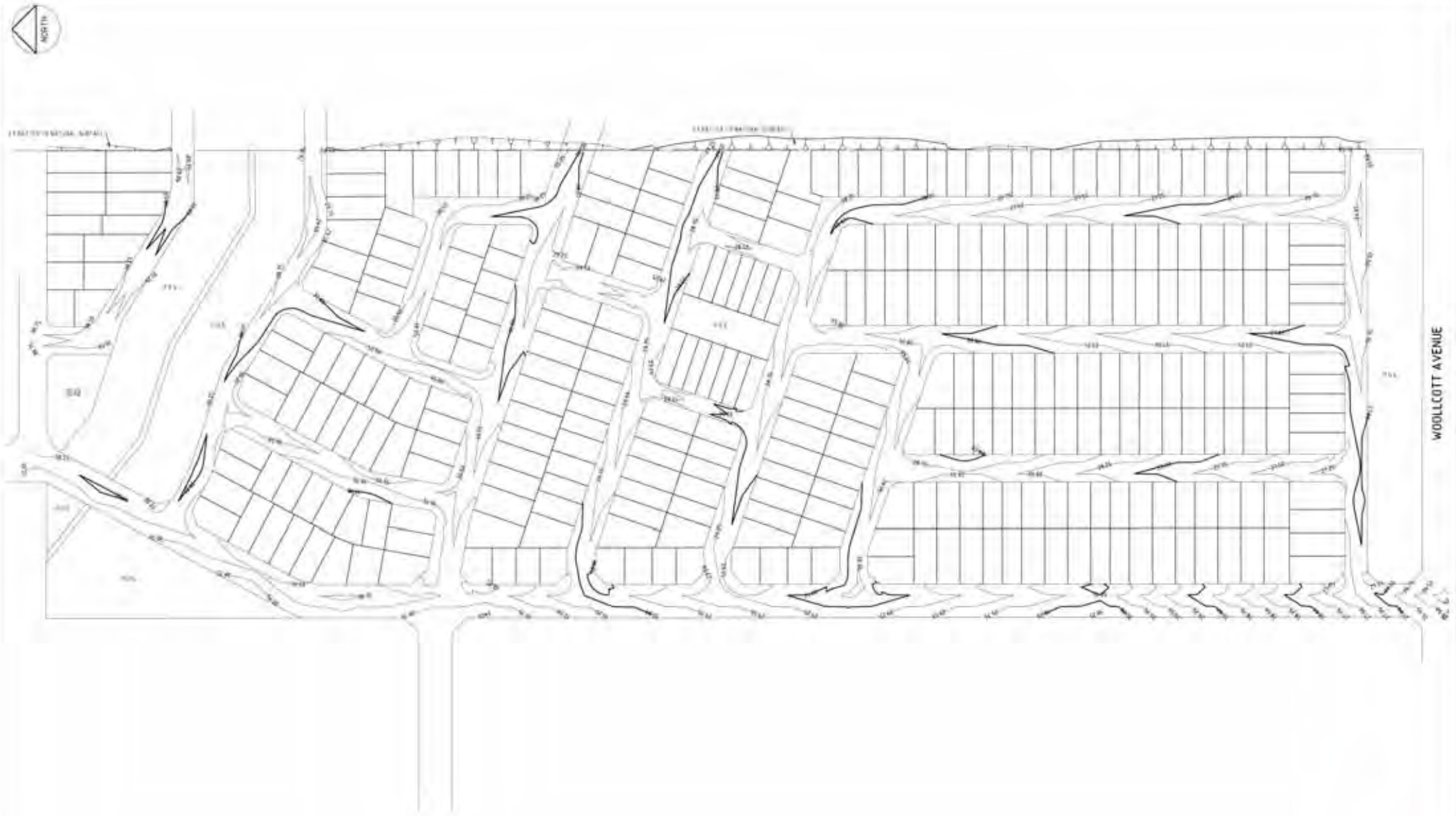
pritchard francis

ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
STORMWATER CATCHMENT PLAN

A1 | 15006-C9-SK-01 | A



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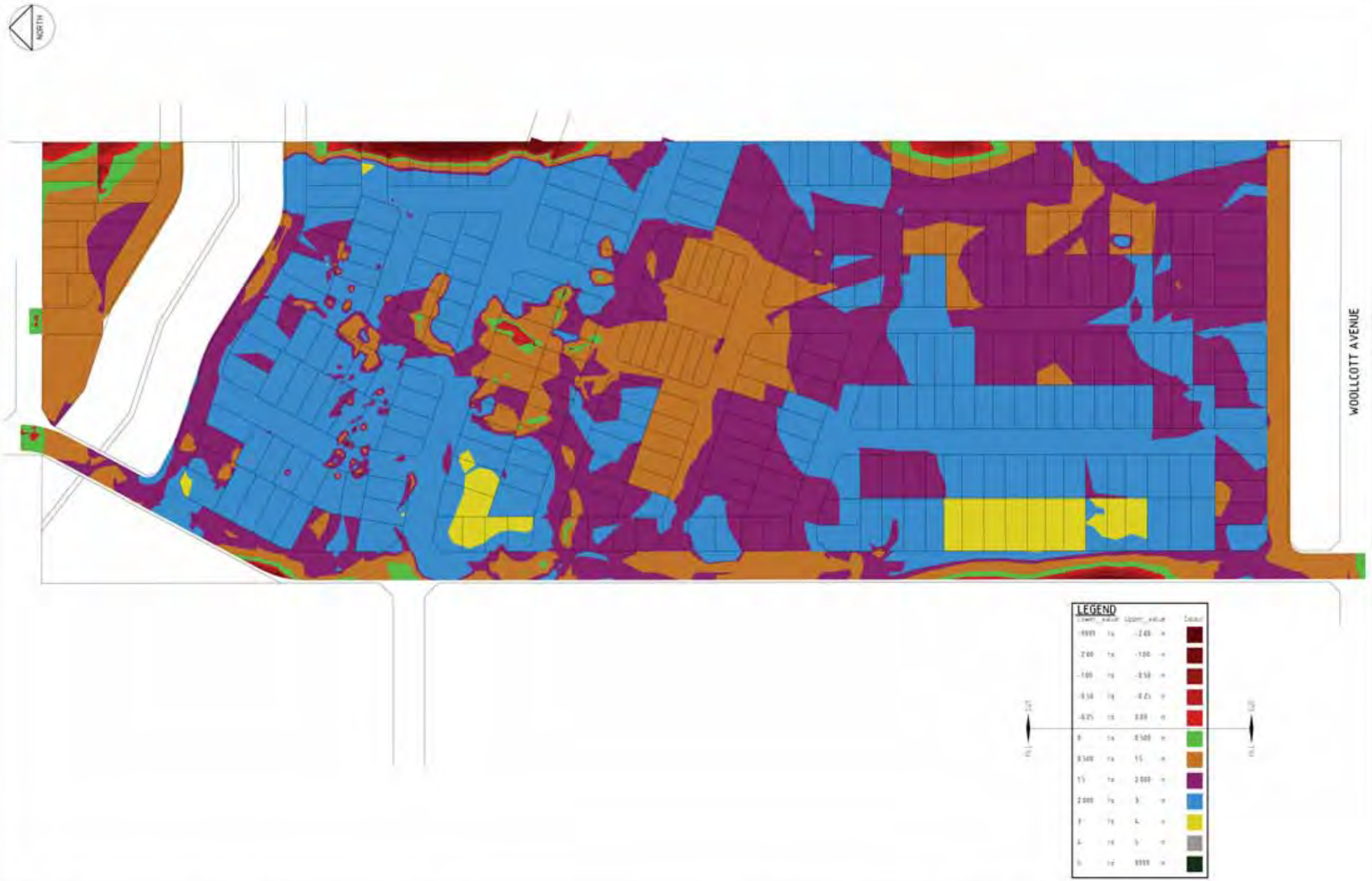
ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
ROAD CONTOURS PLAN

A1 | 15006-C9-SK-08 | A

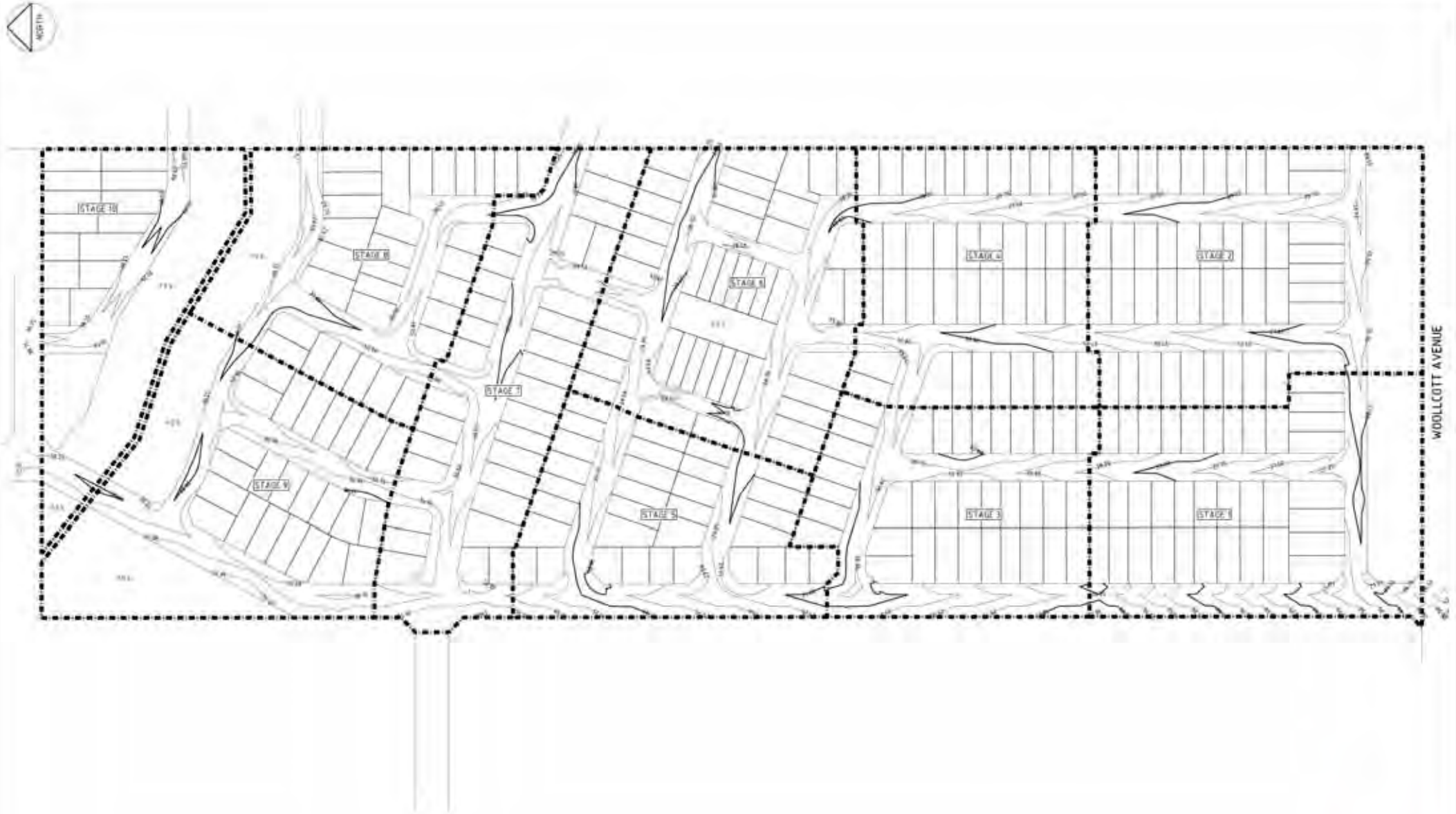


PRELIMINARY
NOT FOR CONSTRUCTION

pritchard francis

ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
CUT & FILL DEPTH LOCATION PLAN

A1 | 15006-C9-SK-04 | A



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ABN DEVELOPMENTS
LOT 345 WOOLLCOTT AVENUE, BRABHAM
PROPOSED STAGING PLAN

A1	15006-C9-SK-05	A

Appendix Four *Galt Geotechnics Geotechnical Study of Lot 345 Woollcott Avenue*

Report on

DUE DILIGENCE LEVEL GEOTECHNICAL STUDY PROPOSED RESIDENTIAL DEVELOPMENT 345 WOOLLCOTT AVENUE, BRABHAM

Submitted to:

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J1501018 001 R Rev0

20 February 2015

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FIGURES

APPENDICES

1. INTRODUCTION

This report presents the outcomes of a due-diligence level geotechnical study conducted by Galt Geotechnics Pty Ltd (Galt) for the proposed residential development at 345 Woollcott Avenue, Brabham ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The study was authorised by Jeremy Cordina of Alcock Brown-Neaves Group in an email dated 30 January 2015.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the site is rectangular in shape and covers 20.2 ha in plan area (18.8 ha allowing for an easement for the Parmelia gas pipeline on the western boundary of the site). Publicly available topography shows that the site surface level is generally at around RL 26 m in the south and around RL 28 m to RL 29 m AHD in the north, with a number of local low points, mainly in the north.

A review of aerial photography shows that the site is bounded by Woollcott Avenue to the south, a residential development (Whiteman Edge) to the north and existing undeveloped rural properties to the east and west. The site is undeveloped and the surface comprises a mix of open sandy areas, grassed areas and several stands of mature trees, mainly in the centre of the site.

It is apparent that sand mining has been undertaken on dunes previously on the site, throughout the 1970s and 1980s. This has resulted in lowering of surface levels by about 3 m to 5 m compared to similar dune levels on adjacent sites. This has also resulted in the site surface being lowered below the groundwater table as surface water is now present across several parts in the north of the site.

We assume that the site will be subdivided into single residential lots as is being done on a number of nearby sites. Level differences are likely to be accommodated by gravity retaining walls.

Some sand filling will be necessary to raise site surface levels for the development.

3. PROJECT OBJECTIVES

The due diligence study is intended to inform the purchaser about geotechnical risks on the site and provide a geotechnical basis for making a financial commitment. A detailed investigation will be required prior to detailed design.

The objectives of the study were to:

- broadly assess subsurface soil and groundwater conditions across the site, with a particular emphasis on:
  - the thickness of sand overlying clayey soils;
  - the depth to groundwater and/or surface expressions of groundwater; and
  - the reactivity of clayey soils;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide recommendations and geotechnical design parameters for earth retaining structures;
- recommend appropriate site preparation procedures including compaction criteria, with a particular emphasis on any unusual/onerous site preparation measures required for this site;
- make a preliminary assessment of the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration;
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others; and

- provide recommendations for detailed geotechnical studies required for detailed design.

4. FIELDWORK

Fieldwork was conducted on 6 and 16 February 2015 and comprised:

- a walkover of the site including taking photographs;
- cone penetration testing (CPTs) at 6 locations, extending to depths between 4.2 m and 5.8 m;
- excavation of test pits at 15 locations, extending to depths of between 1.6 m and 3.0 m;
- testing with a Perth sand penetrometer at each test pit location, extending to a depth of 0.9 m; and
- infiltration tests using the 'inverse auger hole' technique at 4 locations between depths of 0.6 m and 0.85 m below ground.

General

Test locations were selected by a geotechnical engineer from Galt. The locations of the test pits, cone penetration tests and permeability tests were recorded using a handheld GPS accurate to about 5 m in the horizontal plane. Our engineer observed the CPT testing and test pitting, logged the materials encountered in the test pits, drilled the hand auger boreholes and performed the infiltration testing.

The test locations are shown on Figure 1, Site and Location Plan and details are summarised in Table 1. Photographs of the site are presented in Appendix A, Site Photographs.

Table 1: Summary of Tests

Test Name	Test Depth (m)	Depth to Water Table (m)	Reason for Termination	Stratigraphy[1]
CPT01	5.5	0.8	Target Depth	SAND
CPT02	4.5	1.2	Target Depth	SAND
CPT03	4.3	*	Target Depth	SAND
CPT04	5.9	1.0	Target Depth	SAND
CPT05	4.2	*	Target Depth	FILL: Clayey SAND overlying SAND
CPT06	4.2	*	Target Depth	SAND
TP01	2.0	1.8	Collapse	SAND
TP02	2.0	1.7	Collapse	SAND
TP03	2.1	1.6	Collapse	SAND
TP04	1.8	1.5	Collapse	SAND
TP05	1.6	1.3	Collapse	SAND
TP06	3.0	1.9	Target Depth	SAND
TP07	2.0	1.5	Collapse	FILL: Clayey SAND overlying SAND
TP08	1.9	1.3	Collapse	SAND
TP09	1.7	1.4	Collapse	SAND
TP10	2.1	1.5	Collapse	SAND

Test Name	Test Depth (m)	Depth to Water Table (m)	Reason for Termination	Stratigraphy[1]
TP11	3.0	1.4	Collapse	SAND
TP12	1.9	1.3	Collapse	SAND
TP13	3.0	1.5	Target Depth	SAND
TP14	2.0	1.3	Collapse	SAND
TP15	2.2	1.8	Collapse	SAND

Note: 1 – Stratigraphy from CPTs inferred from Robertson et al. (1986)
* – Water table depth not recorded

Test Pits

Test pits were excavated using an 8 tonne Volvo BL71 tractor mounted backhoe equipped with a 600 mm toothed bucket. The backhoe was supplied and operated by All West Plant Hire. Test pit reports are presented in Appendix B, Test Pit Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports.

Perth Sand Penetrometer Tests

Perth sand penetrometer (PSP) tests were carried out in accordance with AS 1289.6.3.3 although to a greater depth than the 0.45 m covered in the standard.

The test locations were adjacent to each test pit as shown on Figure 1, Site and Location Plan and the PSP records are presented in Appendix C, Perth Sand Penetrometer Test Results.

Cone Penetration Tests

CPTs were undertaken using an 11 tonne track mounted CPT rig supplied and operated by Probedrill Pty Ltd. The results of the CPTs are provided in Appendix D, Cone Penetration Test Results along with a method of interpretation proposed by Robertson et al (1986).

Permeability Tests

Permeability testing was carried out in hand augered boreholes using the method described by Cocks[1]. The spoil from the boreholes was sand. The results of the permeability testing are presented in Appendix E, Permeability Test Results and summarised in Table 2.

Table 2: Summary of Permeability Test Results

Test Location	Description	Pipe Embedment (m)	Minimum Unsaturated Permeability[1], k (m/day)		
			Test 1	Test 2	Test 3
HA01	SAND	0.75	70.9	61.3	50.8
HA02	SAND	0.60	57.5	44.8	48.9
HA03	SAND	0.60	12.8	11.5	11.2
HA04	SAND	0.85	3.0	1.6	1.3

Note: The minimum unsaturated permeabilities shown are typically recorded towards the end of the test, with pressure head varying between about 0.5 m and dry (0 m).

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

5. SITE CONDITIONS

5.1 Geology

The Perth sheet of the 1:50,000 scale Environmental Geology series maps indicates that the area is underlain by two soil units:

- Peaty CLAY (southern one-third of site), described as *dark grey and black with variable sand content, of lacustrine origin;* and
- Bassendean sand (northern two-thirds of the site, plus far southern fringe), described as *SAND – white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.*

The Bassendean sand is shown to overlie Guildford Formation soils at shallow depth across the middle and southern parts of the site.

The findings of our study are mostly in accordance with the geological mapping. However, Bassendean sand was found to cover the entire site to the full investigated depth (with the exception of minor clayey pockets in parts). In addition, we did not find any evidence of the Peaty CLAY as described by the Environmental Geology series maps.

5.2 Subsurface Conditions

The subsurface conditions are relatively consistent across the site. In general, the typical soil profile comprises:

- SAND (SP): fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey/pale yellow, trace rootlets in top 100 mm, trace localised layers of very weakly cemented coffee rock with increased organic content (about 5%), generally loose up to 0.3 m depth and medium dense to dense below, extending to the maximum depth investigated of 5.8 m.

Note: Below 3.0 m depth, the subsurface conditions are inferred from CPT data.

We note that localised areas of clayey sand were encountered (e.g. CPT05, TP07). These were inferred to be fill, probably remnants of unsuitable material encountered during the sand mining operation. These layers were thin (about 0.3 m). The CPTs indicated the presence of thin, slightly clayey horizons at depth in some areas. These clayey pockets are unlikely to be represent a significant volume of the near-surface soils based on the information gathered to date.

6. LABORATORY TEST RESULTS

Laboratory testing on soil samples was undertaken by Mining & Civil Geotest in their NATA accredited laboratory and comprised the determination of:

- particle size distribution on 2 samples;
- organic content on 1 sample; and
- Atterberg limits and linear shrinkage on 1 sample.

Laboratory test results along with the test methods followed are included in Appendix F, Laboratory Test Results Geotechnical and are summarised in Table 3, Summary of Laboratory Test Results.

Table 3: Summary of Laboratory Test Results

Test ID	Depth (m)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)	OC (%)
TP05-1	0.9-1.1	0	96	4	-	-	-	4
TP07-1	0-0.15	0	51	49	29	16	6.5	-

LL: Liquid Limit PI: Plasticity Index LS: Linear Shrinkage
OC: Organic Content

7. GEOTECHNICAL ASSESSMENT

7.1 Preliminary Site Classification

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

We have assessed the site in accordance with AS2870 (2011) "Residential Slabs and Footings". We consider that a site classification of "Class A" is appropriate provided the site preparation measures outlined in Section 7.4 are followed.

We note that the "Class A" site classification should not be taken as an indication of a small scope of earthworks being necessary to develop the site. The principal encumbrance to development of the site is the shallow (locally surface) groundwater table. The site surface will need to be raised to comply with local council requirements.

7.2 Groundwater

The Perth Groundwater Atlas (1997) shows the historical maximum groundwater levels at the site to vary between RL 29 m (northwest) to RL 26 m (southeast) which is within about 1.0 m of the current site surface level (**Note:** The site appears to have been excavated to around RL 28 m AHD and lower in northern parts of the site). As a result ground water was present above the surface level in central to north parts of the site. Images of these areas have been included in Appendix A, Site Photographs. The areas are also visible on the aerial photograph in Figure 1.

Therefore, as noted above, raising the site surface levels to some level above the historical maximum groundwater level will be required. We recommend at least a 1.2 m separation of permeable, granular fill from the site surface to the maximum groundwater level.

7.3 Retaining Structures

Retaining structures may be designed in accordance with AS 4678-2002 "Earth-Retaining Structures". For the design of retaining structures, the following parameters in Table 4 are appropriate.

Table 4: Retaining Wall Design Parameters

Soil Type	Bulk Density (t/m^3)	Soil Friction Angle (°)	Wall Interface friction angle			
			$\delta = 0°$		$\delta = 0.5\Phi$	
			Coefficient of Active Earth Pressure K_a	Coefficient of Passive Earth Pressure K_p	Coefficient of Active Earth Pressure K_a	Coefficient of Passive Earth Pressure K_p
Medium dense sand	17	35	0.27	3.7	0.24	6.1
Dense and compacted sand compacted sand	18	37	0.25	4.0	0.21	7.0

Notes:

1. Earth pressure coefficients are provided in this table for conditions of zero friction between the wall and the soil and with wall friction of 0.5Φ. The retaining wall designer should make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction. A horizontal ground surface behind the wall has been assumed.

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.

7.4 Site Preparation

The site preparation measures outlined below are aimed at preparation of the site prior to construction of the building and pavement subgrades. Landscaped areas (if any) will not require this preparation.

The following site preparation measures must be followed:

- Remove all topsoil and vegetation from the site, including grubbing out of roots. A topsoil strip of 150 mm should be assumed. **Note**: the removal of large trees will require excavation to depths of 1 m or more which will require geotechnical remediation. Topsoil should be retained for potential screening and re-use in structural fill (refer to Section 7.6).
- Remove any rubbish and deleterious material (present in several localised areas across the site, see Attachment A, Site Photographs).
- Excavate to the required levels, if at all. Segregate any clayey pockets in stockpile for potential re-use in deep fill. Clayey soils can be identified by their cohesive texture.
- Where fill is required to build up levels (mainly in the central and northern regions of the site), use approved fill (see Section 7.6), placed and compacted in layers of no greater than 300 mm loose thickness (see Section 7.5).
- Compact the exposed sandy ground to achieve the level of compaction specified in Section 7.5 to a depth of at least 0.9 m below the base.
- Any areas of loose sand or unsuitable material must be removed and replaced with approved fill as outlined in Section 7.6.
- Excavate for pad and strip footings (including retaining wall footings) and compact the exposed bases to achieve the level of compaction specified in Section 7.5 to a depth of at least 0.9 m below the underside of all footings. Remove, replace and compact as required with approved fill any zone not achieving the level of compaction specified in Section 7.5.

Bulk filling of the site with imported sand fill will be relatively expensive. The large volume of sand potentially available on site (subject to any environmental/acid sulfate soil considerations) should be considered for use as fill.

We consider that it would be possible to strip and stockpile the sand from the site in sections, extending below groundwater table (this would necessitate dewatering) and then build up the site with a lower quality (general) fill prior to capping the site with (say) 1.5 m to 2.0 m of sand fill extracted from on-site borrow.

Possible materials that could be used in the lower fill are:

- 'Recycled' sand fill, which often contains significant organic and fines portions, as well as minor construction rubble, etc.
- Crushed concrete or other construction debris.
- Clay or clayey sand (derived from nearby developments, given that many sites in the area are removing clayey fill).
- Screened sandy topsoil derived from other sites, with up to 6% organic content.

7.5 Compaction

In situ sand and granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio of at least 95% of maximum modified dry density (MMDD) as determined in accordance with AS 1289 5.2.1.

After compaction, verify that the level of compaction has been achieved by testing to a minimum depth of 0.9 m:

- On each lift of fill on a 40 m grid
- At each spread footing location;
- At 15 m centres along pavement subgrades;
- At 15 m centres along strip footings, including retaining wall footings; and
- On a grid of 15 m centres below on-ground slabs and pavements.

Where clean sand is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control. The following minimum PSP blow counts must be met:

- 150 mm-450 mm: 8
- 450 mm-750 mm: 10
- 750 mm-1050 mm: 11

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 required to achieve the required dry density ratio.

Over-excavation and replacement of loose materials may be required where the minimum density 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 structures. This is particularly important if vibratory compaction is being carried out. Tynan (1973)[2] provides assistance with the selection of compaction equipment for use adjacent to structures.

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

7.6 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". Sand fill must comprise clean sand that has less than 2% organic matter and a fines content of less than 5%.

Generally, the sandy material present on site is considered suitable for re-use as inert structural fill (other than any organic rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size)).

'Coffee Rock'

The 'coffee rock' present on site will not be suitable for re-use as permeable structural fill without blending with clean sand (1 part 'coffee rock' to 2 parts clean sand (<5% fines, <1% organics)), subject to the 'coffee rock' having a maximum particle size of 200 mm. The 'coffee rock' is easily identifiable by its dark brown to black colour in contrast to the generally pale coloured sand on site.

Topsoil

Sand topsoil may be re-used as structural fill provided it is screened (over a 50 mm or finer screen) and blended with clean sand fill (<5% fines, <1% organics) to produce a blended material with <5% fines and <2% organics. It is our experience that this will produce a relatively permeable blend. This is likely to require between 1 part and 2 parts clean sand to 1 part screened topsoil. The blended sand must be subjected to laboratory testing for particle size distribution and organic content prior to its use. If permeability is an issue for the blended fill, the blend ratio must be determined on site by permeability testing of compacted trial pads.

Site-derived Clayey Sand

Where clayey sand is encountered, we must be engaged to comment on its potential re-use as fill. It is likely that this material can be used in deep fill areas without detriment to the site classification. Significant quantities of site-derived clayey fill are not expected.

Various General Fill Materials

Where 'general fill' is proposed in accordance with our suggestions in Section 7.4, we must review the proposed material and develop a suitable filling method with the earthworks contractor and client. This may require additional sampling, laboratory testing and field trials.

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

7.7 Stormwater Disposal

The results of infiltration tests are included in Appendix E, Permeability Test Results. The minimum measured unsaturated permeability of the sand was 1.3 m/day. This was recorded in P04 located in south east corner of the site where a proposed drainage basin is to be situated. The three permeability tests (P01-P03) in the central and northern regions of the site recorded a minimum unsaturated permeability of 11.2 m/day.

We consider that the sands at the site are generally suitable for the disposal of stormwater by infiltration by means of soak wells. We expect that a general permeability rate of at least k=5 m/day will apply (notwithstanding one low result obtained on the site, which may be due to the close proximity of the test to groundwater). We note that this

permeability rate (k~5 m/day) only applies where stormwater disposal occurs above the groundwater table (at least 0.5 m above).

The permeability of any stormwater disposal system may be expected to decrease over time due to compaction of sands during site preparation and clogging of the pore spaces by fines during the life of the stormwater disposal system.

7.8 Pavement Design

Where design of flexible pavements is undertaken, a subgrade California bearing ratio (CBR) of 12% may be assumed for pavement thickness design. This CBR assumes that the site preparation requirements outlined in Section 7.4 have been carried out in pavement subgrade areas.

8. FUTURE STUDIES

We consider that the following works will be required for detailed design purposes:

- Additional infill testing across the site to check for clayey or peaty horizons in areas between existing test locations.
- Evaluation of general fill sources, if required.
  If sand borrow and dewatering is to be done, an acid sulfate soils (ASS) and dewatering assessment.

9. CLOSURE

We draw your attention to Appendix G, "Understanding Your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimize risks associated with groundworks for this project. 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.

GALT GEOTECHNICS PTY LTD

Owen Woodland CPEng

Geotechnical Engineer

Martin Ward

Geotechnical Engineer

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Figures

Galt GEOTECHNICS

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Address U2, 39 Flynn Street, Wembley, WA, 6014

CLIENT	ABN GROUP
PROJECT	PROPOSED RESIDENTIAL DEVELOPMENT
LOCATION	345 WOOLCOTT AVENUE BRABHAM
TITLE	TEST LOCATION PLAN
Job No.	J1501018
Fig No.	FIGURE 1
Rev	A

Appendix A: Site Photographs

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Photograph 1: Looking north east from TP02

Photograph 2: Looking north from TP03

Photograph 3: Looking west from TP03

Photograph 4: Looking west from TP06

Photograph 5: Looking south from TP07

Photograph 6: Looking west from TP12 towards localized fly-tipped rubbish

Photograph 7: Looking west from TP14 at surface expression of groundwater table

Photograph 8: Looking north from site entry (Woollcott Avenue)

Appendix B: Test Pit Reports

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

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 (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

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

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces 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
	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

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	

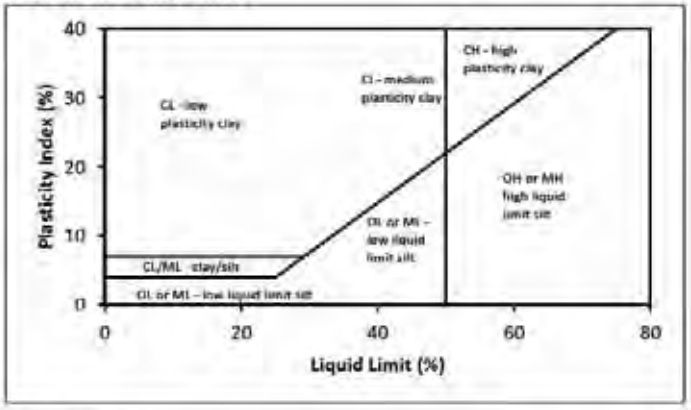
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

TEST PIT: TP01

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403216 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478985 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	L	
			0.5							Pale grey	M	MD	
		▼ (1.8)	1.0 – 2.0								W		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.8 m			

Sketch & Other Observations

Comments:

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

Galt GEOTECHNICS

TEST PIT: TP02

Job Number:	J1501018	**Easting:**	403041 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478994 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ (1.7 m)	0.0 – 2.0					(sand pattern)	SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D (0.0–0.5)	L (0.0–0.3)	
											M (0.5–1.7)	MD (0.3–2.0)	
										Brown/black, increased organic content (5-10%) ("coffee rock") (from 1.7 m)	W (1.7–2.0)		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.7 m			

Sketch & Other Observations


Comments:

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

Galt GEOTECHNICS

TEST PIT: TP03

Job Number:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478875 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming orange-brown and then yellow below 0.2 m, trace rootlets in top 100 mm	D	L	
			1.0							Pale yellow	M	MD	
		▼ (1.6 m)								Black-brown, with increased organic content (5-10%) ("coffee rock")	W		Localised pockets of SAND: with some CLAY (Guildford): 10-15% low to medium plasticity
			2.1							Hole terminated at 2.10 m Collapse Groundwater encountered at 1.6 m			

Sketch & Other Observations


Comments:

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

TEST PIT: TP04

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403041 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478710 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace non-plastic fines, with some roots/rootlets (1-20 mm in diameter) in top 100 mm	D	MD	
										Grey	M		
		▼	1.5							Pale grey/brown	W		
			1.8							Hole terminated at 1.80 m Collapse Groundwater encountered at 1.5 m			
			2.0										

Sketch & Other Observations

Comments:

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

TEST PIT: TP05

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Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403186 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478689 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, with some rootlets in top 100 mm, trace non-plastic fines	D	L	
										Pale grey	M	MD	
			0.5										
					B(TP05-01)					Brown/black, weakly cemented nodules ("coffee rock")			
			1.0							Pale grey			
		▼									W		
			1.5										
										Hole terminated at 1.60 m Collapse Groundwater encountered at 1.3 m			
			2.0										

Sketch & Other Observations

Comments:

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

TEST PIT: TP06

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478582 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ 1.9	0.0 – 3.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 500 mm	D	L	
											M	MD	
										Brown-grey, trace rootlets			
										Grey becoming pale grey	W		
			3.0							Hole terminated at 3.00 m Target depth Groundwater encountered at 1.9 m			

Sketch & Other Observations


Comments:

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

TEST PIT: TP07

Job Number: J1501018	**Easting:** 403237 m	**Contractor:** All West Plant Hire	**Date:** 06/02/2015
Client: ABN Group	**Northing:** 6478507 m	**Machine:** Volvo BL71	**Logged:** MW
Project: Proposed Residential Development	**Datum:** MGA94 Zone 50	**Operator:** Derrik	**Checked Date:** 19/02/2015
Location: 345 Woolcott Avenue, Brabham		**Bucket:** 600 mm toothed	**Checked By:** ORW
		Width: 2 m **Length:** 3 m	

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0		B(TP07-01)				SC	FILL: Clayey SAND, fine to coarse grained, sub-angular to sub-rounded, dark grey/brown, low to medium plasticity fines (~50%), trace rootlets in top 100 mm	D	L	
									SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey			
	F		0.5							Pale grey			
	E		1.0								M	MD	
		▼	1.5								W		
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.5 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP08

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403081 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478457 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey/brown, trace rootlets in top 100 mm	D	L	
			0.5							Grey with layers of pale yellow and localised pockets of orange	M	MD	
		▼ (1.3)	1.0		B(TP08-01)						W		
			1.5										
			2.0							Hole terminated at 1.90 m Collapse Groundwater encountered at 1.3 m			

Sketch & Other Observations

Comments:

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

TEST PIT: TP09

Sheet 1 OF 1

Job Number:	J1501018	**Easting:**	403229 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478326 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines, trace rootlets in top 100 mm		MD	
										Pale grey	D - M		
			0.5							Orange-brown, trace fine to medium grained gravel	M		
			1.0							Grey/orange mottled blue, with some low to medium plasticity fines			East half of test pit: iron cemented coffee rock refused
		▼ (1.4)	1.5								W		
										Hole terminated at 1.70 m Collapse Groundwater encountered at 1.4 m			
			2.0										

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:	J1501018	**Easting:**	403058 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478329 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100mm	D	L - MD	
										Pale grey	M		
			0.5										
			1.0										
	F	▼	1.5							Brown/black, increased organic content (5-10%), weakly cemented pockets ("coffee rock")			
	E									Grey	W		
			2.0										
			2.5							Hole terminated at 2.10 m Collapse Groundwater encountered at 1.5 m			

Sketch & Other Observations

Comments:

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

GALT LIB 1.01.GLB Log GG_EXCAVATION J1501018.GPJ <<DrawingFile>> 20/02/2015 09:23 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2015-02-21 Prj: GALT 1.01 2015-02-21

TEST PIT: TP11

Job Number:	J1501018	**Easting:**	403134 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478338 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation: METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	Field Material Description: GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	Groundwater at 1.4 m	0.0 – 3.0					sand pattern	SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace rootlets in top 100 mm	D	MD	
										Pale grey	M		
										Dark grey/brown becoming grey	W		
			3.0							Hole terminated at 3.00 m Collapse Groundwater encountered at 1.4 m			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

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:	J1501018	**Easting:**	403139 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478415 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey, trace rootlets in top 100 mm	D	MD	
			0.5								M		
			1.0										
		▼ 1.3								Pale yellow			
			1.5							Brown/black ("coffee rock")	W		
										Pale grey			
			2.0							Hole terminated at 1.90 m Collapse Groundwater encountered at 1.3 m			

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:	J1501018	**Easting:**	403234 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478642 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ (1.5)	0.0 – 3.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, with some roots/rootlets (1-30 mm) in top 600 mm	D	MD	
			1.3							Pale grey/pale yellow			
			1.9							Brown/grey			
			2.2							Grey			
			3.0							Hole terminated at 3.00 m Target depth Groundwater encountered at 1.5 m			

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:	J1501018	**Easting:**	403106 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478811 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	MD	
										Orange-brown	M		
			0.5										
										Pale yellow			
			1.0										
		▼ (1.3)									W		
			1.5							Pale grey			
			2.0							Hole terminated at 2.00 m Collapse Groundwater encountered at 1.3 m			

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:	J1501018	**Easting:**	403129 m	**Contractor:**	All West Plant Hire	**Date:**	06/02/2015
Client:	ABN Group	**Northing:**	6478988 m	**Machine:**	Volvo BL71	**Logged:**	MW
Project:	Proposed Residential Development	**Datum:**	MGA94 Zone 50	**Operator:**	Derrik	**Checked Date:**	19/02/2015
Location:	345 Woolcott Avenue, Brabham			**Bucket:**	600 mm toothed	**Checked By:**	ORW
				Width: 2 m	**Length:** 3 m		

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E	E	▼ 1.8	0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets in top 100 mm	D	MD	
										Pale grey	M		
			2.0							Brown	W		
			2.2							Hole terminated at 2.20 m Collapse Groundwater encountered at 1.8 m			

Sketch & Other Observations

Comments:

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

Appendix C: Perth Sand Penetrometer Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

PERTH SAND PENETROMETER FIELD TEST DATA (Standard Depth 900mm)
(AS12896.3.3)

Client: ABN Group
Project: Proposed Residential Development
Location: 345 Woollcott Avenue, Brabham

Job No: J1501018
Date: 16/02/2015
Engineer: MW

Test No:	1	2	3	4	5	6
Location:	TP01	TP02	TP03	TP04	TP05	TP06
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	2	1	2	1	2
150-300	3	3	3	4	3	4
300-450	4	3	4	4	4	4
450-600	4	4	4	5	4	4
600-750	5	5	5	5	5	4
750-900	5	5	5	6	5	5
900-1050						

Test No:	7	8	9	10	11	12
Location:	TP07	TP08	TP09	TP10	TP11	TP12
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	1	1	2	2	1
150-300	3	3	4	3	4	3
300-450	4	3	4	4	4	3
450-600	5	4	4	3	4	4
600-750	5	4	5	3	4	4
750-900	5	5	5	4	5	4
900-1050						

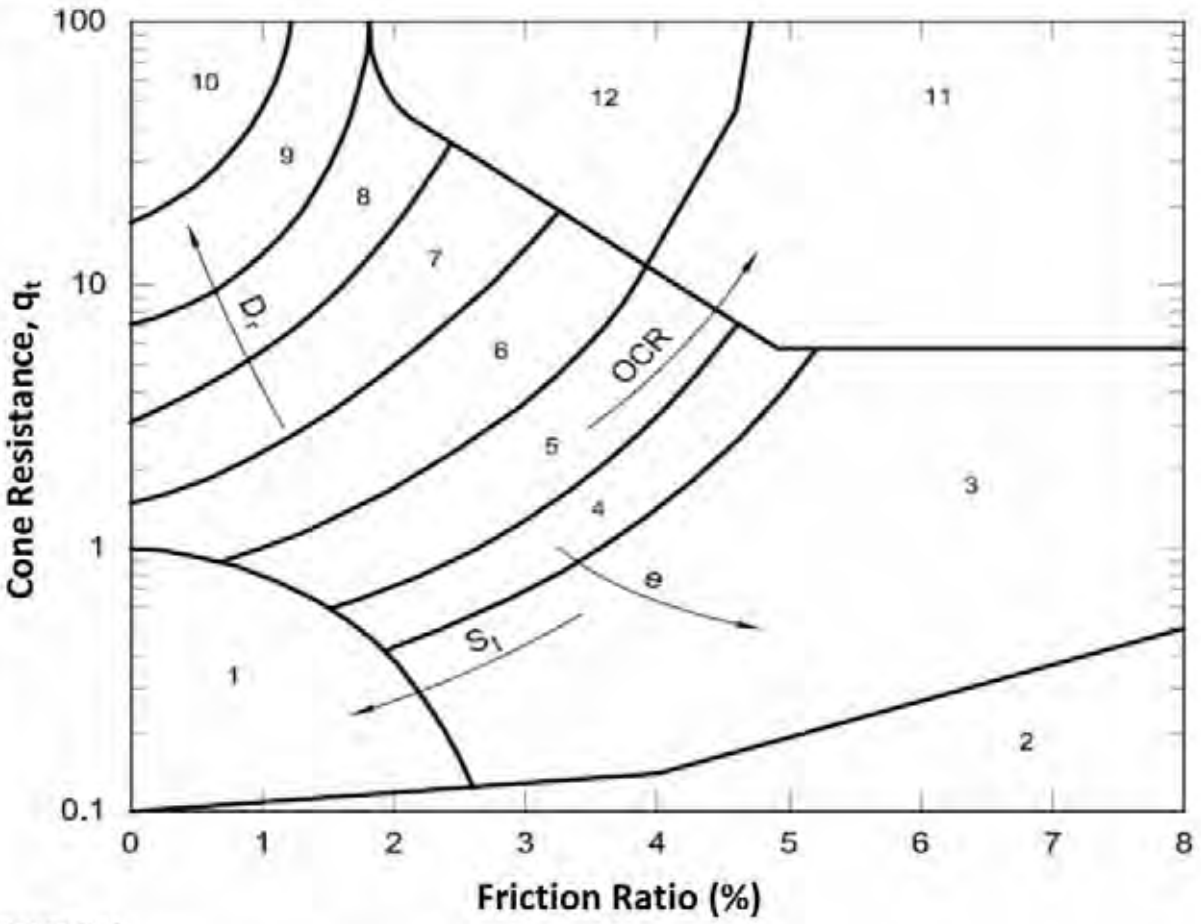
Test No:	13	14	15			
Location:	TP13	TP14	TP15			
Depth (mm)	**N° of Penetrometer Blows per 150 mm Depth Interval**					
0-150	2	1	2			
150-300	3	4	4			
300-450	4	5	5			
450-600	4	5	5			
600-750	5	6	6			
750-900	5	6	6			
900-1050						

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						
900-1050						

Perth Sand Penetrometer tests done in accordance with AS 1289.6.3.3 (except blow counts are reported per 150 mm, rather than 300 mm)
R: Refusal

Appendix D: Cone Penetration Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155



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: ABN

PROJECT: Residential Development

LOCATION: Brabham

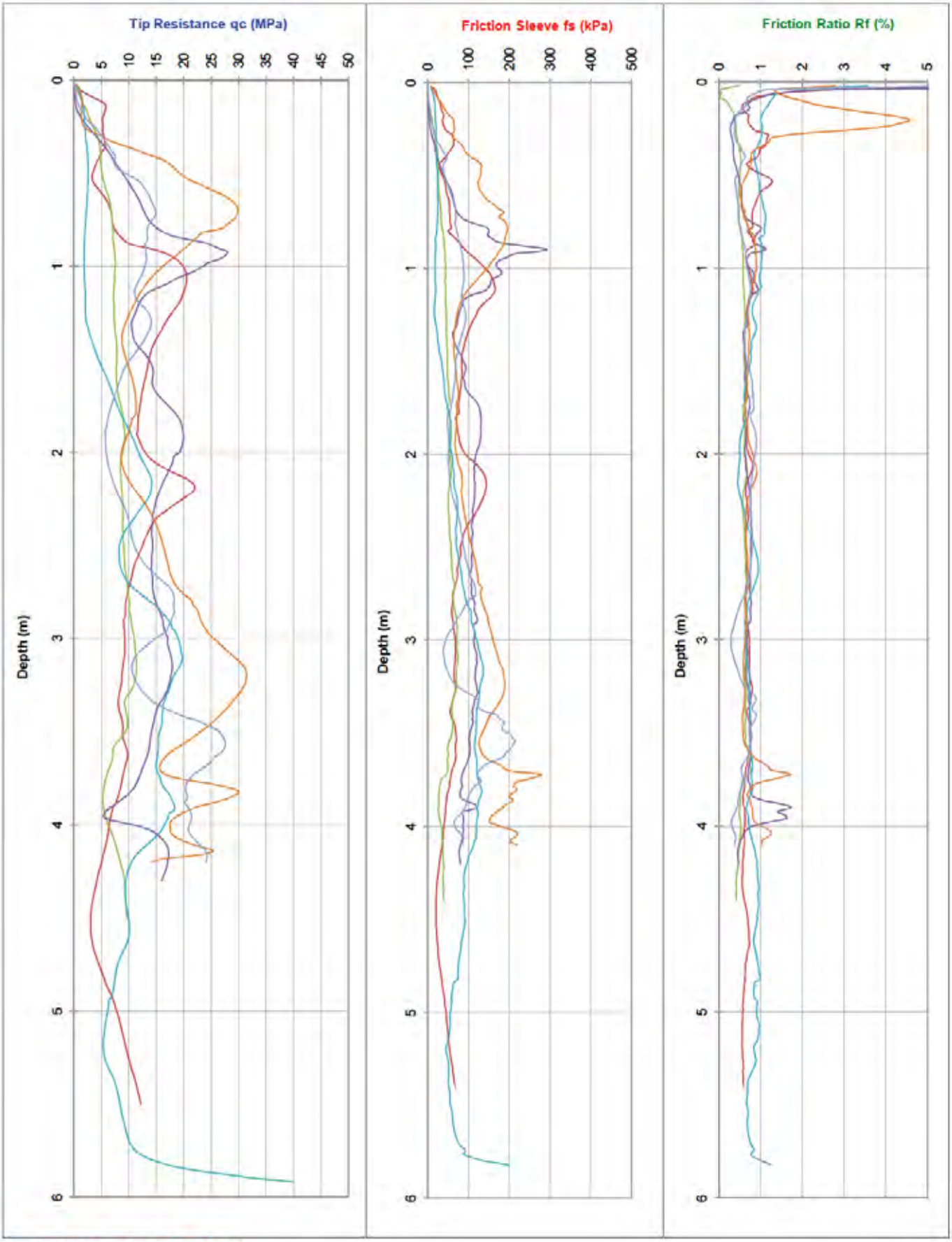
RL (m):

Date: Friday, 6 February 2015

Probe No.: All Data

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m):

Refusal:

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

File:

Cone I.D.:

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

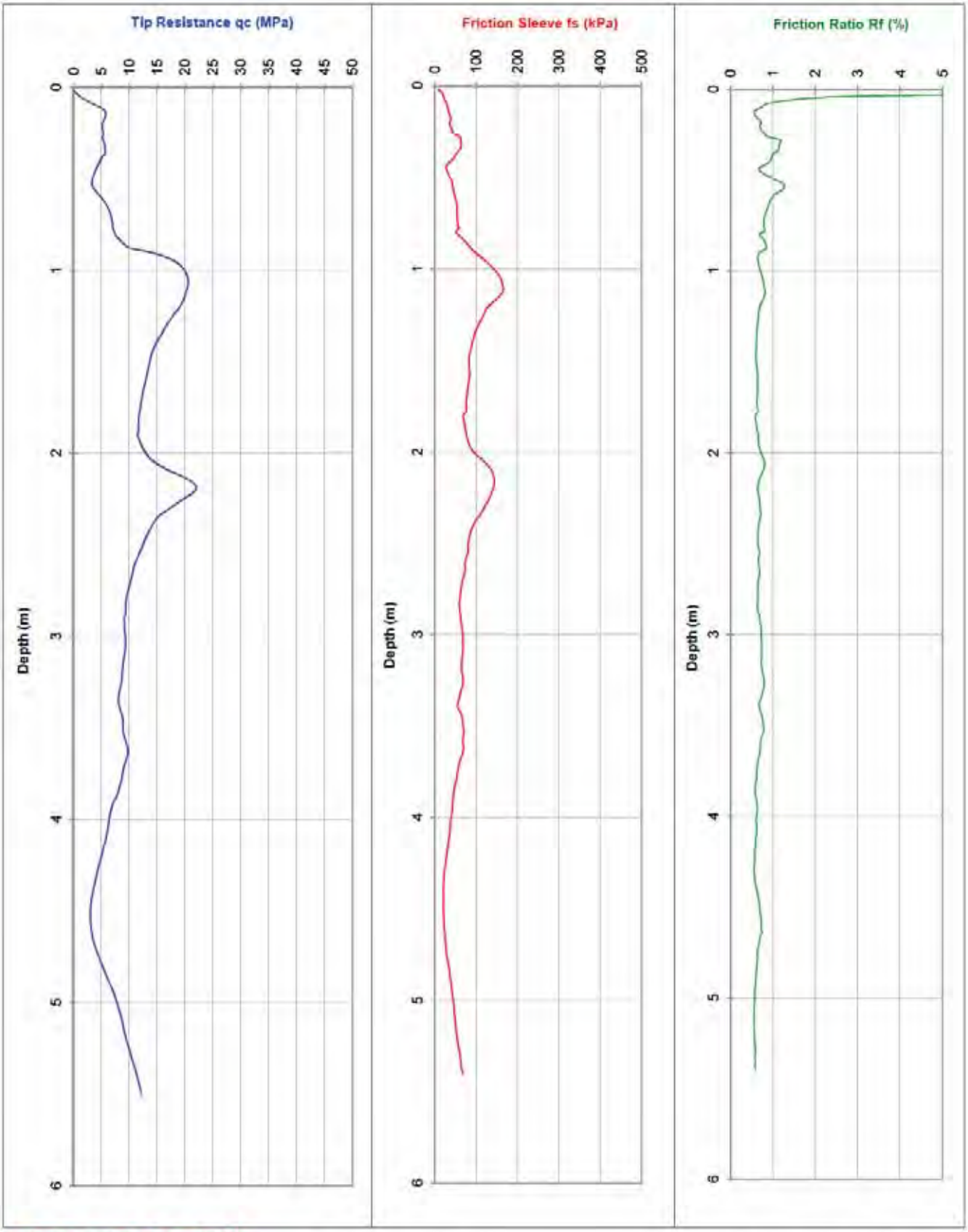
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 1

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): Dry to 0.8

Refusal:

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

File: GL0683M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

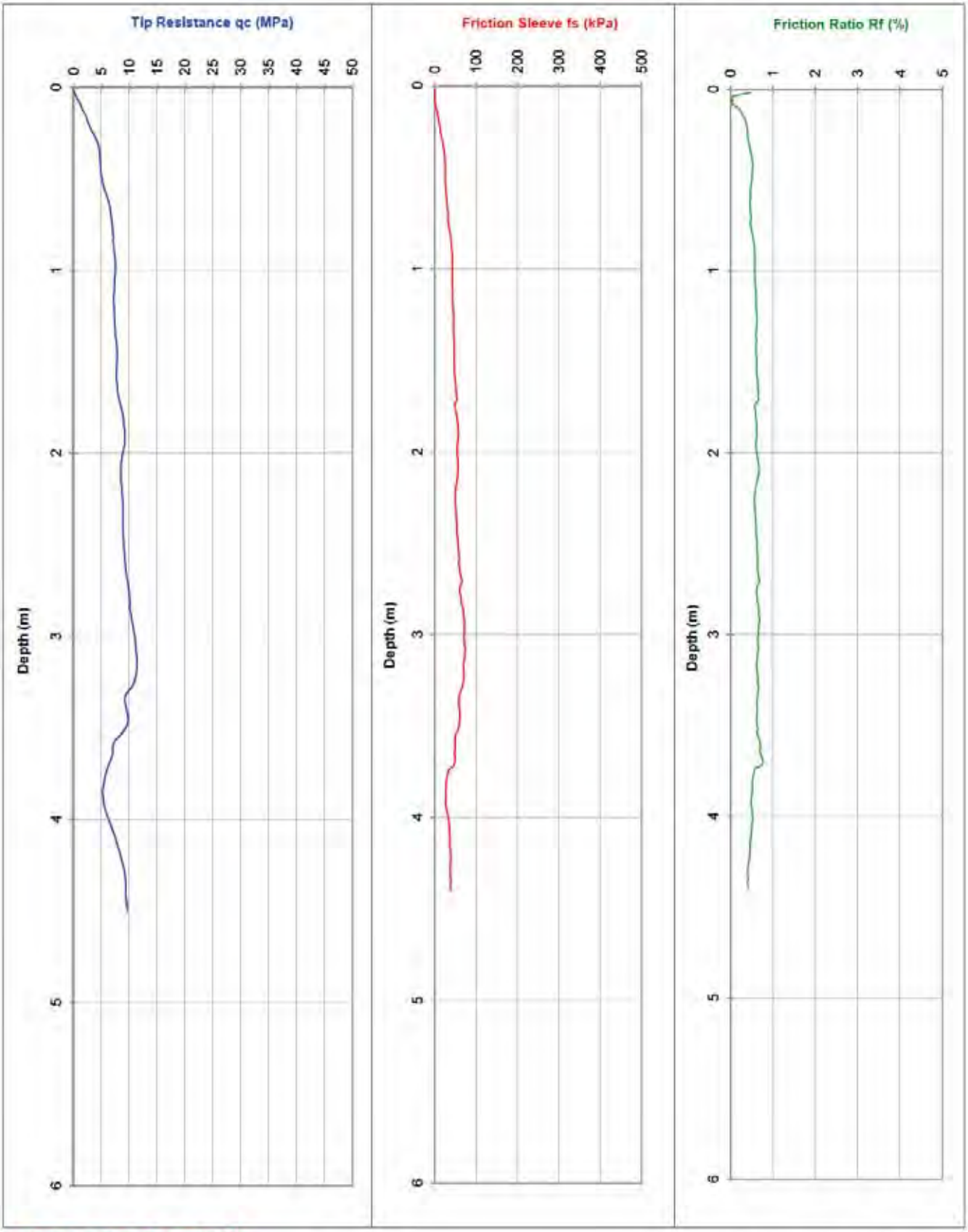
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 2

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): 1.2

Refusal:

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

File: GL0684M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

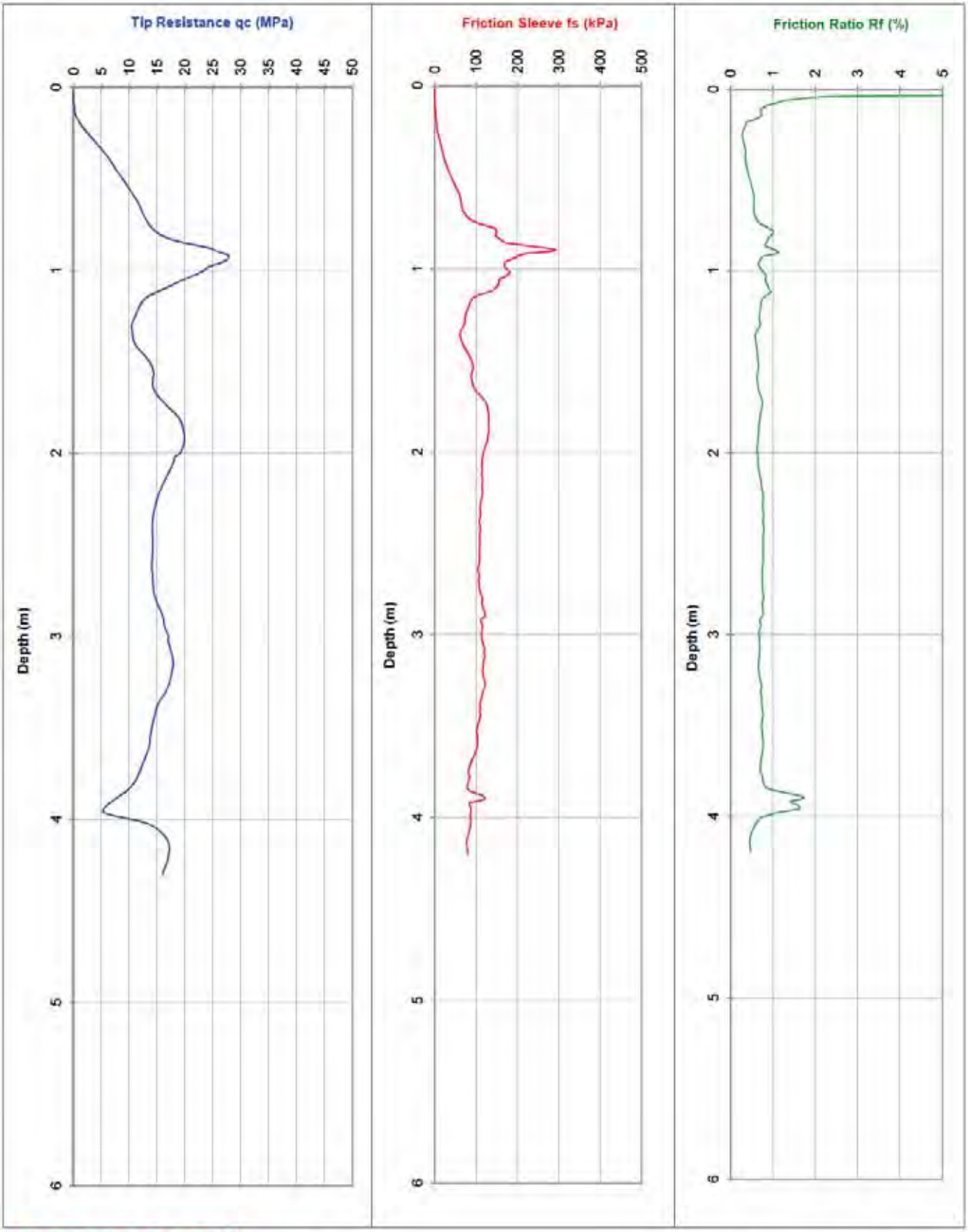
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 3

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0685M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

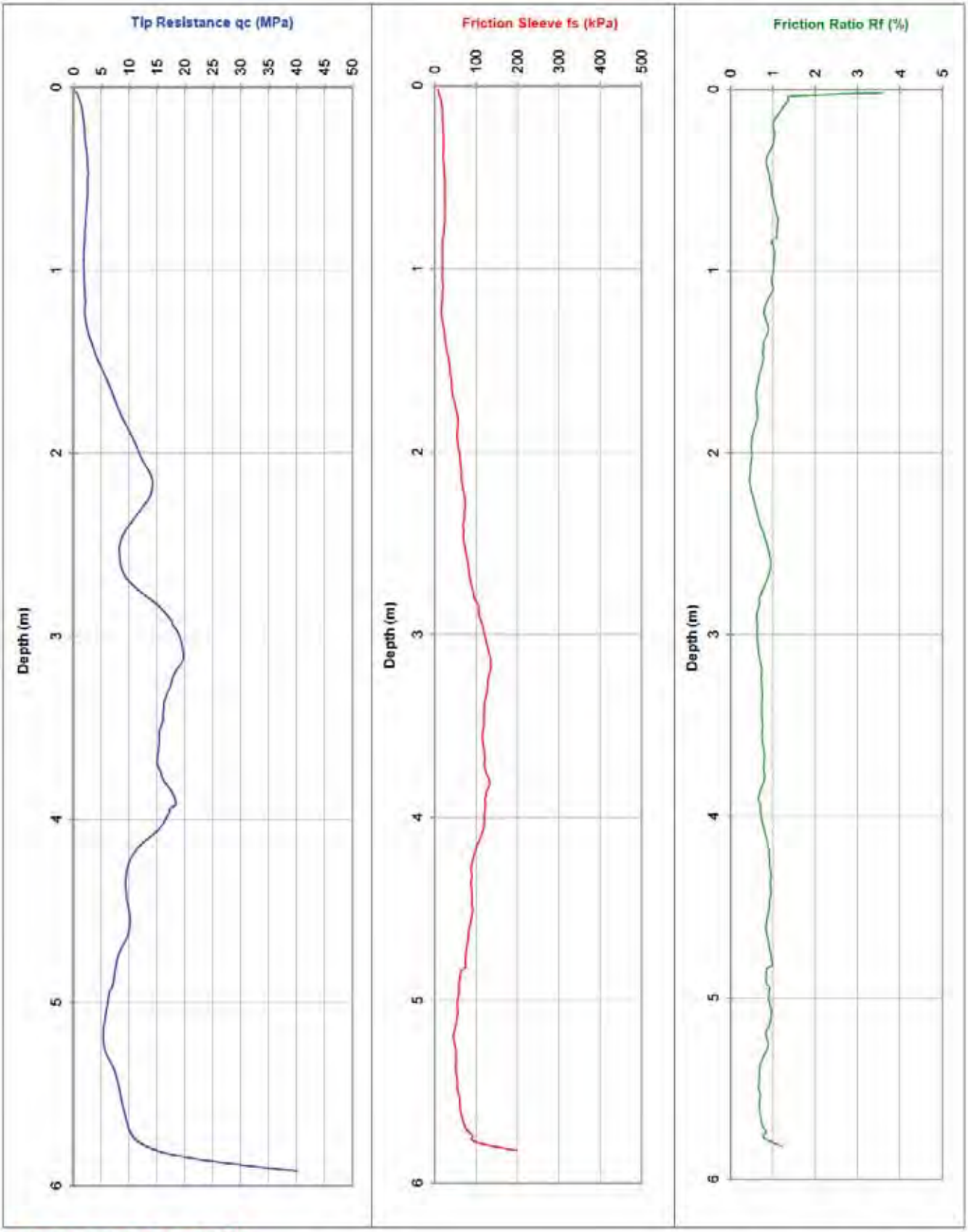
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 4

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): 1.0

Refusal:

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

File: GL0686M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

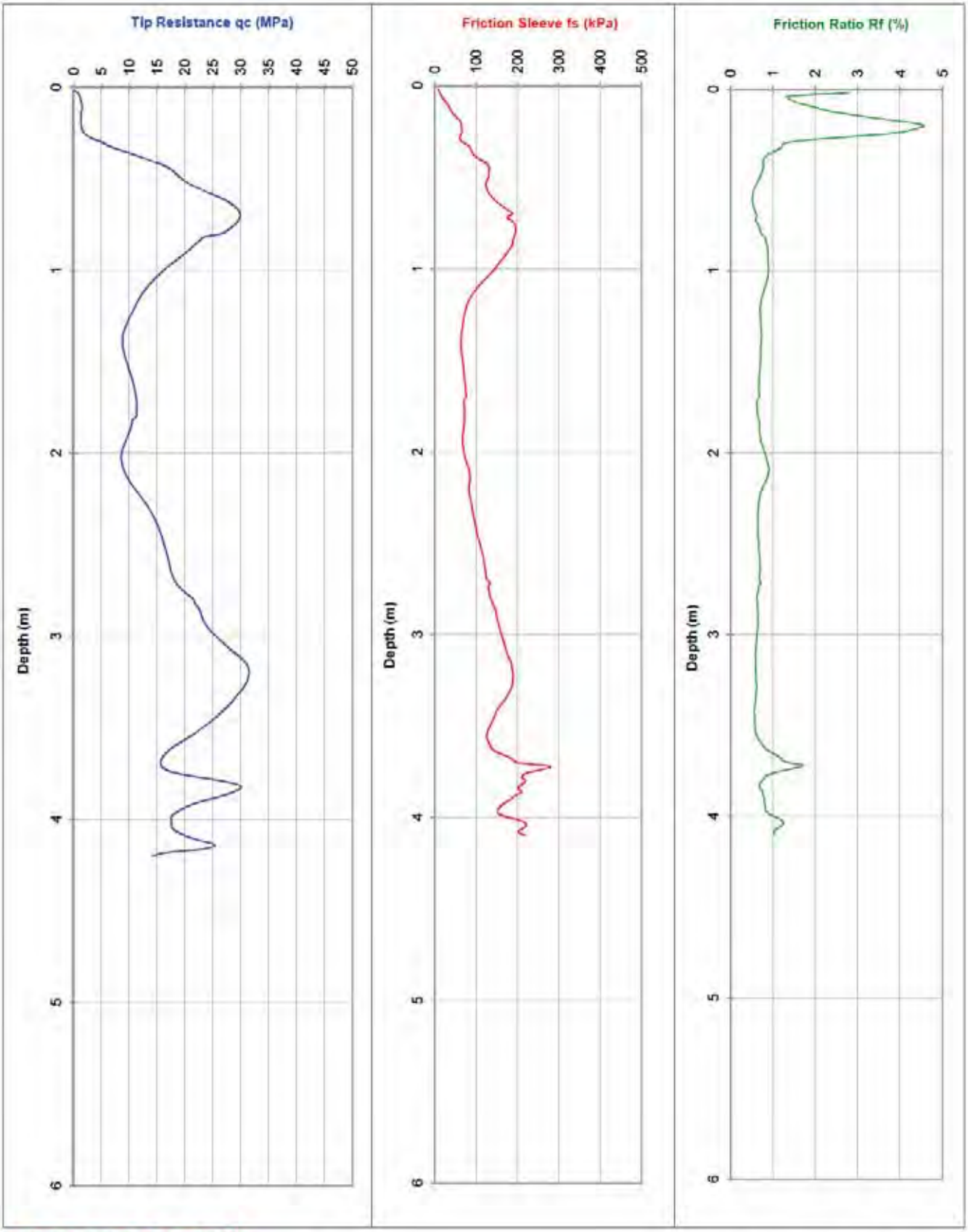
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 5

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0687M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

ELECTRIC FRICTION-CONE PENETROMETER

CLIENT: ABN

PROJECT: Residential Development

LOCATION: Brabham

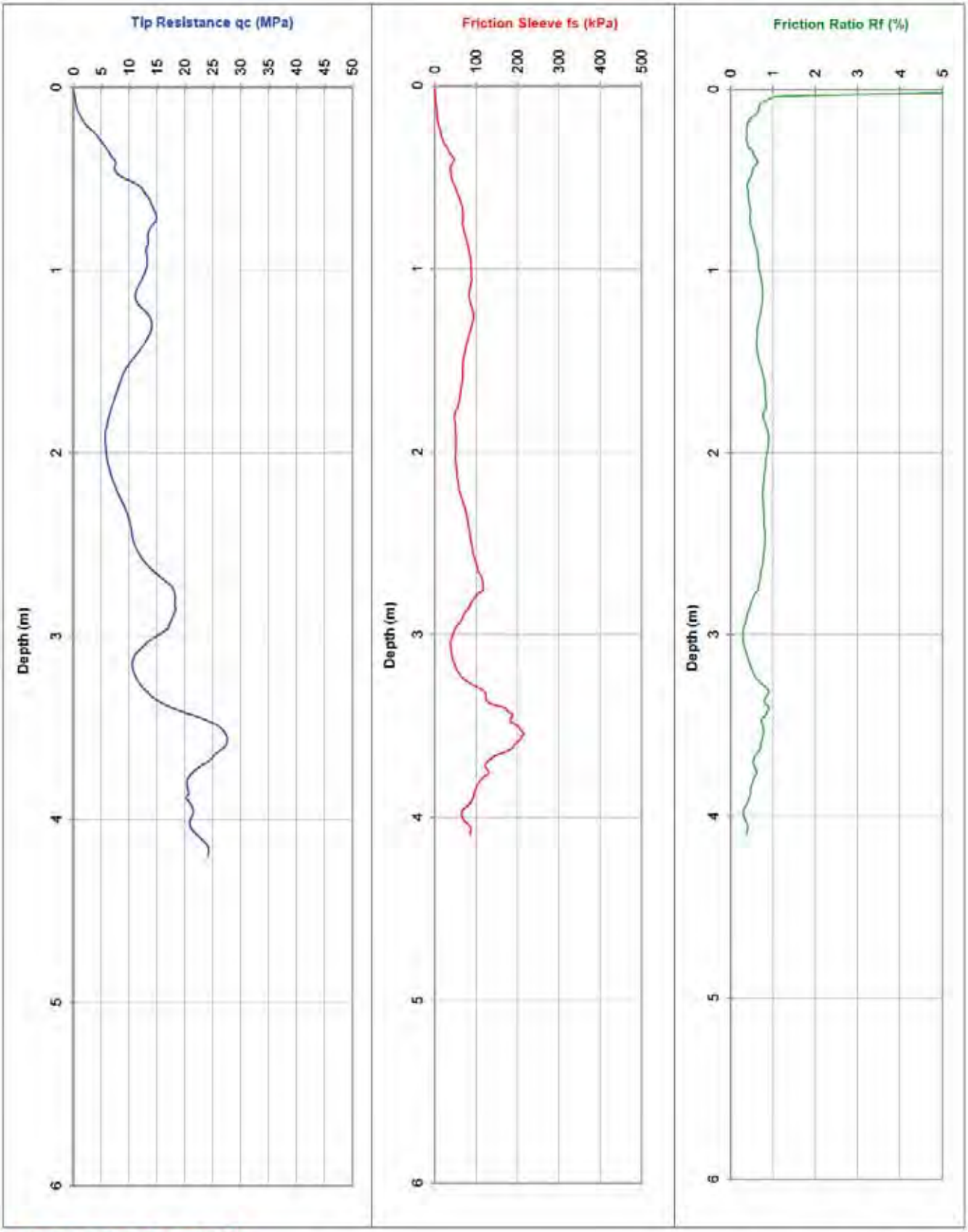
RL (m):

Date: Friday, 6 February 2015

Probe No.: CPT 6

Job Number: J1501018

Co-ordinates:



PROBEDRILL GEOTECHNICAL SURVEY

Water (m): -

Refusal:

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

File: GL0688M

Cone I.D. : EC28

Dummy probe to (m):

12 tonne track mounted CPT Rig (M1)

Appendix E: Permeability Test Results

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2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Permeability Calculation - Inverse Auger Hole Method

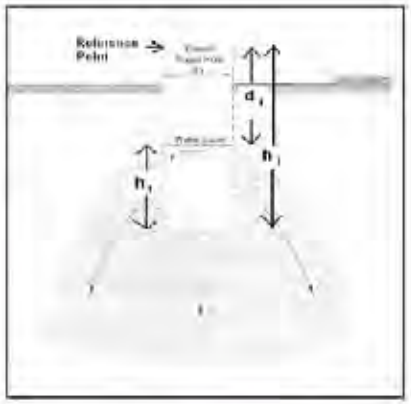
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P01
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 Septembre 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	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.75	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

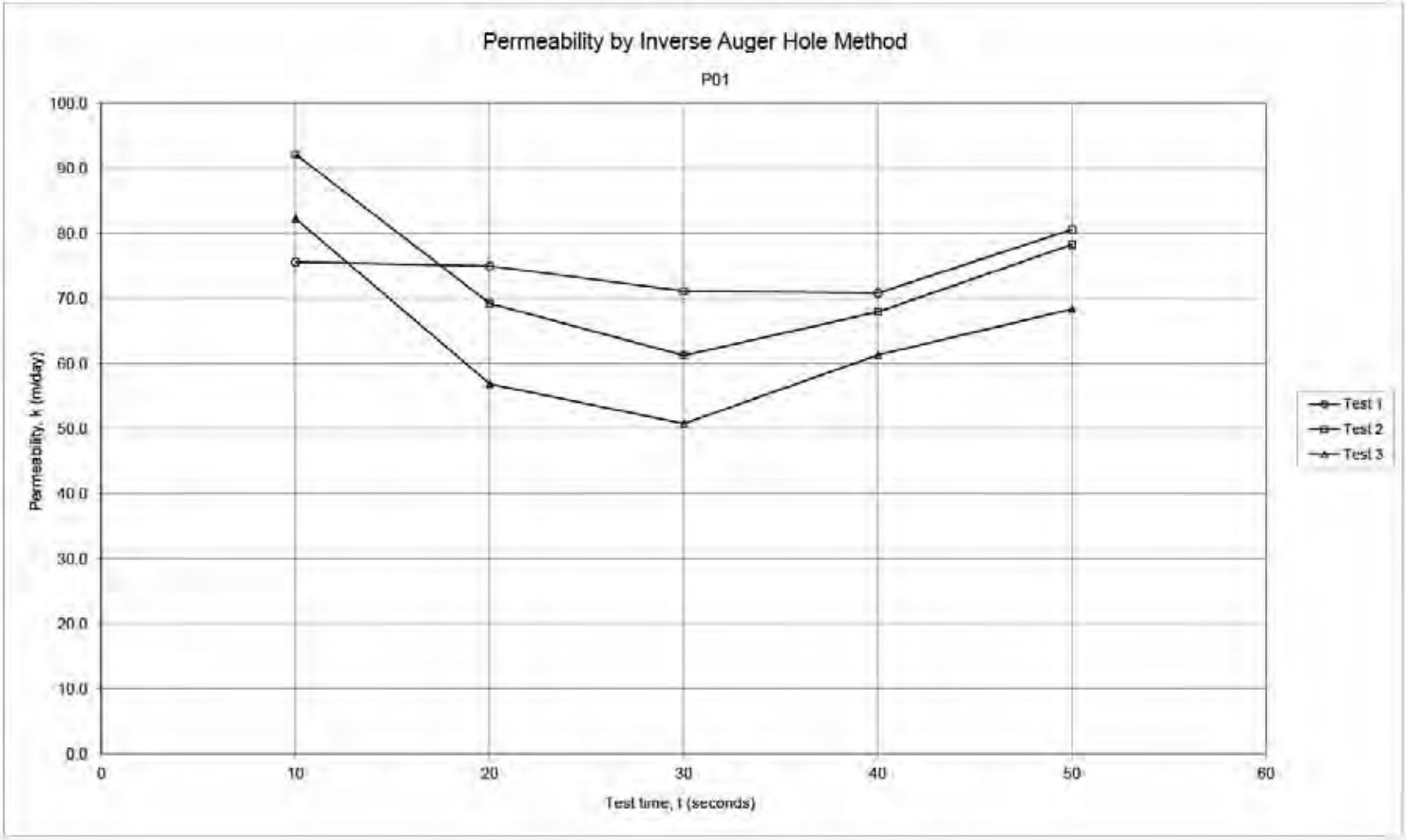
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.46	0.29		
10	0.57	0.18	8.8E-04	75.6
20	0.64	0.11	8.7E-04	75.0
30	0.68	0.07	8.2E-04	71.2
40	0.71	0.04	8.2E-04	70.9
50	0.74	0.01	9.3E-04	80.6
		AVERAGE	8.6E-04	74.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.48	0.27		
10	0.6	0.15	1.1E-03	92.2
20	0.64	0.11	8.0E-04	69.2
30	0.67	0.08	7.1E-04	61.3
40	0.71	0.04	7.9E-04	68.0
50	0.74	0.01	9.1E-04	78.3
		AVERAGE	8.5E-04	73.8

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.48	0.27		
10	0.59	0.16	9.5E-04	82.3
20	0.62	0.13	6.6E-04	56.9
30	0.65	0.1	5.9E-04	50.8
40	0.7	0.05	7.1E-04	61.3
50	0.73	0.02	7.9E-04	68.4
		AVERAGE	7.4E-04	63.9


Permeability by Inverse Auger Hole Method
P01
Permeability, k (m/day)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

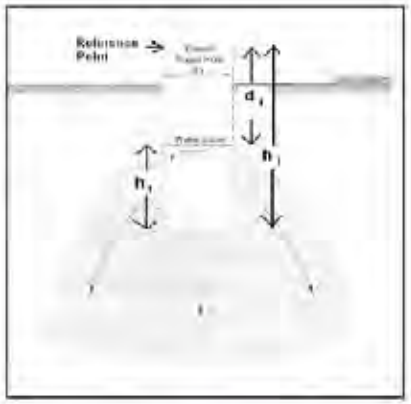
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P02
Test Depth:	0.6 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 Septembre 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	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.6	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 P

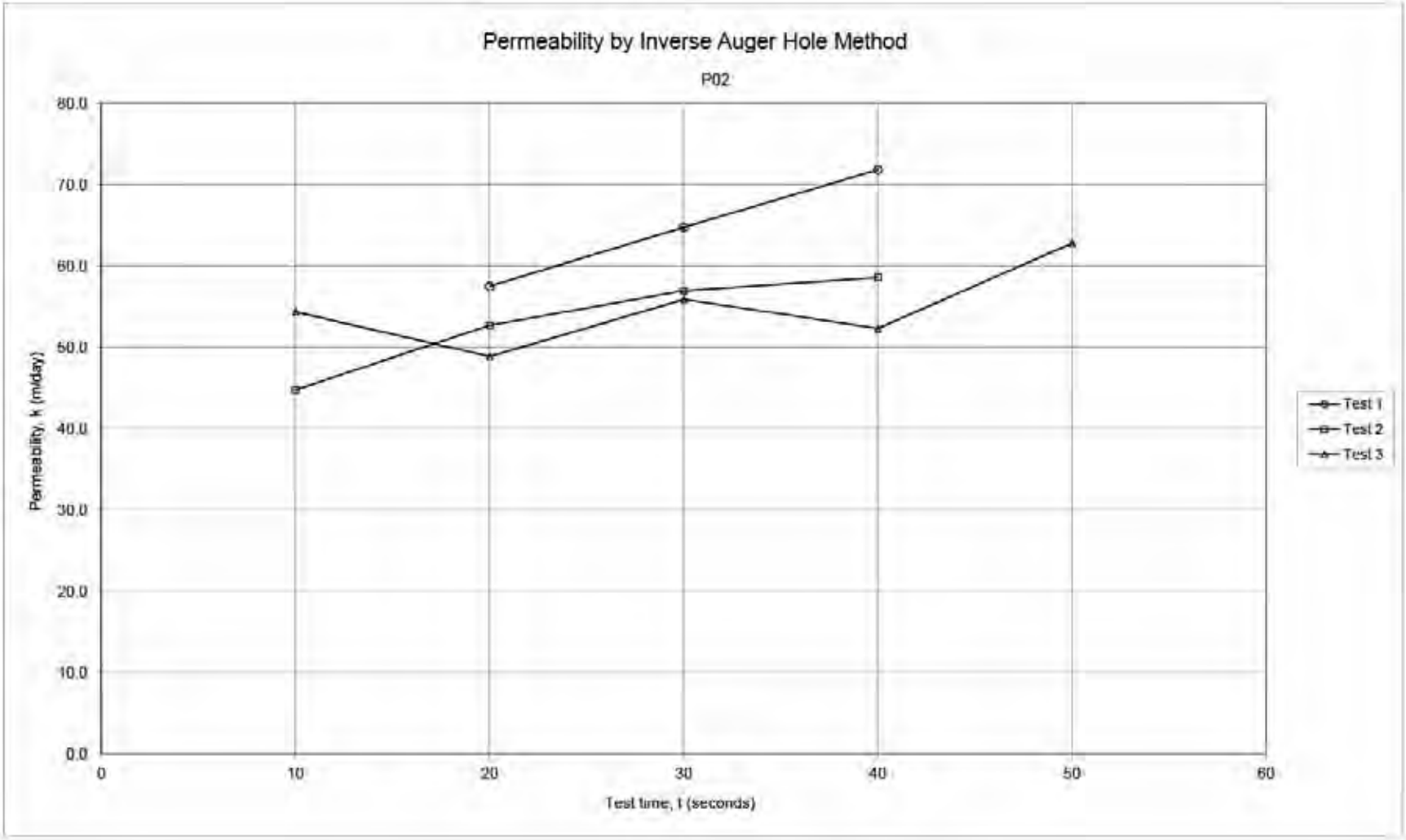
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.35		
20	0.43	0.17	6.7E-04	57.5
30	0.5	0.1	7.5E-04	64.8
40	0.55	0.05	8.3E-04	71.8
		AVERAGE	7.5E-04	64.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.27	0.33		
10	0.35	0.25	5.2E-04	44.8
20	0.43	0.17	6.1E-04	52.7
30	0.49	0.11	6.6E-04	57.0
40	0.53	0.07	6.8E-04	58.6
		AVERAGE	6.2E-04	53.3

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.35		
10	0.35	0.25	6.3E-04	54.4
20	0.41	0.19	5.7E-04	48.9
30	0.48	0.12	6.5E-04	55.9
40	0.51	0.09	6.1E-04	52.3
50	0.56	0.04	7.3E-04	62.8
		AVERAGE	6.4E-04	54.9


Permeability by Inverse Auger Hole Method
P02
Permeability, k (m/day)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

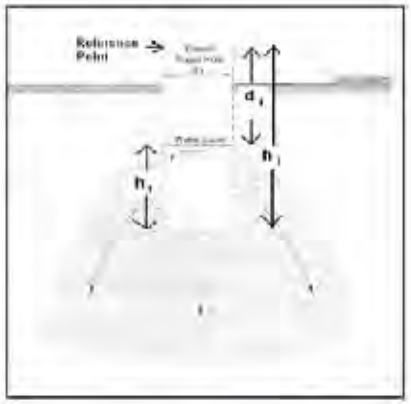
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woolcott Av
Calc by:	MW
BH Name:	P03
Test Depth:	0.6 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 Septembre 2007, pp101-114



Spreadsheet Legend

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

Parameter	Description	Value	Units
K	Permeability	X	m/s
r	radius of test hole	0.04	m
t	time since start of measurement	X	s
h_r	reference point height above base	0.6	m
d_t	depth from reference point to water at time t	X	m
h_t	Water column height at time t	X	m
h_0	h_t at t=0	X	m

Test 1

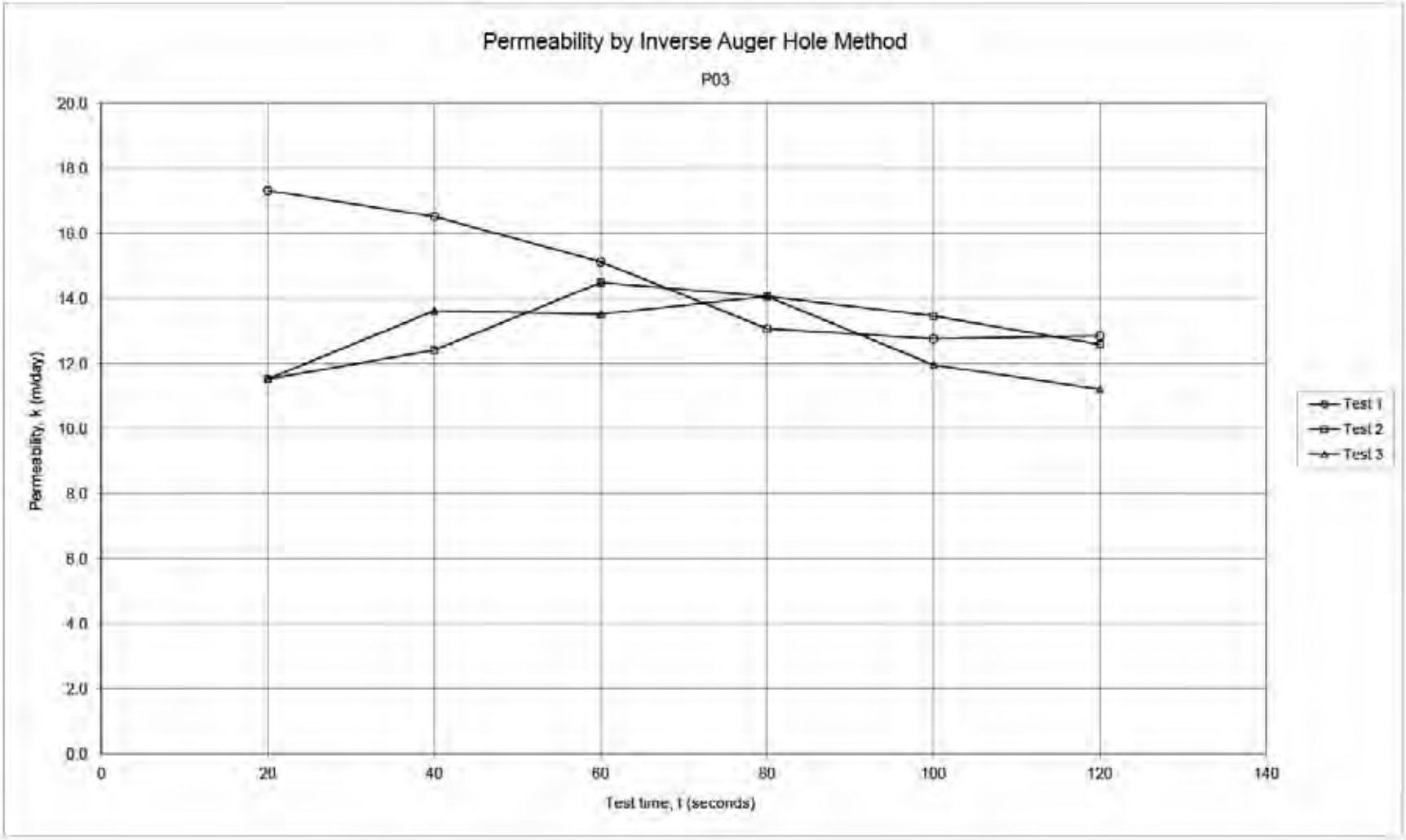
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.4	0.2	X	X
20	0.44	0.16	2.0E-04	17.3
40	0.47	0.13	1.9E-04	16.5
60	0.49	0.11	1.8E-04	15.1
80	0.5	0.1	1.5E-04	13.1
100	0.515	0.085	1.5E-04	12.8
120	0.53	0.07	1.5E-04	12.9
		AVERAGE	1.7E-04	14.6

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.38	0.22	X	X
20	0.41	0.19	1.3E-04	11.5
40	0.44	0.16	1.4E-04	12.4
60	0.475	0.125	1.7E-04	14.5
80	0.495	0.105	1.6E-04	14.1
100	0.51	0.09	1.6E-04	13.5
120	0.52	0.08	1.5E-04	12.6
		AVERAGE	1.5E-04	13.1

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.38	0.22	X	X
20	0.41	0.19	1.3E-04	11.5
40	0.445	0.155	1.6E-04	13.6
60	0.47	0.13	1.6E-04	13.5
80	0.495	0.105	1.6E-04	14.1
100	0.5	0.1	1.4E-04	12.0
120	0.51	0.09	1.3E-04	11.2
		AVERAGE	1.5E-04	12.7


Permeability by Inverse Auger Hole Method
P03
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
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

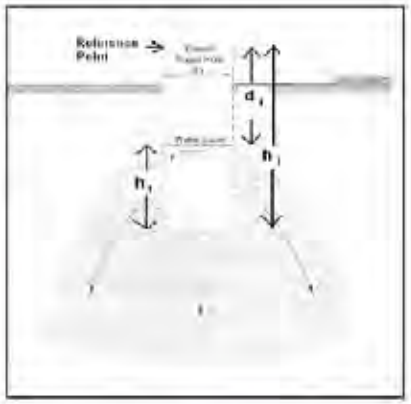
Galt Geotechnics

Job No:	J1501018
Client:	ABN Group
Site:	Brabham
Location:	345 Woollcott Av
Calc by:	MW
BH Name:	P04
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 Septembre 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	0.04	m
t	time since start of measurement		s
h_r	reference point height above base	0.85	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

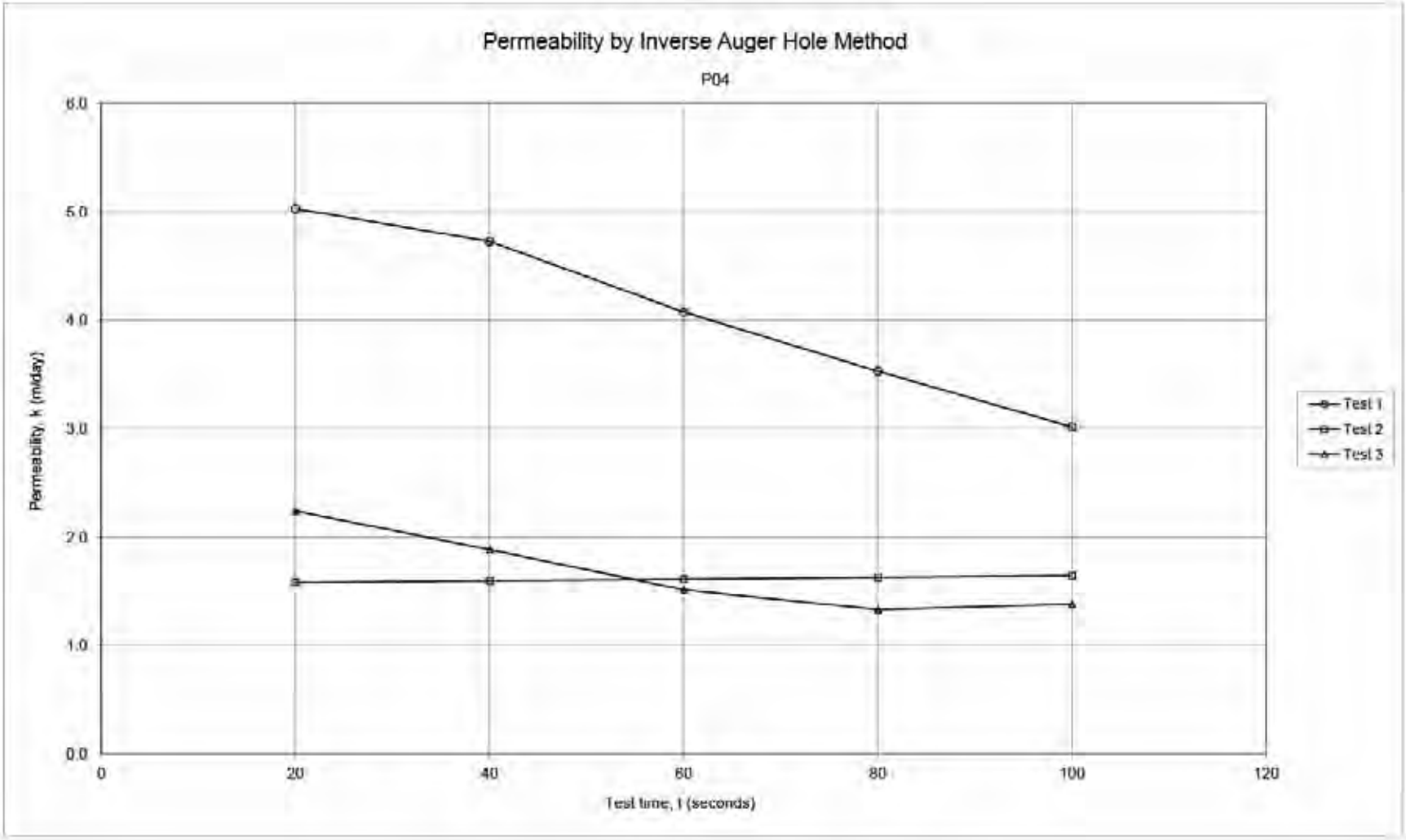
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.34	0.51		
20	0.37	0.48	5.8E-05	5.0
40	0.395	0.455	5.5E-05	4.7
60	0.41	0.44	4.7E-05	4.1
80	0.42	0.43	4.1E-05	3.5
100	0.425	0.425	3.5E-05	3.0
		AVERAGE	4.7E-05	4.1

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.32	0.53		
20	0.33	0.52	1.8E-05	1.6
40	0.34	0.51	1.8E-05	1.6
60	0.35	0.5	1.9E-05	1.6
80	0.36	0.49	1.9E-05	1.6
100	0.37	0.48	1.9E-05	1.6
		AVERAGE	1.9E-05	1.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.285	0.585		
20	0.3	0.55	2.6E-05	2.2
40	0.31	0.54	2.2E-05	1.9
60	0.315	0.535	1.8E-05	1.5
80	0.32	0.53	1.5E-05	1.3
100	0.33	0.52	1.6E-05	1.4
		AVERAGE	1.9E-05	1.7


Permeability by Inverse Auger Hole Method
P04
Permeability, k (m/day)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix F: Laboratory Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022 Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/736
Sample No:	P15/736
Issue Date:	19 February 2015

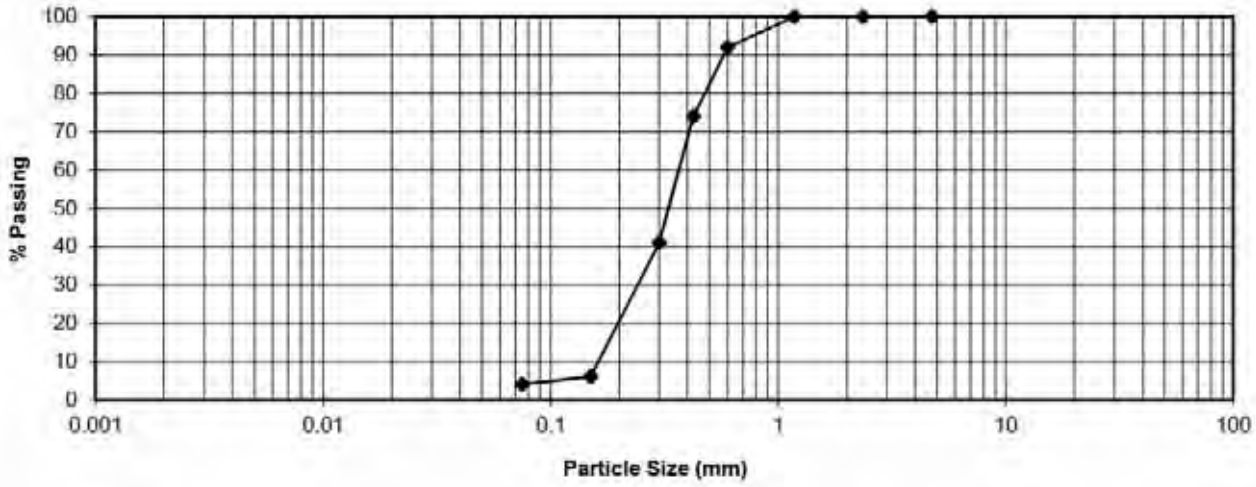
Client: Galt Geotechnics (J1501018)

Project: ABN Group

Location: DD SI, Brabham

Sample location: TP 05

Sample Depth (m): 0.9 - 1.1



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	92
0.425	74
0.300	41
0.150	6
0.075	4

Plasticity index tests

AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025
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Approved signature

Matthew van Herk
AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022 Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/737
Sample No:	P15/737
Issue Date:	19 February 2015

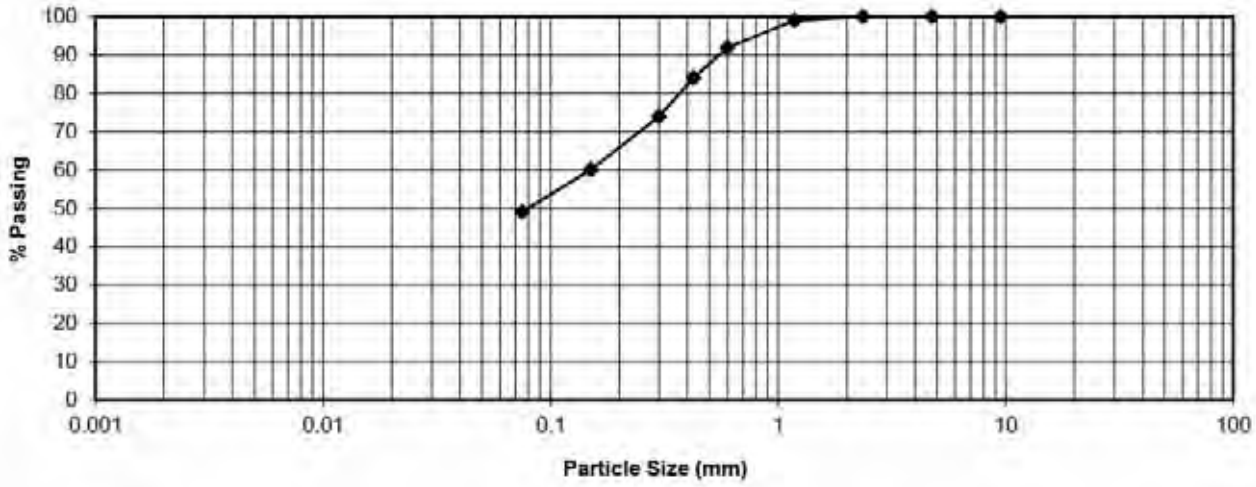
Client: Galt Geotechnics (J1501018)

Project: ABN Group

Location: DD SI, Brabham

Sample location: TP 07

Sample Depth (m): 0.0 - 0.15



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	99
0.600	92
0.425	84
0.300	74
0.150	60
0.075	49

Plasticity index tests

AS 1289

Liquid limit 3.1.1	29	%
Plastic limit 3.2.1	13	%
Plasticity index 3.3.1	16	%
Linear shrinkage 3.4.1	6.5	%

Cracked ☑

Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Accreditation for compliance with ISO/IEC 17025

Accreditation No 15545

Approved signature

Matthew van Herk

AS PSDPI May 2009

Mining & Civil Geotest Pty Ltd

Ph (08) 9414 8022 Fax (08) 9414 8011

Email matt@mcgeotest.com.au

Unit 1/1 Pusey Road, JANDAKOT WA 6164

Organic content of Soils
ASTM: D 2974-07a
Test Method C

Job No: 60083

Report No: 60083-P15/736

Date of issue: 19 February 2015

Client:	Gult Geotechnics (J1501018)	Date tested:	12 February 2015
Project:	ABN Group	Tested by:	P Culverston
Location:	DD SL Brabham	Checked:	K M Jones

Sample Number	Sample Identification & Depth (m)	Ash content %	Organic content %
P15/736	TP 05, 0.9 - 1.1	96.0	4.0

Tested as received | Furnace temperature 440^{oc}

Client address: 2/39 Flynn St, Wembley WA

Organic content April 2009

Approved Signature Matthew van Herk

Appendix G: Understanding Your Report

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical 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 geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. 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 geotechnical problems 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 geotechnical 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 geotechnical engineering 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 design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical 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 as a consequence 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 geotechnical 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 as a result of anthropogenic events (such as construction 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 engineering 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 engineering 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 ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.

Appendix Five *Worley Parsons Pipeline Risk Management Plan and Protection Plan*

WorleyParsons Consulting

EcoNomics

BIRCH FALLS

Lot 345 Woollcott Avenue Brabham

Pipeline Risk Management Plan and Protection Plan

401012-02213 – 401012-02213-00-SR-RP-001

18 May 2015

Level 7, QV1 Building,
250 St Georges Terrace Perth WA 6000
Australia
Telephone: +61 8 9278 8111
Facsimile: +61 8 9278 8110
www.worleyparsons.com
ABN 61 001 279 812

Disclaimer

PROJECT 401012-02213 - LOT 345 WOOLLCOTT AVENUE BRABHAM

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	W S Woo	M Karyagina	N/A	18-May-15	N/A	
B	Issued for Client Review	W S Woo	M Karyagina	M Karyagina	18-May-15		

CONTENTS

Appendices

1 INTRODUCTION

Birch Falls are currently in the process of developing Lot 345 Woollcott Avenue (the Brabham residential area). This area is planned as a residential site and will include general infrastructure upgrades.

The APA Parmelia pipeline corridor is located on the development site while the Dampier-Bunbury Pipeline (DBP) and Dampier-Bunbury Loop line are on the adjacent block, Lot 346. All three of these pipelines contain high pressure (HP) natural gas.

In preparation for the proposed development a pipeline risk assessment was undertaken. This risk assessment was conducted on 13th May 2015 in the WorleyParsons office at 235 St Georges Tce, facilitated by WorleyParsons. The full workshop minutes and actions are included in Appendix 4 and Appendix 5 respectively.

1.1 Requirement

The WA Planning Commission (WAPC) requires that any land development in the vicinity of high pressure gas transmission pipelines maintains certain setback distances [Ref. 1]. These distances vary depending on the area of the metropolitan Perth traversed by the pipeline.

For developments within the setback distances, a pipeline risk management plan (PRMP) is required by the Planning Bulletin 87 (PB 87) [Ref. 1] as part of the application for planning approval. Preparation of the PRMP requires a pipeline risk assessment to be undertaken. There are two documents that set the guidelines for pipeline risk assessments:

- Australian Standard 2885 Pipelines – Gas and Liquid Petroleum (AS 2885.1) [Ref. 2], which uses qualitative risk assessment.
- PB 87 – High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region [Ref. 1], which includes quantitative guidelines.

This document covers the requirements for both standards and specifically covers the requirements of the following:

- Safety management study (SMS) – required to be carried out for high pressure gas pipelines if new threats to the pipeline are introduced, as per AS 2885.1 section 2.2.4 [Ref. 2].
- Pipeline risk management plan (PRMP) to demonstrate that the risk from the pipeline is within acceptable risk levels as per PB 87. Due to the commonality of the AS 2885.1 SMS and the PB 87 PRMP, these are presented as a single assessment and referred to as PRMP.
- Pipeline protection plan (PPP) to detail the precautions taken and processes used to implement risk management plan mitigation measures and construction works as per PB 87 [Ref. 1].

1.2 Study Objectives

The objectives of this PRMP and PPP are to identify:

- Threats to pipeline integrity in the area of the development.
- Existing controls and processes which will protect the pipelines during both construction of the works and lifetime of the development (including implementation of risk management plan mitigation measures).
- Further mitigation measures needed to achieve negligible, low or as low as reasonably practicable (ALARP) risk levels to the populations adjacent to HP gas pipelines within the scope of this study.
- Timing and responsibility for the installation of mitigation measures.
- Any on-going management measures.

1.3 Study Scope

This report considers the sections of the DBNGP Main, DBNGP Loop and Parmelia pipelines bordering the western boundary of the proposed Birch Falls development site.

Threats to the pipeline from the development during and after construction are the focus of the risk assessment workshop. The scope of the risk assessment work includes:

- The relevant section of the buried natural gas pipelines.
- Roads, crossings and drainage near the Parmelia pipeline.
- Civil construction works near the Parmelia pipeline.
- Future maintenance of services and infrastructure crossing the Parmelia pipeline.

The setback distance in this area is driven by the Parmelia pipeline, so the main focus of the risk assessment is the Parmelia pipeline, although risks to DBNGP/Loop are also covered. Risks to DBP were addresses as part of the Lot 346 PRMP and it is assumed that the risk mitigation measures identified therein will be fully implemented.

Any additional pipeline threats which become apparent due to changes in the scope of the development works must be reassessed.

1.4 Abbreviations

ALARP	As Low As Reasonably Practicable
APA	APA Group
AS	Australian Standard
CIC	Common Infrastructure Corridor

CP	Cathodic Protection
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DBYD	Dial Before You Dig
DCVG	Direct Current Voltage Gradient
DMP	Department of Minerals and Petroleum
DOC	Depth of Cover
EIP	External Interference Protection
EPA	Environmental Protection Authority
EPR	Earth Potential Rise
HDD	Horizontal Directional Drilling
HP	High Pressure
ILI	Inline Inspection
LFI	Low Frequency Induction
MAOP	Maximum Allowable Operating Pressure
NLST	Non Location Specific Threat (applies along the entire pipeline)
PB 87	Planning Bulletin 87
PPP	Pipeline Protection Plan
PRMP	Pipeline Risk Management Plan
ROW	Right of Way
SMS	Safety Management Study
WAPC	Western Australian Planning Commission
WT	Wall Thickness

2 FACILITIES DESCRIPTION

2.1 Development Proposal

The APA Parmelia pipeline corridor is located on the development site while the Dampier-Bunbury Pipeline (DBP) and Dampier-Bunbury Loop line are on the adjacent block, Lot 346.

2.2 Pipeline Specifications

The pipeline details in Table 2-1 were presented and agreed at the start of the workshop.

Table 2-1 Pipeline Details

	DBNGP Main	DBNGP Loop	Parmelia
Design Code	AS 2885	AS 2885	AS 2885
Diameter (OD), mm	660	660	355.6
Pipe Wall Thickness, mm	12.7	14.6	5.16
Maximum Allowable Operating Pressure (MAOP), MPag	8.48	8.48	7.48
Pipe Grade	API 5L X65 DSAW	API 5L X70 ERW	API 5L X52
Design Factor	0.5	0.5	0.72
Pipe Coating	MobiloxD1003		Yellow Jacket
Corrosion Prevention System	DC Impressed Current	DC Impressed Current	DC Impressed Current
Depth of Cover (DOC, min nominal), mm	1000 to 1520	1500 to 1800	~1000
Distance to 4.7 kW/m^2 (Measurement Length), m	660	660	320

2.3 Location Class

The location classes are defined in Sections 4.34 and 4.35 of AS 2885.1 [Ref. 2]. These classes describe what the predominant land use will be and what physical and procedural controls are required for each class.

With the advent of this development the primary location class of the land has changed to "Residential (T1)"[1]. Residential land is defined as land that has been developed for community living and applies where multiple dwellings exist in proximity to each other or in areas served by common public utilities.

A secondary location class of "Common Infrastructure Corridor (CIC)" is also applied as the function of the land results in multiple infrastructure development within a common easement.

As a result of the Birch Falls development, the primary location class is Residential (T1) with a secondary location class of Common Infrastructure Corridor (CIC).

2.4 Setback Distances

Setback distances are based on the type of land use or development, generic quantitative risk assessment and individual fatality risk values set in EPA guidance for different land use. The setback distance mandated in PB 87 [Ref. 2] for a residential area in the vicinity of the DBNGP corridor and Parmelia pipeline easement when adjoining between Muchea and Baldivis is 75 m from the edge of the pipeline easement. This distance corresponds with a fatality risk level of one in a million per year or less.

The development plan shown in Appendix 2 indicates the closest residential land is within the residential setback distance of 75 m, with a separation distance of approximately 18 m from the Parmelia pipeline easement.

[1] DBNGP and Loop line were designed to meet T1 requirements in this area, whereas Parmelia pipeline was designed for "Rural (R1)" location class.

3 RISK ASSESSMENT

A qualitative pipeline risk assessment in accordance with AS 2885.1 was conducted on the 13th of May 2015 for the sections of the DBNGP Main, DBNGP Loop and Parmelia pipelines adjacent to the site of the Birch Falls development at Lot 345 Woollcott Avenue, Brabham.

3.1 Team Composition

The pipeline risk assessment group included representatives from the developer (Birch Falls), pipeline operators (APA and DBP), construction contractor (PACT Construction) and design engineer for the development (Pritchard Francis).

The workshop was facilitated by a facilitator from WorleyParsons.

The attendance sheet for the workshop can be found in Appendix 1.

3.2 Methodology

The risk assessments followed the following process:

- A PowerPoint presentation covering the meeting agenda, highlighting the potential for harm from high pressure gas pipelines, and introducing the risk based AS 2885.1 process [Ref. 2].
- The Birch Falls representative responsible for the Brabham development described the proposed works. The plot plan (Appendix 2) was used to assist with the attendees' understanding of the potential issues/threats.
- PRMP: The AS 2885.1 [Ref. 2] risk methodology was used to brainstorm and document operational (post construction) related threats and the associated risks to the pipelines. The risk matrix from AS 2885.1 [Ref. 2] was used and ALARP documented if required. Actions were also logged as necessary. The risk matrix is included in Appendix 3.
- PPP: The AS 2885.1 [Ref. 2] risk methodology was used to brainstorm and document construction related threats and the associated risks to the pipelines. The risk matrix from AS 2885.1 [Ref. 2] was used to risk assess each credible threat. ALARP was documented and actions logged as necessary.

3.3 Workshop Results

The AS 2885 risk assessment of the construction and post-construction phases determined threats to the DBNGP Main, DBNGP Loop and Parmelia pipelines resulting from the proposed development and threats to the occupants who are adjacent to the pipeline.

Threats to the pipelines included the following:

- Pipeline joint corrosion.

- Heavy vehicles on the northern road crossing and on the Parmelia pipeline easement.
- Installation and maintenance activities of 3rd party services – power / communications cables, water and sewerage.
- Construction and maintenance activities of the northern road crossing.
- Installation of fences and signage posts.
- Vegetation over the Parmelia pipeline easement
- Vibrating machinery.

Where appropriate the existing and required risk mitigation measures were discussed and documented.

Minutes from the AS 2885 pipeline risk assessment for construction and post-construction phases are attached in Appendix 4.

Thirteen (13) actions were raised and are presented in Appendix 5. Implementation of these actions will ensure that risks to the integrity of the pipelines and therefore to adjacent populations remain ALARP.

4 RISK MITIGATION MEASURES AND RESPONSIBILITIES

The risk mitigation measures in Table 4-1 to be implemented during the development of the site have been agreed between the land developer and pipeline operators.

Table 4-1 Summary of Risk Mitigation Measures

Mitigation Measures	Responsibility	Project Phase
Increased signage may be required (if not already installed as part of Lot 346).	Birch Falls / ABN	Design
Crossing design to comply with AS 2885.1 and APA requirements (slab, minimum DOC requirement, minimum separation between 3rd party services, etc.).	Birch Falls / ABN	Design
Bollards to prevent vehicle access to pipeline easement (but ensuring pipeline operator has access to it).	Birch Falls / ABN	Design
Ground cover in pipeline easement to comply with APA requirements.	Birch Falls / ABN	Design
Temporary fence restricting access to the pipeline. Points of note: • Provide access gates / keys to the pipeline operator. • Non-excavation installation method is preferred for the fence sections that cross the pipeline.	Birch Falls / ABN	Construction
Approved machinery and construction method to ensure no loading over the pipeline / vibration risk.	Birch Falls / ABN	Construction
Installation of services in the road crossing should be post crossing construction (i.e. slab is in place).	Birch Falls / ABN	Construction
Liaison with APA (and where appropriate with DBP) to ensure appropriate supervision during high risk activities (crossing construction, sewerage line horizontal direction drilling (HDD), etc.)	Birch Falls / ABN	Construction
Weld joints will be inspected as part of Lot 346 development for entire length of development.	APA	N/A
Existing controls as required by AS 2885.3 and APA / DBP safety cases commensurate with the T1 location class.	APA, DBP	Ongoing

5 CONCLUSIONS

The proposed Birch Falls development at Lot 345 Woollcott Avenue, Brabham poses potentially ongoing threats to the DBNGP Main line, DBNGP Loop line and Parmelia pipeline. These threats were evaluated using the AS2885.1 methodology.

The results of the AS2885 risk assessment for construction and post-construction phases can be seen in Appendix 4.

Thirteen (13) actions were raised and responsibilities assigned – it remains the responsibility of the actionees to actively and expeditiously progress the actions to a suitable conclusion in order to bring the various pipeline threats to ALARP risk levels.

Correspondence and active liaison between the pipeline operators and the land developer will occur on an ongoing basis to progress the proposed development. The actions raised also reflect this.

6 REFERENCES

1. High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region. Planning Bulletin 87, Western Australian Planning Commission, October 2007.
2. AS2885.1: Australian Standard: Pipelines – Gas and Liquid Petroleum, Part 1 Design and Construction, 2012.

Appendix 1 Workshop Attendance Record

WorleyParsons

Meeting Attendance Record

Date 13 May 2015
Meeting topic 345 Woolcott Avenue Brabham Risk Assessment
Held by WorleyParsons
Venue Level 2, 235 St Georges Terrace, Avon Conference Room

NAME	SIGNATURE	POSITION	COMPANY
Marina KARYAGINA	[illegible]	Facilitator	WorleyParsons
Sebastian Montez	[illegible]	Site Manager	PACT construction
Chathura Dean	[illegible]	Engineer	Pritchard Francis
Mark Riddell	MRiddell	Civil Engineer	Pritchard Francis
Wai Sum WOO	[illegible]	Scribe	WorleyParsons
Adam Crichton	[illegible]	Pipeline Engineer	APA Group
Kathy Chick	[illegible]	Lands Officer	DBP
Bill Evans	[illegible]	Land Agent	APA
Jeremy Cordina	[illegible]	ABN Land Development	ABN

DISTRIBUTION

- ☐ Personnel Manager
- ☐ Other (please specify)
- ☐ Other (please specify)

Appendix 2 Development Plan

LAND USE SCHEDULE	
TOTAL SITE	20.29
DEDUCTIONS.	
PIPELINE EASE'T	1.34
1:1 yr DRAINAGE	0.1
NET SUBDIVISIBLE	18.85ha

P.O.S. PROVIDED	2.35ha = 12.5%

TOTAL SITE AREA (NDA)	= 11.35 ha.

LOT YIELD	
SINGLE LOTS	325
G.H. LOTS.	1
TOTAL.	326 LOTS

CONCEPT PLAN

Lot 345 Woollcott Avenue, Brabham
City of Swan

plan no: 3403-03A-01
scale: 1:2500 @ A3
date: 06.03.2015

Appendix 3 AS 2885 Pipeline Risk Assessment – Matrix

AS2885.1 2012 - Risk Matrix

			Typical Severity Classes	Catastrophic	Major	Severe	Minor	Trivial
CONSEQUENCES			People	Multiple fatalities result	Few fatalities, or several people with life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health & safety
			Supply	Long term interruption of supply	Prolonged interruption; long term restriction of supply	Short term interruption; prolonged restriction of supply	Short term interruption; restriction of supply but shortfall met from other sources	No impact; no restriction of pipeline supply
			Environment NOTE: Significant environmental consequences may occur in locations which are relatively small & isolated	Effects widespread; viability of ecosystems or species affected; permanent major changes	Major off-site impact; long term severe effects; rectification difficult.	Localised (<1 ha) & short-term (<2 yr) effects, easily rectified.	Effect very localised (<0.1 ha) and very short term (weeks), minimal rectification	No effect; minor on-site effects rectified rapidly with negligible residual effect
FREQUENCY	Frequent	Expected to occur once per year or more		Extreme	Extreme	High	Intermediate	Low
	Occasional	May occur occasionally in the life of the pipeline		Extreme	High	Intermediate	Low	Low
	Unlikely	Unlikely to occur within the life of the pipeline, but possible.		High	High	Intermediate	Low	Negligible
	Remote	Not anticipated for this pipeline at this location.		High	Intermediate	Low	Negligible	Negligible
	Hypothetical	Theoretically possible, but has never occurred on a similar pipeline		Intermediate	Low	Negligible	Negligible	Negligible

Risk Management Actions	
Extreme:	Modify the threat, the frequency or the consequences so that the risk rank is reduced to 'intermediate' or lower. For an in-service pipeline the risk shall be reduced immediately.
High:	Modify the threat, the frequency or the consequences so that the risk rank is reduced to intermediate or lower. For an in service pipeline the risk shall be reduced as soon as is possible, typically within a timescale of not more than a few weeks.
Intermediate:	Repeat threat identification and risk evaluation processes to verify and, where possible, quantify the risk estimation; determine the accuracy and uncertainty of the estimation. Where the risk rank is confirmed to be 'intermediate', if possible modify the threat, the frequency or the consequence to reduce the risk rank to 'low' or 'negligible'. Where the risk rank can not be reduced to 'low' or 'negligible', action shall be taken to: (a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable; and (b) demonstrate ALARP. For an in-service pipeline the reduction to 'low' or 'negligible' or demonstration of ALARP shall be completed as soon as possible, typically within a timescale of not more than a few months.
Low:	Determine the management plan for the threat to prevent occurrence and to monitor changes that could affect the classification.
Negligible:	Review at the next review interval.

Appendix 4 AS 2885 Risk Assessment Minutes

Threats and Safeguards

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
NLST	1.1.1. Corrosion	1.1.1.1 Potential for joint corrosion of Parmelia pipeline	APA	T1, CIC	Yes	No			Inline inspection (ILI) Direct current voltage gradient (DCVG) surveys Cathodic protection (CP) Weld joints will be inspected as part of Lot 346 development for entire length of development	Yes	No		Yes	
		1.1.1.2 Potential for joint corrosion of DBNGP	DBP	T1, CIC	Yes	No			ILI DCVG surveys (5 yearly) Cathodic protection (CP)	Yes	No		Yes	
	1.1.2. Natural Event	1.1.2.1 No additional credible threats identified due to development	DBP, APA	T1, CIC										Existing creek will be widened and walls stabilised to reduce risk of flooding
	1.1.3. Electrical Effect	1.1.3.1 Electrical cables (LV and HV) installed on east side of road reserve have potential to impact Parmelia pipeline's CP system	APA	T1, CIC						No		1. Developer to provide Earth Potential Rise (EPR) and Low Frequency Induction (LFI) studies for APA approval	No	
	1.1.4. Operations and maintenance activities (pipeline operator)	1.1.4.1 No additional credible threats identified due to development	DBP	T1, CIC										
	1.1.5. Construction defects	1.1.5.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.6. Design defects	1.1.6.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.7. Material defects	1.1.7.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.8. Intentional damage	1.1.8.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.9. Other - Seismic and blasting	1.1.9.1 No additional credible threats identified due to development	DBP, APA	T1, CIC	No	No								
	1.1.10. Inundation area	1.1.10.1 Flotation of pipeline	APA	T1, CIC	No	No			Subject to APA investigation Screw anchors					Ground water table is close to surface in this area and will be rectified as part of development to comply with building code
Birch Falls	1.2.1. New road crossing over pipelines	1.2.1.1 Vehicle loading over pipeline leading to increased pipe stress	DBP, APA	T1, CIC	Yes	No			> 1200 mm DOC required at road crossing Load calculations API RP 1102	No		2. Submit northern crossing design for approval by APA	No	
		1.2.1.2 Road maintenance by the City of Swan to a maximum depth of ~ 300 mm for resealing	APA	T1, CIC	Yes	Yes	Burial, minimum DOC > 1200 mm (as per approved road crossing design) Slab will be installed as part of approved road crossing design	Dial before you dig (DBYD) Third party liaison Signage Patrolling, aerial		No		2. Submit northern crossing design for approval by APA	No	EIP controls assume crossing design as per API RP 1102
		1.2.1.3 Road maintenance by the shire to a maximum depth of ~ 300 mm for resealing	DBP	T1, CIC	Yes	Yes	Burial, minimum DOC > 1200 mm Wall thickness	DBYD Third party liaison Signage Patrolling, aerial		No			No	This crossing is outside of the development. It is assumed that it will have typical controls required by DBP.
		1.2.1.4 Installation of future underground services (i.e. casing)	DBP, APA	T1, CIC	Yes	Yes	Burial, minimum DOC >1000 mm	DBYD		Yes	Yes	3. Obtain standard third party services crossing drawing	Yes	

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
		trenchless techniques)					Additional protection (e.g. slab), will be provided as agreed with APA	Third party liaison Signage Patrolling, aerial				from APA and design crossing as per standard API RP 1102		
	1.2.1.5. Use of vibrating equipment for compaction of road leading to damaged coating and potential long term corrosion failure		DBP, APA	T1, CIC	Yes	No			ILI DCVG surveys Third party liaison Patrolling, aerial	No			No	No additional requirements on developer for post-construction phase
	1.2.2. Residential development adjacent to pipeline easement	1.2.2.1. Vehicle access onto pipeline easement opposite residential housing resulting in decreased DOC over time	APA	T1, CIC	Yes	No		Third party liaison Signage Patrolling, aerial	Bollards to prevent vehicle access onto easement Battered bank in some areas	No		4. Install bollards in road reserve as per City of Swan regulations to restrict access to pipeline easement 5. Obtain details of access points for pipeline easement from APA	No	
	1.2.3. Maintenance of third party utilities installed in road reserve	1.2.3.1. HDD to reconnect services between two developments may impact pipelines	DBP, APA	T1, CIC	Yes	Yes	None	DBYD Third party awareness Signage Patrolling, aerial		Yes			Yes	
	1.2.4. Installation and repair of street lights	1.2.4.1. Street lights installed in road reserve - not a credible threat to pipeline	APA	T1, CIC										
	1.2.5. Vegetation in pipeline easement	1.2.5.1. Coating damage from roots	APA	T1, CIC	Yes	No			Mulch and plant ground cover with root penetration not exceeding 100 mm across entire span of easement	No		6. Provide details of landscaping plan for pipeline easement to APA for approval	No	
	1.2.6. Installation of signage in pipeline easement	1.2.6.1. Coating damage of pipeline by signs supports if installed deep enough (typical 600 mm posts)	APA	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm	Patrolling, aerial Signage Third party awareness		No		7. Ensure no advertising signs are installed in pipeline easement	No	
	1.2.7. Failure of high pressure sewerage line	1.2.7.1. HP sewerage line crosses Parmelia pipeline on southern part of development, release from HP sewerage line may result in the wash out of soil from underneath pipeline leading to unacceptable stresses	APA	T1, CIC	Yes	No			No controls	No		8. Provide information on pump station shut down philosophy in event of leak or breakage	No	Gravity type sewerage line will not have this issue
Existing fences(s) south of development	1.3.1. Fence	1.3.1.1. Fence post hole digging	APA	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm Wall thickness, sufficient to protect from post hole digger	Landowner liaison Marker tape Signage (might not be as per T1 location class)		No		9. Check if signage in pipeline corridor, at road crossings and at any fences is as per new location class and if not, increase signage	No	Sensitive class signage spacing will be implemented as part of Cedar Woods development on northern side of development
		1.3.1.2. Fence post hole digging	DBP	T1, CIC	Yes	Yes	Burial, minimum DOC – 1000 mm Wall thickness, sufficient to protect from post hole digger	Landowner liaison Marker tape Signage as per T1 location class		No			No	
Existing	1.4.1. Minor watercourse	1.4.1.1. Cleaning silt using backhoe or excavator to depth 300 mm silt. Overall depth of drain is unaffected. Not a credible threat to pipeline as watercourse does not cross pipelines in the development	DBP, APA	T1, CIC	No									
	1.4.2. Overhead power line	1.4.2.1. Maintenance, replacement of power pole	DBP, APA	T1, CIC	No									There is no overhead power line on the development. There is a power line along Woolcott Avenue. No power poles on

Phase: Post-Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
														assessment

Phase: Construction

Location	Threat	Threat Identification	Pipeline Operator(s)	Sec Loc Class	Threat Credible (Y/N)	EIP (Y/N)	Physical Controls for EIP	Procedural Controls for EIP	Controls for non-EIP	Failure Possible (Y/N)	Further Threat Controls (Y/N)	Action	Risk Assessment Required	General Comments
	1.1.1. Road construction	1.1.1.1. Vehicle load on pipeline.	DBP, APA	T1, CIC	No	No			Calculations performed to determine allowable vehicles	No		10. Obtain vehicle load analysis form from APA and utilise construction vehicles as determined by the calculation.	No	
		1.1.1.2. Excavation works may impact pipeline	DBP	T1, CIC	Yes	Yes	Slab will be installed as part of approved road crossing design	DBYD DBP permit to work APA supervisor No digging within 1 m of pipeline - APA requirement				11. Developer to provide method statement for road crossing construction for APA approval. 12. Liaise with Cedar Woods in regards to pipeline slabbing over road crossing, to ensure it complies with requirements of action 4.	Yes	Cedar Woods is slabbing pipeline with protective slab in the area of road crossing
		1.1.1.3. Use of vibratory equipment leading to coating damage and weld joint stresses	APA	T1, CIC	Yes	No			Vibratory equipment cannot be used within 10 m of Parmelia pipeline APA permit to work.	No			No	
	1.1.2. Construction works	1.1.2.1. Storage of materials over pipeline leading to erosion of cover over pipeline and/or unacceptable stresses	APA	T1, CIC	Yes	No			Fence will be installed at commencement of construction in road reserve preventing access to pipeline	No			No	Operator will need to have access gate installed (and be provided with keys)
	1.1.3. Installation of fence	1.1.3.1. Sections of fence may be installed over pipeline. May impact pipeline by auger	APA	T1, CIC			DOC approximately 1 m	APA supervision		Yes		13. Ensure no excavation over pipeline for fence installation (water barrier or above ground fence in this section).	No	Post workshop note: Threat was not progressed to risk assessment because the proposed mitigation measure will eliminate the threat.
	1.1.4. Installation of sewerage line at southern end of development	1.1.4.1. Impact to pipeline from installation of sewerage line	DBP, APA	T1, CIC	Yes	Yes	Separation between Parmelia pipeline, sewerage line and DBNGP will be maintained during installation of sewerage line	APA supervision DBP supervision		Yes			Yes	
	1.1.5. Installation of buried services at northern crossing	1.1.5.1. Excavation works crossing pipeline	APA	T1, CIC	Yes	Yes	Slab will be installed as part of approved road crossing design	DBYD APA permit to work		No			No	

Appendix 5 Actions List

Action ID	Action	Responsibility	Place(s) Used
1	Developer to provide Earth Potential Rise (EPR) and Low Frequency Induction (LFI) studies for APA approval.	Birch Falls / ABN	Threats: 1.1.1.3.1
2	Submit northern crossing design for approval by APA.	Birch Falls / ABN	Threats: 1.1.2.1.1, 1.1.2.1.2
3	Obtain standard third party services crossing drawing from APA and design crossing as per standard API RP 1102.	Birch Falls / ABN	Threats: 1.1.2.1.4
4	Install bollards in road reserve as per City of Swan regulations to restrict access to pipeline easement.	Birch Falls / ABN	Threats: 1.1.2.2.1
5	Obtain details of access points for pipeline easement from APA.	Birch Falls / ABN	Threats: 1.1.2.2.1
6	Provide details of landscaping plan for pipeline easement to APA for approval.	Birch Falls / ABN	Threats: 1.1.2.5.1
7	Ensure no advertising signs are installed in pipeline easement.	Birch Falls / ABN	Threats: 1.1.2.6.1
8	Provide information on pump station shut down philosophy in event of leak or breakage.	Birch Falls / ABN	Threats: 1.1.2.7.1
9	Check if signage in pipeline corridor, at road crossings and at any fences is as per new location class and if not, increase signage.	APA	Threats: 1.1.3.1.1
10	Obtain vehicle load analysis form from APA and utilise construction vehicles as determined by the calculation.	Birch Falls / ABN	Threats: 2.1.1.1.1
11	Developer to provide method statement for road crossing construction for APA approval.	Birch Falls / ABN	Threats: 2.1.1.1.2
12	Liaise with Cedar Woods in regards to pipeline slabbing over road crossing, to ensure it complies with requirements of action 4.	Birch Falls / ABN	Threats: 2.1.1.1.2
13	Ensure no excavation over pipeline for fence installation (water barrier or above ground fence in this section).	Birch Falls / ABN	Threats: 2.1.1.3.1

Appendix Six — *Water Corporation Information Sheet 24 – Non-Standard North-East Corridor Contributions*

Non-standard infrastructure contribution - North East Corridor

Development Services – information sheet 24

Background

The Water Corporation established the North-East Corridor (NEC) as a Non-Standard Infrastructure Contribution Area (NSICA) where a surcharge on the standard infrastructure contributions applied to all new lots created in the corridor.

The surcharge reflects the higher cost of the ongoing operation and maintenance of the Corporations water and wastewater infrastructure due to its remoteness from existing infrastructure.

From 1 July 2013 standard infrastructure contributions for drainage applied.

Conditions for subdivision developments in the NEC

Subdivision
Contribution rates apply to all lots created in the corridor.

Payment Period	Water	Wastewater	Drainage*
1 July 2014 to 30 June 2015 -	$5,977	$3,578	$480

* Drainage infrastructure contributions only apply to lots within the declared drainage area i.e. Ellenbrook and Aveley refer to the map of the Non-standard infrastructure contribution area below

For lots equal to or greater than one hectare the water supply contribution is based on the full scheme costs and may be greater than the the Non-standard infrastructure contribution

Note: NSICA contributions are to cease following the creation of 19,000 lots.

Appendix A Map of the North East Corrridor Area displaying the declared drainage atea
Appendix B Map of North East Corridor

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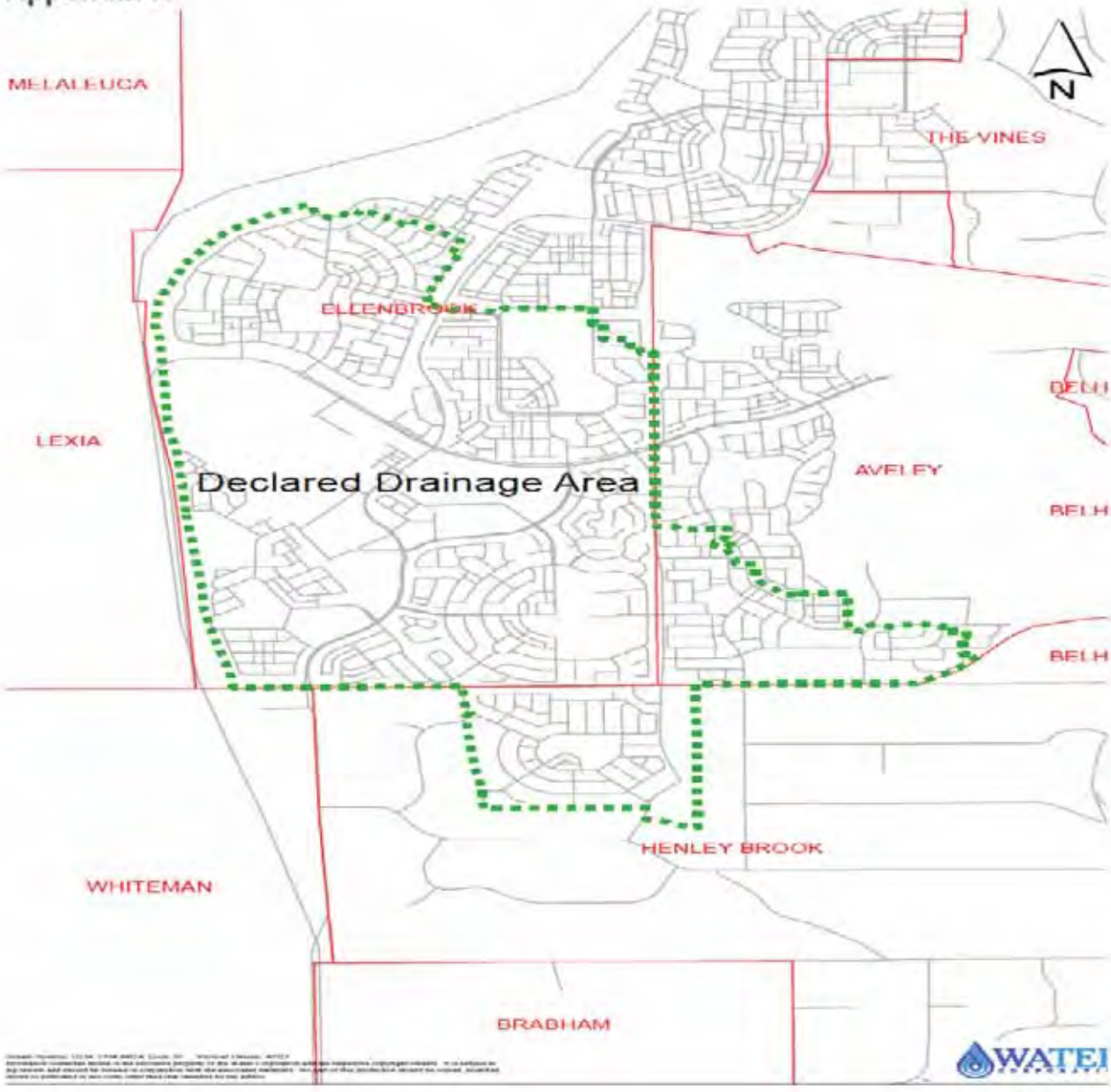
Appendix A



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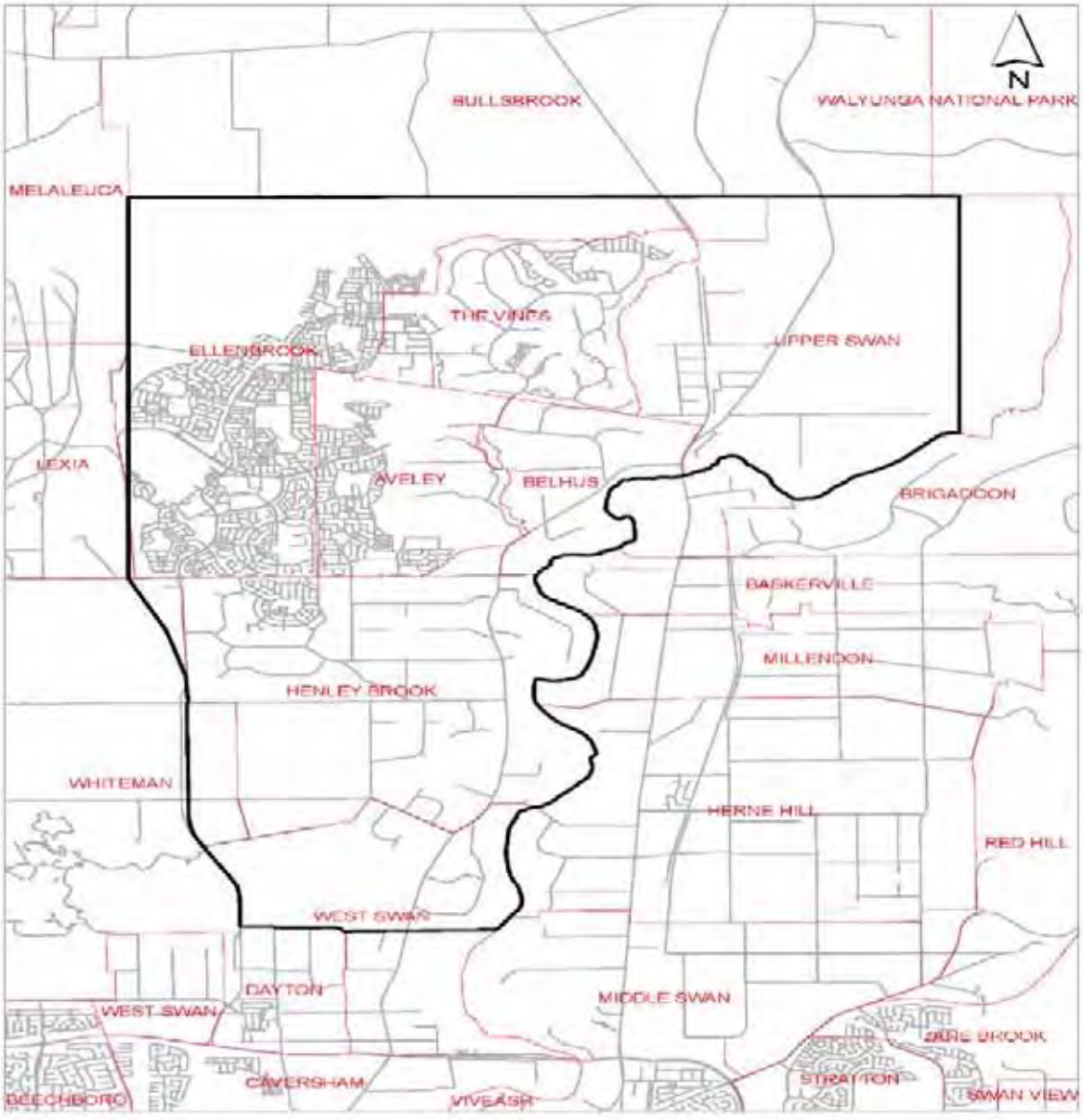
Appendix B



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pritchard francis

providing the right solution

APPENDIX 6

Landscape Strategy - LD Total

LD TOTAL
LEADERS IN LANDSCAPING
64 MILL POINT ROAD,
SOUTH PERTH, WA, 6151
T +61 8 6436 1111
F +61 8 9367 2034
ALCOCK BROWN-NEAVES GROUP

Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

03 SEPTEMBER 2015- REV B : N.T.S

LANDSCAPE PLAN N.T.S

LD TOTAL
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ALCOCK BROWN-HEAVES GROUP

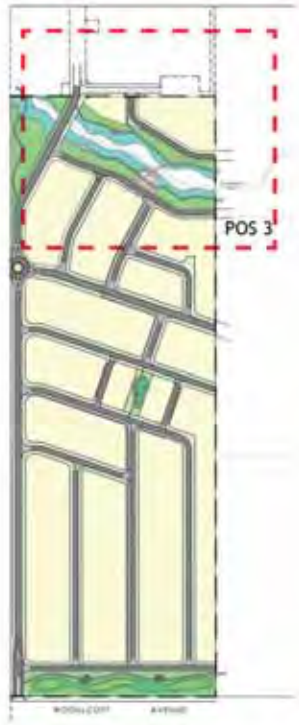
Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

28TH AUGUST 2015- REV B - N.T.S

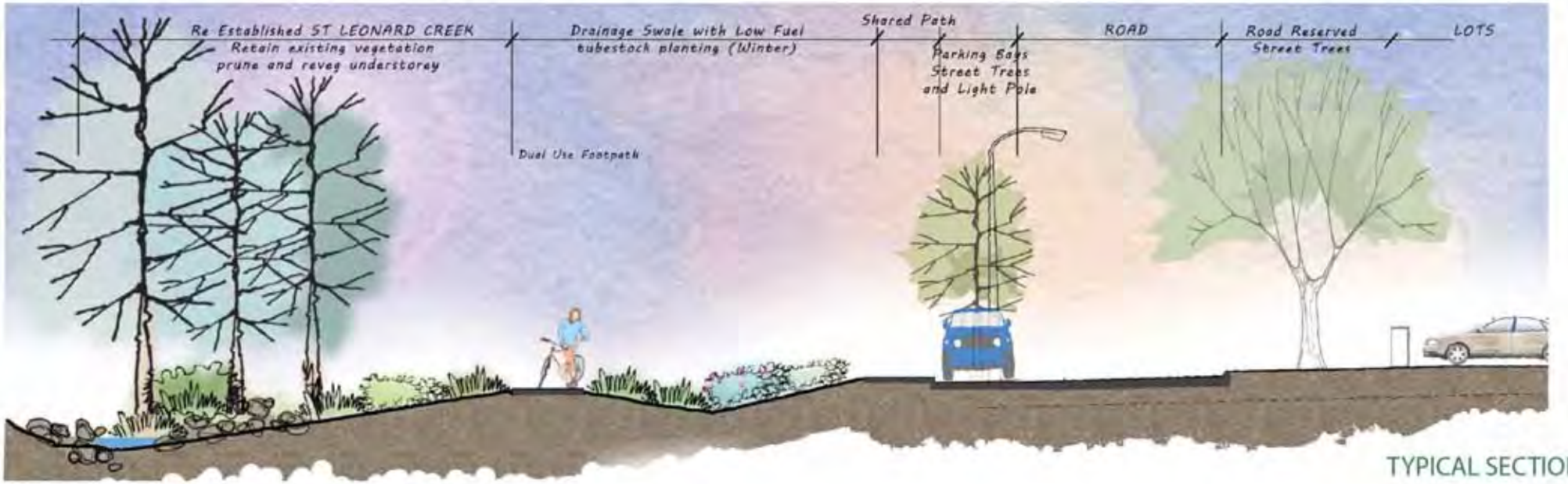
POS 3 PLAN N.T.S

LEGEND

1. Existing St.Leonard Creek
2. Buffer and protection revegetation Winter planting (low fuel zone)
3. Verge turf ng (street)
4. Retained existing vegetation
5. Tubestock planting on swale
6. Crossover bridge in Recycle Plastic
7. Proposed Concrete Footpath
8. Children's Play area and Picnic
9. Feature Node with seating
10. Exercise station with equipment
11. Proposed Street tree planting
12. Parmelia Gas Pipeline Easement with tubestock planting (Winter)
13. Entry Signage
14. Street Parking bays



KEY PLAN



TYPICAL SECTION - A - A

LD TOTAL
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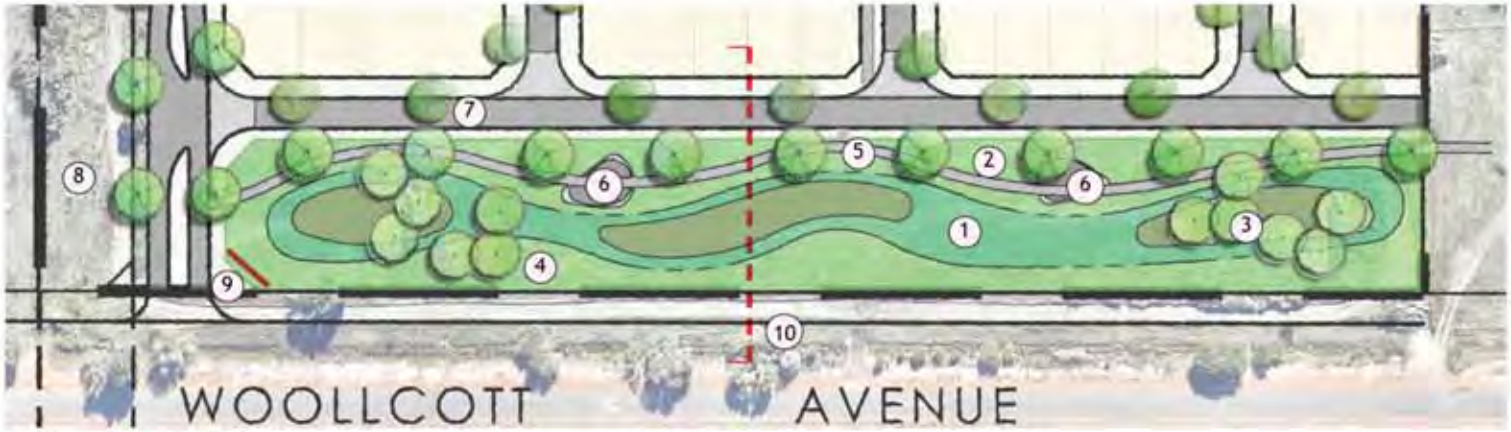
Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

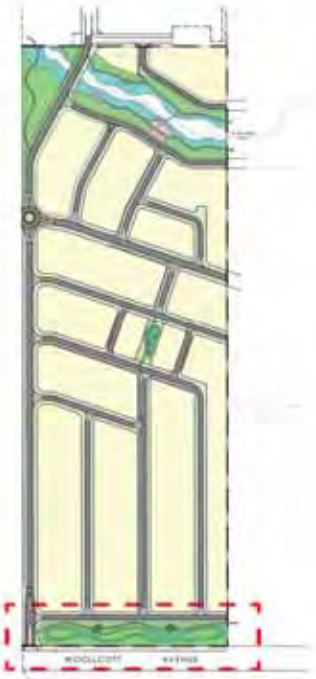
28TH AUGUST 2015- REV B - N.T.S



POS 1 PLAN N.T.S

LEGEND

1. Drainage Basin revegetation Winter planting only (low fuel zone)
2. 10.0M wide swale landscape area
3. Cluster of small tree planting on drainage basin
4. Tubestock planting on bund
5. Proposed Concrete Footpath
6. Exercise station with equipment
7. Proposed Street tree planting
8. Parmelia Gas Pipeline Easement with tubestock planting (Winter)
9. Entry Signage
10. Woollcott Avenue 12.0M wide drainage reserve



KEY PLAN

TYPICAL SECTION - C - C

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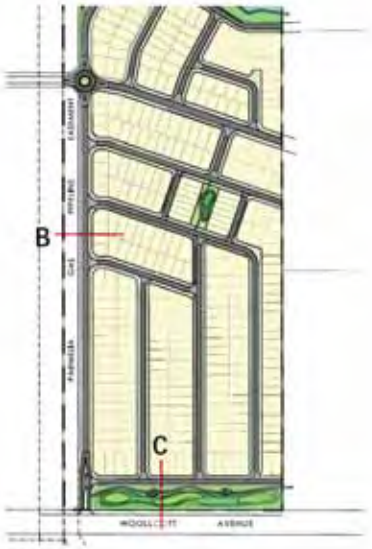
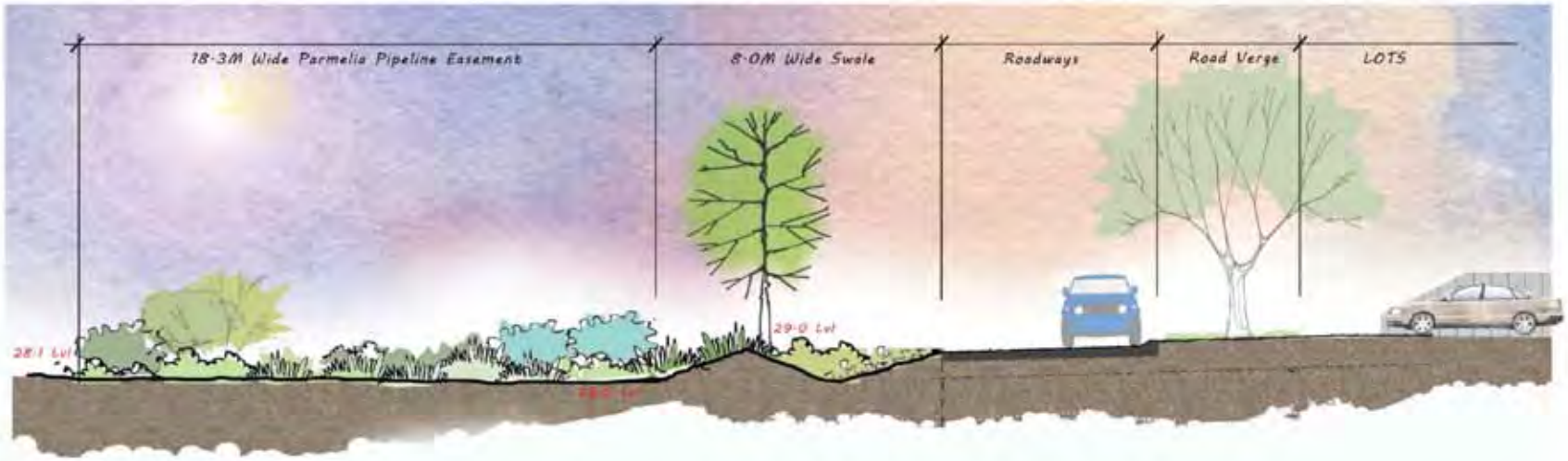
ALCOCK BROWN-HEAVES GROUP

Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

28TH AUGUST 2015- REV B - N.T.S



KEY PLAN



TYPICAL SECTION - B -B

LD TOTAL
LEADERS IN LANDSCAPING
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ALCOCK BROWN-NEAVES GROUP

Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

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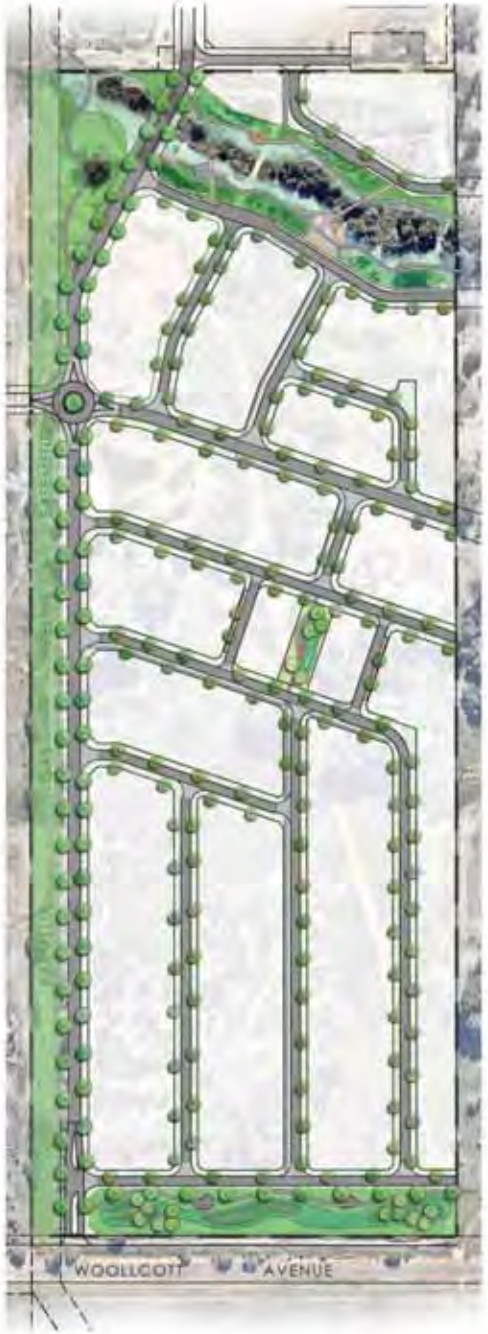

Tubestock Planting (Winter)

NOTE: No grass will be proposed in the landscape as this will be a more 'dry' landscape

Reed Planting along St Leonards Creek

Draft Materials for use

Boulders

Crushed Pea Gravel

Blue Metal

Concrete Footpath

Recycled plastic timber

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Lot 345 Woollcott Avenue, Brabham - Preliminary Landscape

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APPENDIX 7

Transport and Movement Network Assessment - KCTT

TRANSPORT IMPACT ASSESSMENT

Lot 345 Woollcott Avenue, Brabham

April 2016,

Rev C

kctt

HISTORY AND STATUS OF THE DOCUMENT

Revision	Date Issued	Reviewed by	Approved by	Date approved	Revision type
Rev A	29.06.2015	J Heydari	C Kleyweg	29.06.2015	Issued for preliminary comments
Rev B	31.07.2015	M Kleyweg	C Kleyweg	31.07.2015	Issued for Review
Rev C	04.04.2016	M Kleyweg	C Kleyweg	04.04.2016	Revised in accordance with the comments received from the client

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Revision	Date of issue	Quantity	Issued to
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Rev B	31.07.2015	1 (PDF)	Mr Jeremy Cordina (ABN Group)
Rev C	04.04.2016	1 (PDF)	Mr Jeremy Cordina (ABN Group)

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Author	Colin Kleyweg / Marina Kleyweg / Marina Lipovac Tanaskovic / Katarina Pribakovic
Project Manager	Colin Kleyweg
Name of the Project	Lot 345 Woollcott Avenue Brabham
Name of the Document	Lot 345 Woollcott Avenue Brabham - Transport Impact Assessment
Document Version	KC00337.000_R01 Rev C

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Appendix 1 - The layout of the proposed development

Appendix 2 - Transport Planning and Traffic Plans

Appendix 3 - Paramics Modelling

1. Introduction

1.1 Transport Impact Assessment Layout

KCTT have been requested to provide a Transport Impact Assessment for the development of Lot 345 Woollcott Avenue, Brabham. The purpose of this document is to provide detailed commentary and analysis on the potential traffic and transport impact that the proposed development of this Structure Plan Area may have on the surrounding roads and transportation networks. The scope of this report is to provide a detailed assessment of the following: -

- Describe and justify the road network and hierarchy for all roads classified as neighbourhood connectors and arterials (district structure plans).
- Describe any existing roads and/or intersections required to be upgraded as a result of the future subdivision/development and who is responsible for the works.
- Assess road network capacity for peak demand.
- Discuss level of permeability and accessibility provided by the road network.
- Provide estimates of traffic volumes on proposed neighbourhood connectors and above.
- Provide indicative road cross-sections for each road type showing carriageway, median and verge widths and accommodation of service infrastructure and street trees.
- Briefly describe and justify the proposed public transport network – regional, district and local, including any proposed railway stations, park and ride facilities and requirements, and how access will be achieved.
- Identify intersection controls and any traffic management issues and discuss the resolution of these issues.
- Describe the proposed major pedestrian and cyclist network and links with the strategic cycle network.
- Identify any designated freight routes.
- Include a movement networks plan showing estimated traffic volumes, areas requiring traffic management solutions, public transport networks and pedestrian and cyclist networks.
- Compliance with the WAPC's *Transport Assessment Guidelines for Structure Plans (Volume 2).*

This Transport Impact Assessment is presented in the following logical sequence: -

- Section 1 – Introduction

This section provides a brief description on the role of this report in the Structure Planning process, the general layout of the report and a list of the guideline and reference documents used in its composition.

- Section 2 – Transport Impact Assessment

This section provides research and analysis of the key items required for submission of a Transport Impact Assessment for Structure Plans in accordance with the Transport Assessment Guidelines nominated above. In this section, KCTT have examined the following subject areas: -

- Section 2.1 – Structure Plan Outline

This section provides a brief description of the Structure Plan Area and its proposed land uses.

- Section 2.2 – Existing Situation and External Traffic Networks

This section provides a description of the existing land uses within the Structure Plan Area and collates all available traffic data from both within, and external to the Structure Plan Area. The transportation networks are examined for a minimum 800 metre radius from the edge of the Structure Plan Area.

- Section 2.3 – Traffic Modelling for the Proposed Structure Plan Area

This section describes KCTT's 3-step model which is used to determine the future traffic generation / attraction to and from the proposed Structure Plan Area.

- Section 2.4 – Vehicle Access and Parking Requirements

This section will generically describe vehicle access and parking requirements for individual land uses within the Structure Plan Area. Each development proposal will be required to address on-site vehicular access and parking requirements in detail. This section will discuss a broad framework for the consideration of these issues.

- Section 2.5 – Provision for Service Vehicles

This section will provide generic descriptions for service vehicle requirements throughout the Structure Plan Area. Each of the proposed land uses will be reviewed to examine requirements for service vehicles, pending confirmation of the land uses proposed.

- Section 2.6 – Hours of Operation

This section will describe the general operating times for the land uses as they are proposed in the Structure Plan Area. This information will assist in determining the likely timing of the AM and PM peaks, and therefore the peak impact on the existing and surrounding transportation network. The peak vehicle generation is the key for determining intersection capacities within a road network.

- Section 2.7 – Public Transport Access

This section provides a summary of the existing public transportation services available within an 800 metre radius of the Structure Plan Area's boundaries and provides commentary on whether any services are likely to be extended into the Structure Plan Area.

- Section 2.8 – Pedestrian and Cyclist Access

This section provides a summary of the existing pedestrian and cyclist infrastructure available within an 800 metre radius of the Structure Plan Area's boundaries and provides commentary on the infrastructure likely to be extended into the Structure Plan Area.

- Section 3 – Transport Impact Assessment Checklist

This section provides a concise, tabulated summary and review of the detailed information presented in Section 2 of this report. The intention of this checklist is to document the findings of this report, and / or any of the likely transportation / safety issues which should be considered as part of the submission. This checklist has been developed in accordance with the requirements of the Transport Assessment Guidelines: Structure Plan Submissions.

1.2 Notes Pertaining to This Report

This report has been provided as one of the key preliminary inputs into the overall documentation required for the Structure Planning approvals. Whilst the final site yields and land-uses are subject to change prior to the finalisation of the Structure Plan, the traffic and transportation requirements discussed in this report are based on the land uses and yields proposed through the Structure Planning process, in accordance with the Structure Plan Area.

1.3 Available Information and Technical Literature

This section provides a brief description of the inputs used in the compilation of this report:

- WAPC Transport Impact Assessment Guidelines – Volume 2 Structure Plans
- WAPC Transport Impact Assessment Guidelines – Volume 5 (referenced for PM peak hour and traffic splits)
- RTA NSW Guide to Traffic Generating Developments Version 2.2 October 2002 (referenced to determine trip generation / attraction rates for various land uses)
- Guide to Traffic Management – Part 3: Traffic Studies and Analysis, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model)
- Guide to Traffic Management – Part 11: Parking, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model)
- Guide to Traffic Management – Part 12: Traffic Impacts of Developments, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model)
- Guide to Road Design Part 3: Geometric Design, Austroads, 2010
- City of Swan Method of travel to work, 2011
- Lots 346 & 347 Woollcott Avenue, Brabham Local Structure Plan, Transcore, 2013
- Whiteman Edge LSP1C, Transport Assessment and Staging Report, Arup, 2014
- Park Street LSP3A Transport Assessment, Cardno, 2010
- Albion District Structure Plan Transport and Access, SKM, 2009
- Albion 1a Local Structure Plan: Traffic & Movement Network, Bruce Aulabaugh Traffic Engineering & Transport Planning, 2011
- City of Swan, Transport Strategy, Cardno, 2014

1.4 Executive Summary

1. The Structure Plan for Lot 345 Woollcott Avenue, Brabham proposes a homogeneous residential area. It is comprised of 323 individual lots (residential land use) and 1 grouped housing lot. The total area of the subject landholding is 11.35 ha. The estimated year of completion for the proposed development is 2018.
2. In recent years the surrounding area has undergone a major transformation from generally rural to urban.
3. At the time of writing this report, the Ellenbrook Light Rail corridor project has been postponed indefinitely. The PTA confirmed (again at the time of writing this report) that it is reasonable to expect an upgrade in the existing bus service through the area given the growth of the population and the increased demand, however no definite timeframes are known. Youle-Dean Road, Partridge Street and Henley Brook Avenue could be potential corridors for the introduction of new bus lines.
4. For the purposes of this report, we have anticipated that a bus route might be running along the proposed Road 06. Therefore all elements of this road reservation have been designed to accommodate the movement of buses.
5. The former Perth to Darwin National Highway (PDNH) was planned to be constructed along the eastern edge of the Whiteman Park. At present this project has been renamed as Northlink WA and has been relocated west from the Whiteman Park to an alignment from the intersection of the Tonkin Highway and Reid Highway. The previously acquired road reservation for the former PDNH remains and there are some indications that Lord Street south of Woollcott Avenue may be realigned into the current PDNH road reservation. Subsequently, the existing Lord Street reservation will be downgraded south of Woollcott Avenue and will act as a Neighbourhood Connector between Dayton and Brabham.
6. Woollcott Avenue has been modelled without future intersection to Lord Street.
7. It is expected that Lord Street will be upgraded to a dual carriageway by 2025 due to the general growth of traffic. The intersection of Lord Street and Youle-Dean Road will be signalised. Youle-Dean Road will be upgraded to a four lane carriageway between the intersections with Lord Street and Partridge Street and it will remain a two-lane road east of the intersection with Partridge Street.
8. Henley Brook Avenue will be extended providing an additional north-south connection from the subject landholding. This has been allowed in our modelling.
9. Woollcott Avenue will be upgraded to an urban road without connection to Lord Street.
10. *Section 2.3 – Traffic Modelling for the Proposed Structure Plan Area* provides a detailed description of how traffic volumes are calculated for the development options presented by CLE Town Planning + Design for the Structure Plan Area. Our traffic model uses a 3-step approach for the estimation of transportation demand into and out of the Structure Plan Area: -
    - Step 1 – Confirm the size and quantum of the proposed land uses.
    - Step 2 – Confirm how these land uses impact travel patterns and the generation / attraction of transportation trips.
    - Step 3 – Confirm where the likely origins of travel external to the Structure Plan Area are located and confirm the likely destinations for travel from the subject landholdings and determine the impact of those transportation volumes on the local road network.
11. The Structure Plan Area will generate approximately 2,198 vehicles per day and 263 vehicles per hour, requiring a Transport Impact Assessment in accordance with WAPC Transport Impact Assessment Guidelines.
12. The review of the available reporting for DSP and adjoining LSP areas suggest that two Primary Schools are planned immediately North-East and North-West from the subject Structure Plan Area. A Secondary

School is planned south from the subject Structure Plan Area while a Neighbourhood Centre will be located south-west from the subject Structure Plan Area. This type of land-use will act as significant trip attractors within 800 meters of the Structure Plan Area.

13. Traffic distribution and level of service has been analysed through Paramics software. Two major scenarios were assessed
    - Traffic generated by the development only; and
    - Traffic generated by the development and regionally.
14. According to Liveable Neighbourhoods classifications the majority of the internal network can be classified as an Access Street D with road reserve of 14.2 metres. However, the City of Swan have a minimum requirement for the road reservation of 15 metres. This can be reduced where the road reserve is directly adjacent to a POS.
15. The City of Swan require 4.5 metre verges on each side of the road reservation. This particular requirement increases the required road reservation width for Access Street C to 16.2 metres.
16. Major drainage infrastructure will be running along the western side of the road reservation of Road 6. The exact locations of parking areas will be determined at a later stage when the drainage infrastructure is completely defined. The cross sections of the road reservation for Road 6 are therefore indicative in nature.
17. The main access / egress point to Woollcott Avenue is envisaged as a full movement intersection with Give Way yield via Road 06.
18. Intersection controls within the Structure Plan Area shall include a roundabout at the intersection of Road 06 and Road 07. The full plan of the proposed intersection controls has been provided in Appendix 2.
19. Liveable Neighbourhoods suggest 6.0 metres kerb radii for access street intersections while the City of Swan allows up to 12.0 metres, pending intersection design requirements. This LSP proposes usage of the smaller applicable kerb radii at laneway approaches to access streets (6.0 metres) since it discourages excessive vehicular speed through intersections by constraining movement. We believe that this radius provides sufficient manoeuvring space for standard service vehicles from laneways into Access Streets.
20. Pedestrian paths will be provided on all road reservations except for laneways within the Structure Plan Area. The size of the road pavement and low traffic volumes on internal roads create a good on-road cycling environment. The plan of the proposed pedestrian, cycling and shared paths has been provided in Appendix 2.
21. The Structure Plan area has strong connectivity to major road networks including West Swan Road, the future Henley Brook Avenue and Lord Street.
22. The surrounding road network with all committed upgrades has more than sufficient capacity to cater for the proposed development. No adverse impacts are expected from the proposed development once completed.

2. Transport Impact Assessment

2.1 Structure Plan Outline

The Structure Plan Area is located within the Albion District Structure Plan area, under the jurisdiction of the City of Swan. It is located approximately 20km north east of the Perth CBD.

In recent years this area has undergone a major transformation being part of the strategic Swan Urban Growth Corridor. The original Albion DSP area was planned to accommodate for up to 15,000 people in approximately 5,500 dwelling units. Approximately 27,000m² was proposed for Town Centre uses and 1,800m² for additional Local Centre uses. In addition to this the DSP area will contain two primary schools and one high school. The proposed road network heavily relies on the existing roads. Park Street and Youle-Dean Road would provide the main east-west connection while Partridge Street and Henley Brook Avenue would provide the main north-south connectivity internally to the DSP area, with Lord Street forming an important north-south connector on the western boundary of the DSP area.

Review of the TIA reporting for the surrounding Structure Plan Areas (which were made available by the City of Swan) shows that the initial planning heavily relied on transport planning which was current at the time of those reports, namely rapid transit bus routes or light rail line terminating in Ellenbrook, using the Lord Street and former Perth to Darwin National Highway (PDNH) alignments. At the time of writing this report this information has changed as follows: -

- The PDNH is now realigned as part of the Northlink project to the intersection of Tonkin Highway and Reid Highway, with an alignment to the west of Ellenbrook, and then northward to the Great Northern Highway.
- Lord Street is currently planned for a potential upgrade using the former PDNH alignment south of Woollcott Avenue to the intersection of Reid Highway. For the purposes of preliminary design, this has been called "New Lord Street".
- The existing Lord Street alignment south of Woollcott Avenue will therefore be downgraded to a Neighbourhood Connector with some on-street parking in Dayton. KCTT are currently completing detailed design for this section of road between a location south of Youle-Dean Road and Dayton Boulevarde on behalf of the City of Swan.
- There is some consideration by the Department of Transport regarding improved public transport services between Ellenbrook and Dayton along Lord Street and the "New Lord Street" alignment utilising the former PDNH reservation. This is yet to be confirmed.

2.1.1 TIA reporting for the surrounding Structure Plan Areas

Albion District Structure Plan (DSP) area

Sub Regional Structure Plan for the Swan Urban Growth Corridor, prepared for the Department for Planning and Infrastructure by Hassell Ltd, May 2008 (the following text is quoted from the Sub Regional Structure Plan for the Swan Urban Growth Corridor)

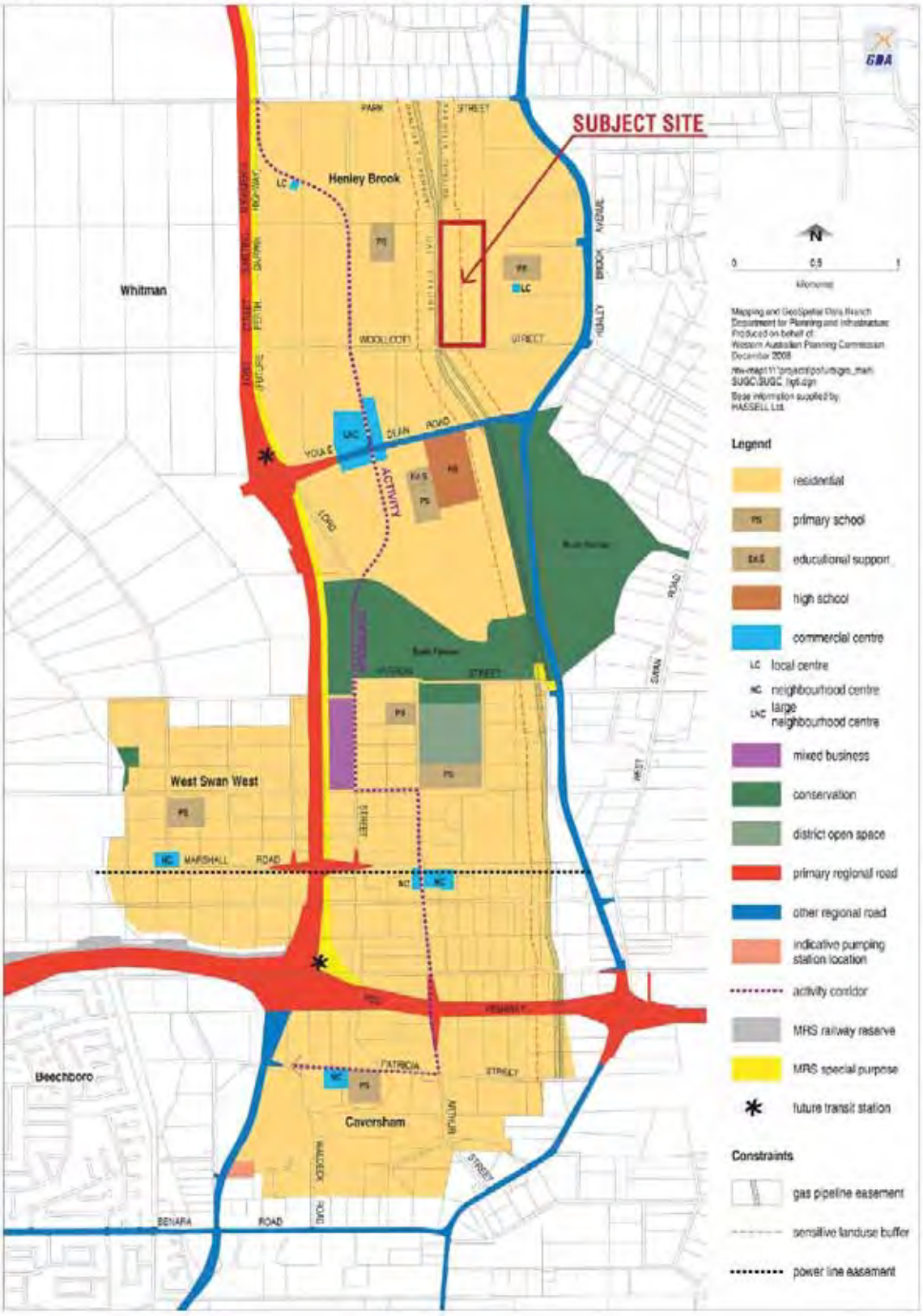
Policy Principle 9.14

Albion is to be provided with a large neighbourhood centre, representative of its status within the region. This will be catered with a larger retail floor area (incorporating 10,000 sqm of retail and 13,000 sqm of non-retail uses) as well as a regional community centre. Similarly, the other neighbourhood centres will contain local community centres. The Albion cell, being larger than the Caversham and West Swan areas, will also include two smaller local centres.

According to the Sub Regional Structure Plan for the Swan Urban Growth Corridor, three public primary schools, one public High School and one education support school, co-located with the high school and primary school will be built within Albion, as shown on the Figure below.

Swan Urban Growth Corridor Sub-Regional Structure Plan, WAPC, February 2009

Figure 1 - Swan Urban Growth Corridor Sub-Regional Structure Plan



Albion LSP1A

The Albion 1A Local Structure Plan: Traffic & Movement Network Final Report, prepared for the City of Swan by Bruce Aulabaugh (January 2010, revised February 2011) (the following text is quoted from the LSP1A TIA): -

The development site is bounded on the south by Woollcott Ave, on the north by Park Street, on the west by Lord Street and on the east by Partridge Street. Refer to Figure 1 locality plan (overleaf) which shows the LSP application boundary in the context of the Albion District Structure Plan.

Currently, Lord Street and West Swan Road provide the north-south travel routes in the study area. In future, the Perth-Darwin Highway (PDH) will replace Lord Street. Also, Henley Brook Ave (4-lane divided Integrator Arterial Type B) and Partridge Street (2- lane divided Integrator Arterial Type B) will add important north-south capacity.

Park Street and Woollcott Ave will serve important east-west local distributor roles. Youle Dean Road will be constructed as an Integrator Arterial Type B, connecting PDH to Henley Brook Ave and West Swan Road. It will have a grade separated interchange at PDH, thus giving a high level of access to the regional road system.

Prior to the construction of Perth-Darwin Highway, Lord Street will provide access for Albion LSP 1A via:

- *Existing Park Street*
- *New 'Road A' Roundabout*
- *New Woollcott t-junction*

After Perth-Darwin is constructed and the above intersections are closed, then Albion LSP 1A vehicle access will be via Partridge Street (Integrator Arterial Type B) with connections to Gnangara Road in the north and Youle Dean Road in the south. Park Street and Woollcott Ave will provide convenient access to the proposed Henley Brook Ave (Integrator Arterial A) and to West Swan Road.

The Lord Street intersection at Road 'A' will be a single lane roundabout as agreed with the City of Swan. One of the benefits of roundabout control (over sign controlled T-Junction design) is a higher capacity to handle side road traffic. Refer to Section 3.4 and Appendix B for further details on the agreement with the City.

At some later stage in the overall development of the Albion District, Woollcott Ave will also connect to Lord Street. At this time it is expected that the Woollcott intersection will be a sign controlled full access T-junction.

A public primary school is located just across Partridge Street from LSP 1A. This report provides a set of traffic management principles for consideration at subdivision stage and construction stage.

Public transport planning information from the Albion DSP Transport & Access Report (SKM 2009) indicates that it would be unlikely that any form of rail would be constructed to Ellenbrook before the year 2030.

Special Note on Woollcott Ave: Woollcott is identified in the District Structure Plan as a Neighbourhood Connector; however the existing reserve is wide enough to allow for a design resembling an Integrator Arterial Type A. Advice provided by Emerson Stewart Engineers is that Woollcott will be designed with 5m carriageways and a 6m central median (consistent with the cross-section provided for an Integrator Arterial Type B).

LSP1B

Lots 346 & 347 Woollcott Avenue, Brabham Local Structure Plan Transport Assessment, prepared for Cedar Woods Properties Limited by Transcore (July 2013) (the following text is quoted from the LSP1B TIA): -

This Transport Assessment addresses the proposed Local Structure Plan for Lots 346 & 347 Woollcott Avenue, Brabham, which is located within the Albion District Structure Plan in the City of Swan.

This LSP area is anticipated to accommodate approximately 440 dwellings and a primary school site, as well as public open space areas.

The LSP is anticipated to accommodate approximately 440 dwellings and a primary school site, as well as public open space areas. The wider Albion District Structure Plan provides for a total of approximately 5,600 dwelling units including a range of residential densities, a future town centre (including 10,000m² NLA of retail floor space), a high school and three primary school sites.

The anticipated 440 dwellings of this LSP area will therefore generate approximately 3,500vpd and 10% of this number in the AM and PM peak hours.

For the primary school the trip rate used is 1.0 vph per student during the before and after school peak periods (typically 8-9am and 3-4pm) and 2vpd per student overall. For this assessment the Education Department's standard 430 student primary school design has been assumed, so this primary school is assumed to attract traffic flows of 860vpd.

Woollcott Avenue east of Partridge Street is planned as a Neighbourhood Connector road in the Albion District Structure Plan. As will be seen later in this report the section adjacent to Lots 346 & 347 is anticipated to carry less than 3,000 vehicles per day (vpd) so a Neighbourhood Connector B cross section is appropriate. The existing 20m road reserve is sufficient to accommodate a Neighbourhood Connector B cross-section as illustrated in the "alternative indicative cross section for Woollcott Avenue" from the Albion District Structure Plan Transport and Access report shown in Appendix B.

Roundabouts are proposed at the Partridge St / Woollcott Ave intersection and two other four-way intersections on Partridge Street abutting the LSP area. Intersection analysis confirms that these will satisfactorily accommodate all right turn traffic flows to and from the LSP area.

Whiteman Edge LSP1C

Whiteman Edge LSP1C Local Structure Plan Transport Assessment and Staging Report, prepared for Stockland by Arup (3 June 2014) (the following text is quoted from the LSP1C TIA): -

Stockland commissioned Arup to provide traffic and transport planning services to assist with the development of a Local Structure Plan (LSP) for Lots 15, 16, 17, 19 and 20 in Whiteman Edge.

Residential land use is proposed excepting for within the Neighbourhood Centre zone. While the Neighbourhood Centre will be subject to separate structure planning process, yield assumptions were incorporated into the LSP1C SATURN models (see Section 6). Overall yield assumptions were thus:

Residential

- *1,267 dwellings at R40*
- *259 units at R80*

Non-residential (Neighbourhood Centre)

- *10,000m² Net Leasable Area (NLA) retail*
- *7,000m² NLA commercial*
- *3,000m² NLA food and beverage*

Most recent advice from Main Roads WA is that the PDNH (Perth-Darwin National Highway) will be constructed sometime before 2031 with timing between 2018 and 2021 being most likely.

Woollcott Avenue is currently a single carriageway rural road with unsealed shoulders, which does not connect to Lord Street. The Albion DSP proposes Woollcott Avenue to be a Neighbourhood Connector (A) road connecting Henley Brook Avenue in the east with Lord Street, although it is proposed to intersect with Partridge Street as off-set Ts.

As part of transport planning for LSP1C, the connection to Lord Street is not anticipated. This is because Main Roads WA has advised Arup an intersection between Woollcott Avenue and an upgraded regional road east of Whiteman Park is not desirable.

Based on traffic modelling undertaken previously by others as part of district structure planning, Woollcott Avenue was forecast to attract up to 3,000 vehicles per day at build-out of Albion. Woollcott Avenue was planned to have an undivided, single carriageway profile and a posted speed limit of 50 kilometres per hour.

Partridge Street/ Woollcott Avenue: modelled as a roundabout with one lane approaches and a single lane circulatory. This roundabout is forecast to operate at LoS A in the AM peak and LoS B in the PM peak with no major queues.

Woollcott Avenue is proposed to function as a two-lane Neighbourhood Connector (B) east of Partridge Street, forecast to carry less than 5,000 vpd by 2031. The relevant indicative mid-block cross-section is shown in Figure 16. A posted speed limit of 50 kph is proposed to apply.

On-street cycle lanes are proposed, which is consistent with the transport planning recommendations incorporated into LSP1A. On-street parking is also included in the cross-section.

Woollcott Avenue is not planned to accommodate buses. The 2.5 metre-wide median proposed east of Partridge Street is sufficient for two-stage pedestrian crossings and may be discontinued to provide space for right-turn pockets in a similar manner to the median treatment along Francisco Street in Belmont.

Woollcott Avenue will have a local access function west of Partridge Street as it is not proposed to connect to Lord Street.

East of Partridge Street, Woollcott Avenue is proposed to be a Neighbourhood Connector (B) with one traffic lane in each direction and restricted property access. West of Partridge Street, Woollcott Avenue is expected to function as a local access street given it is not proposed to connect to Lord Street.

Park Street LSP3A

Park Street LSP3A Transport Assessment, prepared for Terranovis Pty Ltd by Cardno Eppell Olsen, September 2010 (the following text is quoted from the LSP3A TIA): -

The proposed development is located on the south side of Park Street, Henley Brook in the City of Swan between Partridge Street and Murray Road. Proposed land uses comprise a mixture of R20, R30 and R40 residential units, totalling approximately 773 lots over 26.5ha. These residential lots are anticipated to generate approximately 600 vehicle trips in the AM peak hour, 750 trips in the PM peak hour and 7,400 trips per average weekday.

The Park Street LSP3A area resides within the Albion DSP. Nearby existing major road links include: -

- *Park Street - classed as a Local Distributor in the Main Road Functional Hierarchy (MRFH);*
- *West Swan Road - classed as a District Distributor A in the MRFH; and*
- *Lord Street - classed as a District Distributor A in the MRFH.*

Further to these, the Albion DSP defines additional road links as part of future development in the region, including: -

- *Henley Brook Avenue - classed as a Primary Distributor in the Albion DSP;*
- *Partridge Street - classed as an Integrator Arterial B south of LSP3A and an Access Street to the west of LSP3A; and*
- *Park Street - classification intended to be reduced to a Neighbourhood Connector following sub-regional road network upgrades.*

LSP3A has been modelled in two scenarios: -

- *Initial Stage - assessment of the proposed development in its existing context, at full build out. This assumes a single access only onto Park Street; and*
- *Ultimate Stage - assessment of the proposed development including connection to developments to the south and west, the extension and upgrade of sub-regional roads including Partridge Street and Henley Brook Avenue, and the full build out of the Albion District Structure Plan (DSP).*

Ultimate access to LSP3A will include the following: -

- *Northern access - Access to Park Street via full-movements priority T-intersection. Included within initial build out scenario.*
- *Eastern access - Access to Henley Brook Avenue via full-movements or left-in/left-out priority T-intersection. Constructed following extension south past Park Street to Reid Highway (sub-regional road network stage B). Included within the ultimate build out scenario.*
- *Southern access - Access through the remainder of LSP3 to Woollcott Avenue via priority T-intersection. Construction following initial build out of LSP3 area to the south. Included within the ultimate build out scenario.*
- *Western access - Access to Partridge Street via full-movements priority T-intersection. Construction following initial build out of LSP1 area to the west. Included within the ultimate build out scenario.*

Park Street LSP3A Transport Assessment Addendum Report, prepared for Terranovis Pty Ltd by Transcore, September 2012 (the following text is quoted from the LSP3A TIA): -

The City of Swan has requested analysis of the road access arrangements proposed for LSP3A in the short-medium term period before construction of Henley Brook Avenue and full development of the surrounding Albion District Structure Plan area. Therefore, the short-medium term scenario is the existing situation plus full development of LSP1A and 3A only.

The LSP proposes residential land of R30/40 density. The central area spanning the Dampier Bunbury Gas Pipeline Easement has been identified for strata lot development. Overall it is anticipated to yield approximately 754 dwellings.

The anticipated 754 dwellings of the LSP3A area will therefore generate approximately 6,000vpd and 10% of this number in the AM and PM peak hours.

The Albion 1A Local Structure Plan: Traffic & Movement Network Final Report (January 2010, revised February 2011) indicates the LSP1A area will yield approximately 1187 dwellings. This is therefore estimated to generate approximately 9,500vpd.

The traffic model developed for this report also includes existing dwellings on the surrounding local road network bounded by Lord Street, Gnangara Road, West Swan Road and Youle-Dean Road. A total of 817 existing dwellings have been modelled in this area, which are estimated to generate approximately 6,500vpd.

Existing external through traffic on Lord Street and West Swan Road has been calculated manually by subtracting the modelled traffic flows generated by the existing land uses from the existing traffic counts on Lord Street and West Swan Road. This existing through traffic is estimated at 14,000vpd on Lord Street and 11,800vpd on West Swan Road.

It is concluded that the western sections of Park Street may carry up to 5000 vehicles per day in this short-medium term scenario but traffic volumes will reduce substantially in future when Henley Brook Avenue is constructed.

The key findings of this Addendum report relate to intersection requirements on Lord Street.

It is recommended that the Lord Street / Park Street intersection be restricted to left in / left out movements when traffic operation becomes unsatisfactory and that the existing roundabout 500m south on Lord Street be upgraded to two lanes with two-lane entries and exits to accommodate all right turn traffic movements to and from Lord Street in this area. This will allow this intersection to operate. It is estimated that this roundabout upgrade will be required when development in LSP1A and 3A combined reaches approximately 29% of the anticipated dwelling yield in these areas (approximately 560 dwellings). The analysis in this Addendum report demonstrates that these intersection treatments will provide sufficient capacity for the right turn movements to and from Lord Street when LSP1A and 3A are fully developed.

Lot 345 Woollcott Avenue, Brabham

The Structure Plan proposes to subdivide existing landholdings in the Structure Plan area into a new layout comprising 324 lots and one drainage reserve (under the jurisdiction of the City of Swan) as shown in Table 1 below.

Table 1 - Quantities of Proposed Uses

Lots	Proposed Land Use Zoning	Average Yield (Total Area)
323 Lots	Residential Land	323
1	Grouped housing	1,249 m² (5 dwellings) R40
Total Dwellings		**328**

We have assumed a potential dwelling yield on the proposed Group Housing site of 5 dwellings, based on an R40 density. The total number of dwellings used in modelling for this report is therefore 328.

A plan showing the proposed Structure Plan has been provided in Appendix 1 of this report.

2.2 Existing Situation and External Traffic Networks

The existing road network surrounding the subject landholding includes Woollcott Avenue to the west and south-east, Lord Street to the north, Park Street to the east, and West Swan Road to the south. A plan showing the existing network and distribution of the existing traffic volumes is provided in Appendix 2.

Woollcott Avenue is a two-way, two-lane road, classified as an Urban Local Road / Access Road with a speed limit of 70kph. There is no bus service running along this street in the vicinity of the subject site. The 70kph speed environment is a remnant from the roads former rural land-uses. We believe this speed environment will be reduced to 50kph to suit the urban environment.

Park Street is located in the vicinity of the subject site. It is a two-way, two-lane road and is classified as a Significant Urban Local Road / Local Distributor by Main Roads WA. The legal speed limit on Park Street is 70kph. There is no bus service running along this street in the vicinity of the subject site.

Lord Street is a two-way, two-lane road, classified as a Significant Urban Local Road / Distributor B with a speed limit of 80kph. There are bus services on this street between Woollcott Avenue and Park Street.

The following existing traffic volume information has been sourced from Main Roads WA.

Table 2 - Traffic Volumes for Roads Adjacent to the Subject Site

Road Name	Functional Classification / Road Hierarchy	Location of Traffic Count	Vehicles Per Day (VPD)	Vehicles per Peak Hour (VPH)	Heavy Vehicle %	Year	Legal Speed Limit
Lord Street	Significant Urban Local Road / Distributor B	North of Reid Highway	15,033	AM 0730 - 945 PM 1645 - 1,376	11.8	Feb 2014	80kph
Woollcott Avenue	Urban Local Road / Access Road	West of West Swan	942	AM 0700 - 87 PM 1615 - 94	10.7	Feb 2015	70kph
Park Street	Significant Urban Local Road / Local Distributor	West of West Swan Road	1,355	AM 0730 - 116 PM 1630 - 144	12.2	Nov 2013	70kph

Formal peak hour data has been recorded and is shown in Table 2. An analysis of available traffic data within 800 metres of the proposed Structure Plan area suggests: -

Woollcott Avenue:

- AM peak occurs in period between 07:00-08:00. Traffic volumes in the AM peak are approximately 9.23% of total daily volumes;

2.2.1 PM peak occurs in period between 16:15-17:15. Traffic volumes in the PM peak are approximately 9.97% of total daily volumes.**Crash Data**

The following table shows a collation of crash data from the Main Roads WA database for crashes and incidents for roads adjacent to the subject site between the 1st of January 2010 and 31st of December 2014.

Table 3 - Crash Data

Road Name	Road Hierarchy	Functional Classification	Speed Limit	Crash Statistics
Lord Street	Distributor B	Significant Urban Local Road	80kph	Total of 12 incidents: • 2 Hospital • 6 PDO Major • 4 PDO Minor MR Type: • 5 Involving Animal • 7 Other / Unknown
Woollcott Avenue	Access Road	Urban Local Road	70kph	Total of 11 incidents: • 3 Medical • 8 PDO Major MR Type: • 2 Involving Animal • 9 Other / Unknown
Park Street	Local Distributor	Significant Urban Local Road	70kph	Total of 13 incidents: • 3 Medical • 6 PDO Major • 4 PDO Minor MR Type: • 3 Involving Overtaking • 2 Involving Animal • 8 Other / Unknown

The above table represents a comprehensive list of the local road environment and the total volume of crashes in the 5 years between 2010 and 2014.

The accident rate for the mentioned streets in above table is: -

- Killed and Serious Injury (KSI) Crashes (Fatality + Hospital) - 2 per every 5 years;
- All Crashes - 36 per every 5 years.

To compare the rate of incidents at this location with the metropolitan network average, Main Roads WA uses a criterion called Crash Rate / MVKT (million vehicle kilometres travelled).

Using an average daily throughput of 17,330 VPD at this section and the zone of influence at this section is within 400 metres, (i.e. approx. 100 metres on the approach to each of the intersection legs) the total VKT during the 5-year period is 17,330 VPD x 365 days x 5yrs x 0.40 kilometres = 12.65 million kilometres over 5 years.

Therefore, the crash rate is 36 incidents per 12.65 million kilometres travelled or equivalent to an incident rate 2.84 crashes / MVKT. This rate of crashes is lower than the network average of 3.52 crashes / MVKT over the 5 year period. The crash rate for KSI crashes are 2 incidents per 12.65 million kilometres travelled, equating to a crash rate of 0.15 incidents / MVKT. This crash rate is lower than the network average of 0.18 crashes / MVKT over the 5 years.

The following table shows the Crash Density and Crash Rates on Metropolitan Local Roads as obtained from Main Roads WA on the 16th October 2014 by email request: -

CRASH DENSITY AND CRASH RATE ON METROPOLITAN LOCAL ROADS NETWORK ONLY				
	ALL CRASHES		KSI CRASHES (FAT+HOS)	
	DENSITY ALL CRASHES/KM over 5 years	CRASH RATE/MVKT	DENSITY KSI CRASHES/KM over 5 years	CRASH RATE/MVKT
LOCAL - MIDBLOCK	3.52	1.17	0.18	0.06
LOCAL - ALL	7.69	2.54	0.37	0.12
NOTE: BASED ON 5-YEARS DATA FOR THE PERIOD 2009 TO 2013.				

2.3 Traffic Modelling for the Proposed Structure Plan Area

This section provides a detailed description of how traffic volumes are calculated for the development options presented by CLE Town Planning + Design for the Structure Plan Area. Our traffic model uses a 3-step approach for the estimation of transportation demand into and out of the Structure Plan Area: -

1. Step 1 – Confirm the size and quantum of the proposed land uses.
2. Step 2 – Confirm how these land uses impact travel patterns and the generation / attraction of transportation trips.
3. Step 3 – Confirm where the likely origins of travel external to the Structure Plan Area are located and confirm the likely destinations for travel from the subject landholdings and determine the impact of those transportation volumes on the local road network.

The purpose of the Transport Impact Assessment is to determine the likely impact of the proposed development of the structure plan area upon the local road network within an 800 metre radius of the structure plan area.

2.3.1 Step 1 - Proposed Land Uses

Different land uses impact the transportation network in different ways. The purpose of this section is to discuss the land usages as proposed in the Structure Plan Area and to discuss their likely trip generations based on data from trusted guideline sources such as the WAPC Transport Assessment Guidelines and the NSW RTA Guide to Traffic Generating Developments.

The WAPC Transport Assessment Guidelines for Developments offers the following vehicle trip generation rates for the land uses proposed within the development: -

- Residential - 0.8 vehicular trips per dwelling for the AM and PM peak hours. An 80% IN/ 20% OUT split has been adopted for the AM peak and a 67% IN / 33% OUT split for the PM peak hour.

Table 4 - Proposed Land Uses within the Structure Plan Area

Land Use Type	Yield	Daily Trip	Peak Hour Generation	Total VPD	Total VPH

		Generation			(peak)
Residential	323 + 1 Grouped Lot with 5 Dwellings	6.7 vehicle trips per day	0.8 in the peak hour	2,198	263
Total				**2,198**	**263**

2.3.2 Step 2 - Trip Purposes

To understand the likely demand for alternative transportation modes (including public transportation trips, cyclist and pedestrian trips) and the impact of vehicular traffic on the adjacent road network, we need to understand why people are travelling into and out of the Structure Plan Area. These general trip purposes include employment, shopping, social, education and other general purposes. Each land usage will generate a unique matrix of trip purposes. For example, the following table shows the likely percentage share for different trip purposes based on the land usage: -

Table 5 - Trip Purposes by Land Use

Land Use Type	Employment	Shopping	Education	Social / Recreational
Residential	40%	17.5%	25%	17.5%
Total - 2,198	879	385	549	385

2.3.3 Expected Origin / Destination

The expected origin / destination matrix is important to determine the likely route of vehicular and other travel.

Table 6 - Origin / Destination Matrix

Land Use Type	Trip Purpose	Likely Destinations
Residential	• Employment	Therefore, the majority of employment trips will be external to the proposed Structure Plan Area. The Swan i.d. website on the City of Swan's webpage suggests the following breakdown for employment destinations for residents of the City of Swan: • Swan - 30.9% • Stirling (C) - Central - 5.9% • Bayswater (C) - 5.4% • Belmont (C)- 5.3% • Perth (C) - Inner- 5.1% • No usual address - 4.4% • Perth (C) - Remainder - 4.3% • Canning (C) - 4.1% • Wanneroo (C) - South - 2.8% • Mundaring (S) - 2.3% • Others (Bassendean (T), Vincent (T), Victoria Park (T), Kalamunda (S), Subiaco (C), Nedlands (C), Joondalup (C) - North, Gosnells (C), Joondalup (C) - South, Stirling (C) - South-Eastern) less than 2.3 each.
	• Education	The Albion district structure plan proposes two primary schools and one High school. It is expected that approximately 70% of trips for education purposes will be internal to the subdivision while 30% will be external (tertiary education and attendance of private schools).
	• Shopping	It is anticipated that the local centre will cater predominantly for standard weekly shopping.

		The nearest larger shopping area is located north from the proposed development in Ellenbrook. Some occasional speciality shopping will be conducted in the Ellenbrook City Centre, or in Malaga for bulky goods.
	• Social / Recreational	It is deemed that a minimum of 60% of the trips for social and recreational purpose will be within the DSP area given the location.

2.3.4 Estimated Trip Generation from the Structure Plan Area by Mode

This section provides a summary of the likely trip generation by transportation mode from the Structure Plan Area, based on the land uses proposed: -

Table 7 - Standardised Trip Generation Rates by Land-use Per Transportation Mode

Transport Mode	Residential Land Uses (trips per day)
Vehicle as driver	6.7
Vehicle as passenger	0.5
Public Transport	0.45
Pedestrian	1.9
Bicycle	0.48
Total	**9.85**
Note (Combined Vehicle as driver / Vehicle as Passenger = 7.2 or 73.1%	

KCTT have utilised 73.1% of all trips as undertaken using a vehicle (i.e. vehicle as driver plus vehicle as passenger). The trip rates nominated above are justified as follows: -

- The Swan i.d. site shows that up to 78% of all work trips are undertaken using a vehicle (i.e. vehicle as driver plus vehicle as passenger).
- This location will have strong local options for shopping and education, combined with excellent pedestrian path and cyclist connectivity, plus future public transportation options in the Lord Street corridor.
- There should be a strong commitment from local and state government in reducing dependence on private vehicle usage from outer-lying areas such as Brabham.
- Public transportation volumes are not expected to be larger than the metropolitan region average for usage. The goal for public transportation usage in Brabham should be to meet the metropolitan average of 4.56% of all trips by PT.
- The proximity of local schools provides opportunities to improve local walking / cycling trips.

Using these trip rates for all trip purposes and transportation modes, the following table highlights the trip generation expected from the Structure Plan Area: -

Table 8 - Trip Rate Generations by Transportation Mode (Total Vehicles per Day VPD)

Transport Mode	Residential Land Uses		
	Trips Per Household (By Mode)	Yield (Total no of houses)	Total Trip Generation (VPD)
Car	6.7	328	2,198
Public Transport / Car as Passenger	0.95	328	312
Pedestrian	1.9	328	623
Bicycle	0.48	328	158
Total	**9.85 / 8.65**	**328**	**3,291**

2.4 Vehicular Access and Parking

Vehicular access for the proposed Structure Plan Area will be from Woollcott Avenue, Arpent link Road, Partridge Street and Murray Road. Parking requirements for residential land-uses will include provision of some on-street visitor parking around the POS areas and in front of lots that are rear-loaded to laneways.

2.5 Provision for Delivery and Service Vehicles

The provision required for delivery and service vehicles for residential development (low to medium density scale developments) is likely to be minimal above that which is provided for within the road reservation, through good road design in accordance with Liveable Neighbourhoods and the requirements of the City of Swan.

Liveable Neighbourhoods suggest 6.0 metres kerb radii for access street intersections while the City of Swan allows up to 12.0 metres, pending intersection design requirements. This LSP proposes usage of smaller applicable kerb radii at laneway approaches to access streets (6.0 metres) since it discourages excessive vehicular speed through intersections by constraining movement. We believe that this radius provides sufficient manoeuvring space for standard service vehicles from laneways into Access Streets. All other roads will be designed to meet the turning requirements of City of Swan waste vehicles. This will be completed by the nominated civil engineering consultants during submission and approval of civil engineering drawings for each stage of development.

2.6 Hours of Operation

The majority of land uses within the Structure Plan Area are residential. In the short-term it is likely that AM and PM peaks will coincide with journey to / from work times. As such morning and afternoon peaks are likely to be around 7:00am to 8:00am and 5:00pm to 6:00pm during work days.

We have assumed a general peak hour traffic generation of approximately 10% of daily trips for the purpose of this traffic model. This is in accordance with the WAPC Guidelines for Transport Impact Assessments: Volume 5.

2.7 Management of Traffic Generated by the Structure Plan Area

2.7.1 Forecasted Traffic Volumes on Existing and Proposed Roads in the Structure Plan Area

The following tables consider the traffic generation from the Structure Plan Area and its impact upon the existing road network and upon the proposed road network within the Structure Plan Area.

Table 9 - Forecasted Traffic Volumes on Existing Roads within and Adjacent to the Structure Plan Area

Road Name	Functional Class / Road Hierarchy	Location of Forecast Traffic Count	Forecasted Traffic Volumes In 2025	
			Forecast Vehicles Per Day (VPD) - 3% growth rate	Forecast Vehicles per Peak Hour (VPH)
Lord Street	Significant Urban Local Road / Distributor B	North of Reid Highway	20,809	1,905
Woollcott Avenue	Urban Local Road / Access Road	West of West Swan Road	1,266	126
Park Street	Significant Urban Local Road / Local Distributor	West of West Swan Road	1,932	205
Arpent Link	Assumed - Access Street A	North of development	1,250 *	125 *

*Note: * KCTT have assumed an "existing" future volume of 1,250VPD in Arpent Link which may be generally attracted to the south, based on expected development yields directly to the north of this development.*

The following table shows the forecasted traffic volumes on the proposed roads within the Structure Plan area.Table 10 - Forecasted Traffic Volumes on Proposed Roads within the Structure Plan Area

Road Name	Classification	Recommended Cross	Traffic	Total	Forecast

		Sections	generated by the development (VPD)	(VPD)	Vehicles per Peak Hour (VPH)
Road 01 **	Access Street C	7.2m wide pavement in 16.2m wide reservation	29	418	5
	Modified Access Street C (adjacent to POS)	7.2m wide pavement in 13.0m wide reservation (reduced by 3.2m on southern side due to POS)			
Road 02 **	Modified Access Street C (adjacent to POS)	7.2m wide pavement in 13.0m wide reservation (reduced by 3.2m on northern side due to POS)	30	364	5
Road 03	Access Street D	6.0m wide pavement in 15.0m wide reservation	41	41	8
Road 04	Access Street D	6.0m wide pavement in 15.0m wide reservation	126	341	36
Road 05	Access Street D	6.0m wide pavement in 15.0m wide reservation	116	401	32
Road 06 (extension of Arpent Link)	Modified Neighbourhood Connector B	2 x 3.2m wide lanes in a 21.4m road reservation	1,408	1,910	332
Road 07	Neighbourhood Connector B	2 x 3.2m wide lanes in a 20.4m road reservation	747	1,400	104
Road 08**	Access Street C	7.2m wide pavement in 16.2m wide reservation	166	392	25
Road 09	Access Street D	6.0m wide pavement in 15.0m wide reservation	135	165	24
Road 10	Access Street D	6.0m wide pavement in 15.0m wide reservation	277	297	52
Road 11	Laneway	6.0m wide pavement in 9.0m wide reservation	134	244	33
Road 12	Access Street D	6.0m wide pavement in 15.0m wide reservation	180	330	32
Road 13	Access Street D	6.0m wide pavement in 15.0m wide reservation	168	168	20
Road 14	Access Street D	6.0m wide pavement in 15.0m wide reservation	93	93	15
Road 15 **	Modified Access Street C	7.2m wide pavement in 13.0m wide reservation (reduced by 3.0m on southern side due to POS)	759	759	159
Road 16 *	Access Street C	6.0m wide pavement in 15.0m wide reservation	134	1,087	25
Road 17	Laneway	6.0m wide pavement in 9.0m wide reservation	79	287	11
Woollcott Avenue	Neighbourhood Connector A	2 x 7.1 wide pavement in 24.4m wide reservation	1,370	3,206	224

*Note: * Refer to Park Street I SP3A Transport Assessment, Cardno, 2010*
*Note: ** Having in mind the future residential development and the future primary school to the east, this road classification for the roads that will provide connection to them is considered appropriate.*

The requirements for each of the cross sections are explained in detail below in Section 2.7.2.

2.7.2 Cross Sections within the Structure Plan Area

KCTT proposes the following road classification for the existing and proposed roads: -

- **Neighbourhood Connector B** - 2 x 7.1 wide pavement in 24.4m wide reservation (Woollcott Avenue),
- **Modified Neighbourhood Connector B** - 2 x 3.2m wide lanes in a 21.4m road reservation (Road 06),
- **Access Street C** – 7.2m wide pavement in 16.2m wide reservation. 16.2 metres is the minimum requirement for the City of Swan given minimum 4.5 metre verges. (Road 07)
- **Modified Access Street C** – 7.2m wide pavement in a 13.0m wide reservation. The road reservation is reduced by 3.2m adjacent to a proposed POS),
- **Access Street D** – 6.0m wide pavement in 15.0m wide reservation. As for Access Street C above, the City of Swan has a minimum requirement for 4.5 metre verge widths.
- **Modified Access Street D** - 6.0m wide pavement in 13.0m wide reservation (reduced reservation by 3.0m - adjacent to the proposed POS), as for Modified Access Street C.
- **Laneway** - 6m wide pavement in 9.0m wide reservation.

Requirement for Embayed Parking

According to the City of Swan's requirements, the design will require embayed parking in Road 06 (extension of Arpent Link). The locations for embayed parking should consider the stormwater drainage design requirements. Generally the parking should not be located to coincide with lowpoints in the road where drainage can accumulate.

Incorporation of Swale Drainage

An open swale drain will be provided on the western side of Road 06 (extension of Arpent Link). The intended maximum width for the swale drain is as shown in the Typical Cross Sections provided in Appendix 2 and will be determined during the detailed design phase by the civil engineering consultants.

Requirements for Public Transport

The cross section for Road 6 (extension of Arpent Link) allows for potential public transportation linkage. The road incorporates a standard width footpath on the western side of the road cross section (at 1.8 metres width) and a Dual Use Path (2.3 metres width) on the eastern side of the road reservation. As for parking embayments, any future bus stops / embyaments should be located such that they do not coincide with drainage low points.

Minimum Requirements for Road Reservations

The City of Swan have a policy for minimum 4.5 metre width verges. This means that Access Streets C and D have slightly wider road reservation widths when compared with the general requirements of Liveable Neighbourhoods. A reduction to this requirement is in road reservations which are adjacent to Public Open Space areas. The requirements for minimum verge widths is relaxed in these locations because the infrastructure corridors are not required on the POS side of the road reservation. (Services are generally required on the side of the road which has future lots, not to service POS).

The following figures show the typical cross-sections within the proposed development.

Figure 2 - Neighbourhood Connector B (Woollcott Avenue)

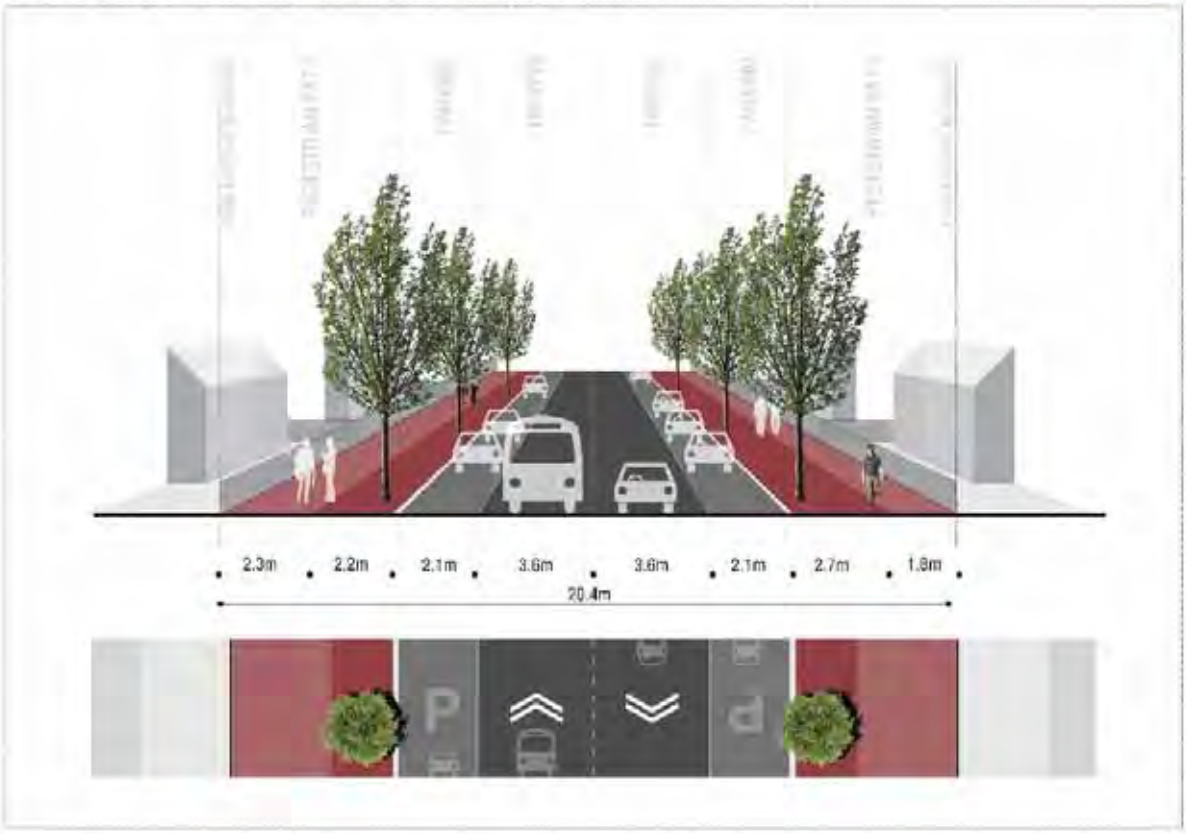


Figure 3 - Neighbourhood Connector B (Road 06)

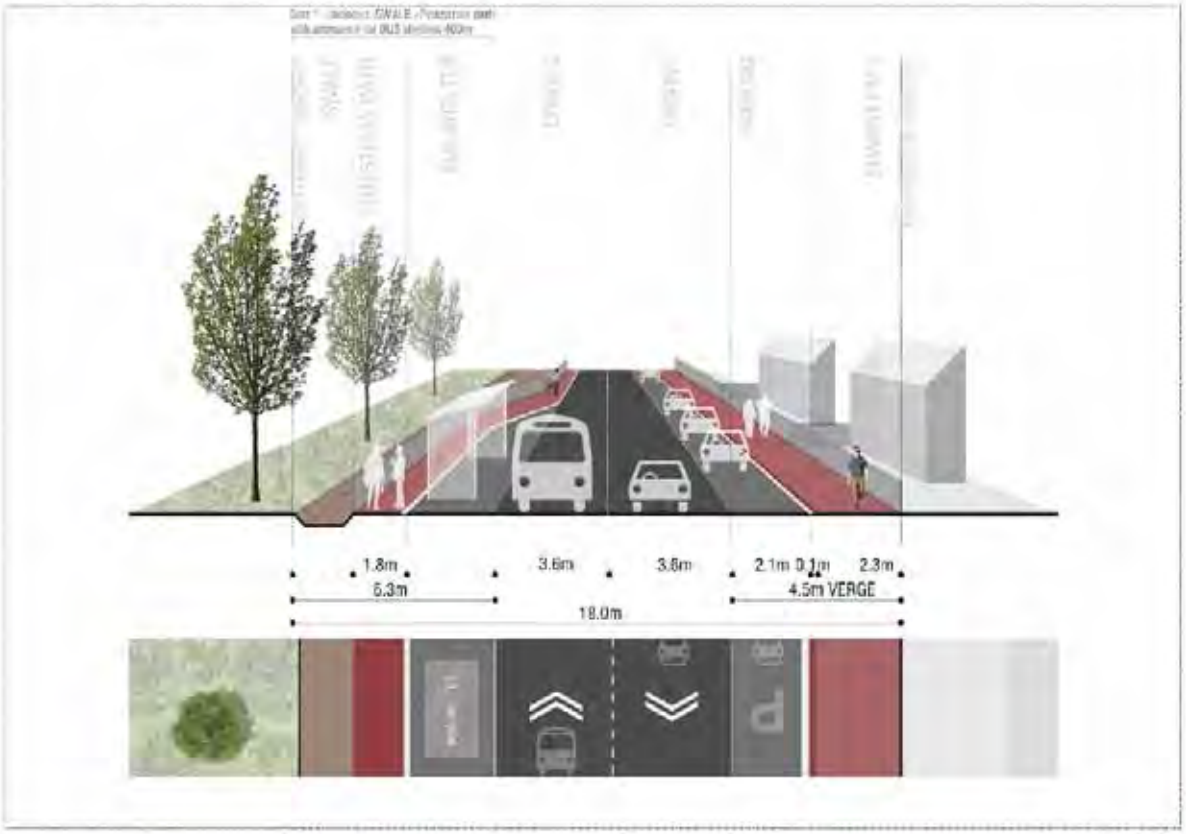


Figure 4 - Access Street C (Road 07)

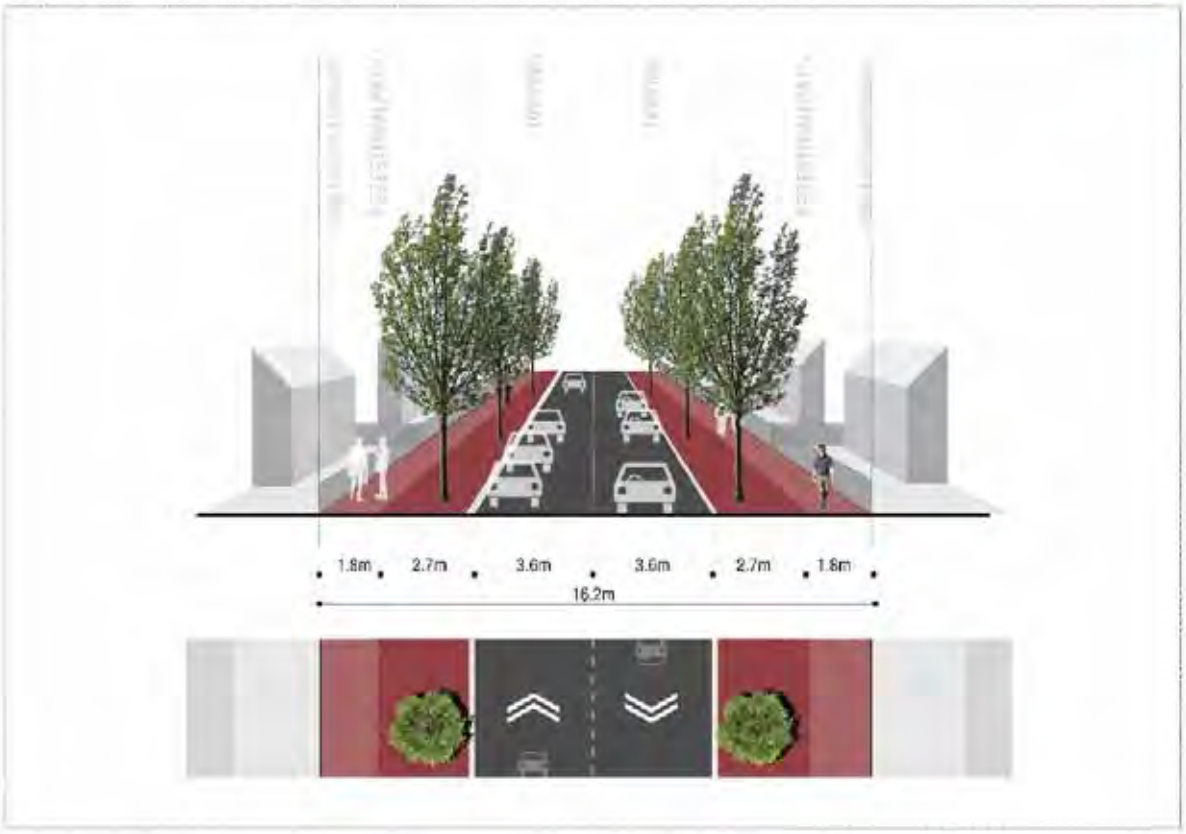


Figure 5 – Modified Access Street C (Adjacent to Proposed POS)

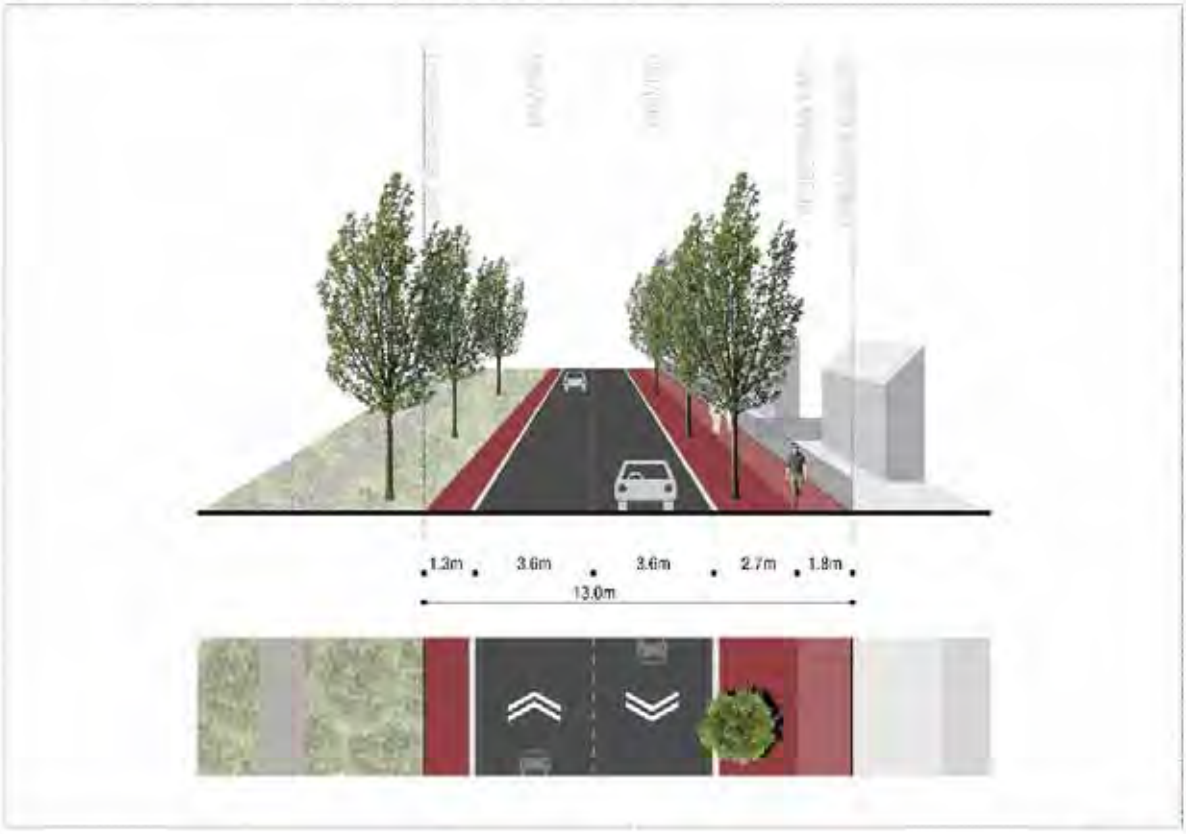


Figure 6 - Access Street D

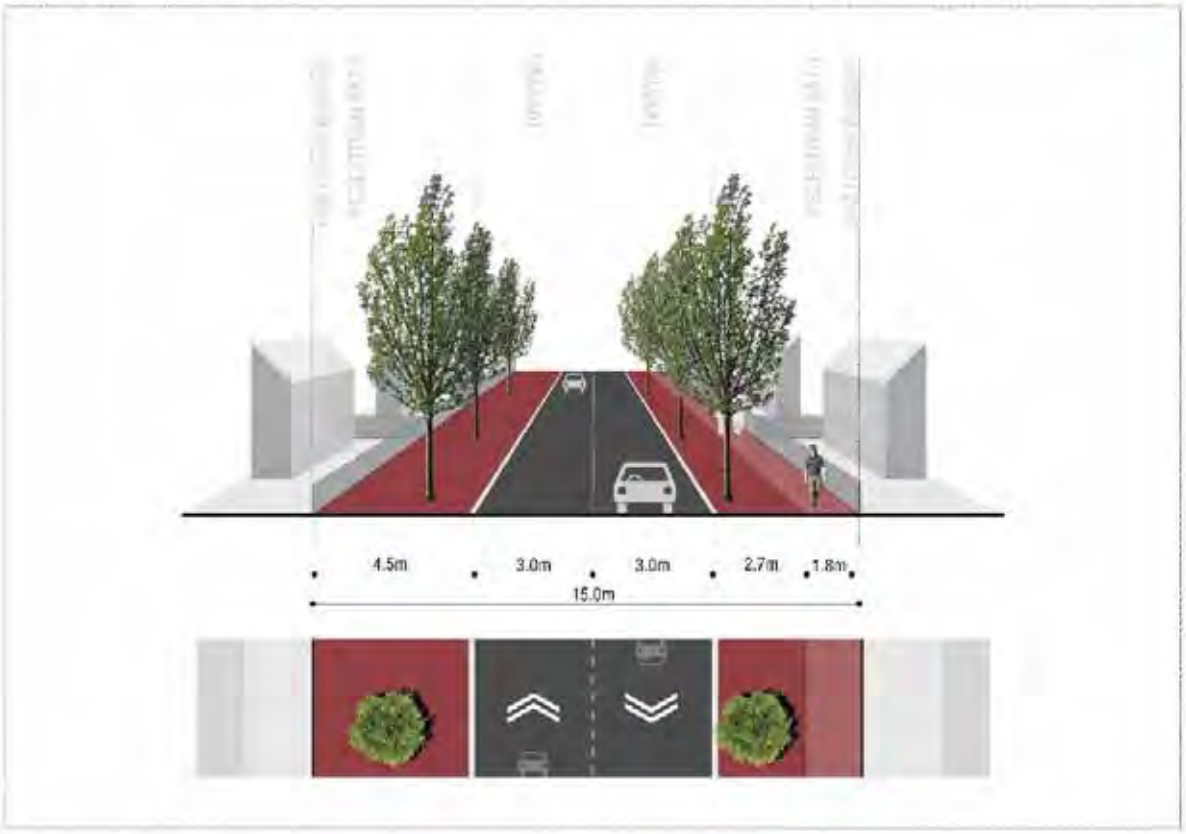


Figure 7 -- Modified Access Street D (Adjacent to the Proposed POS)

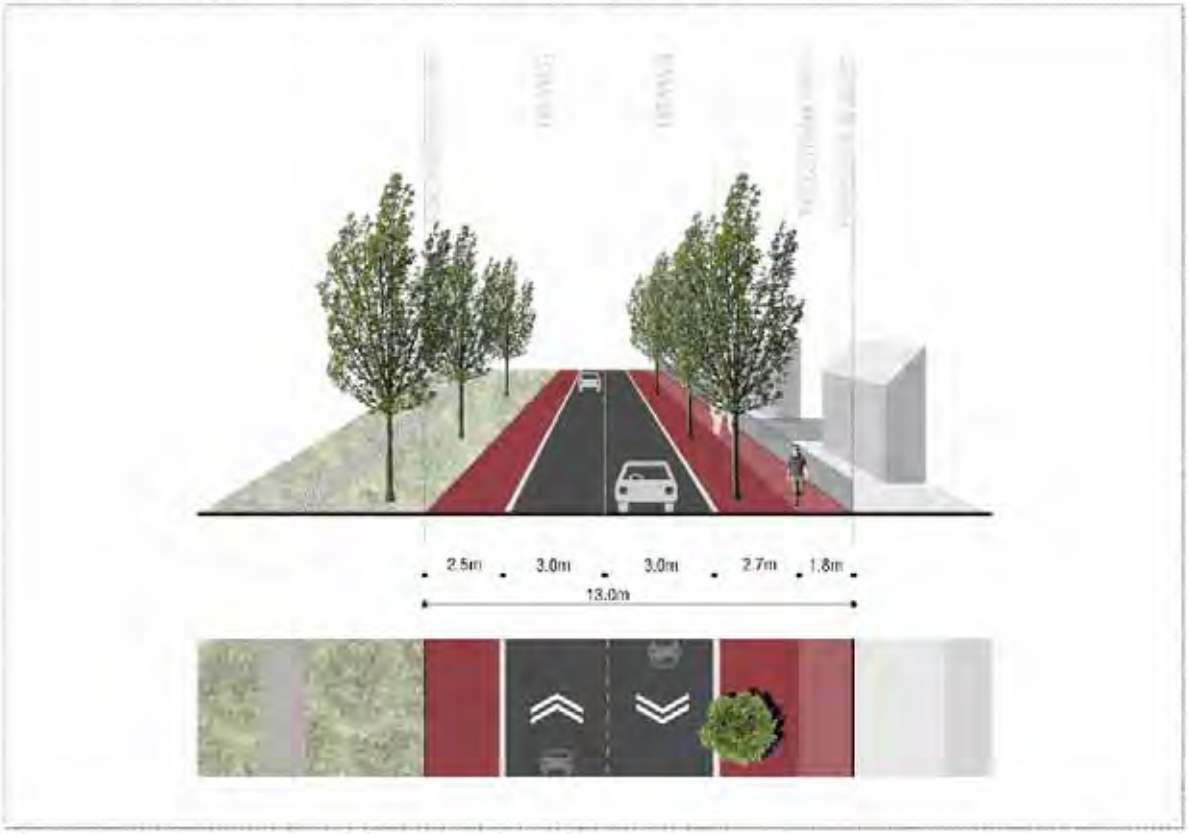
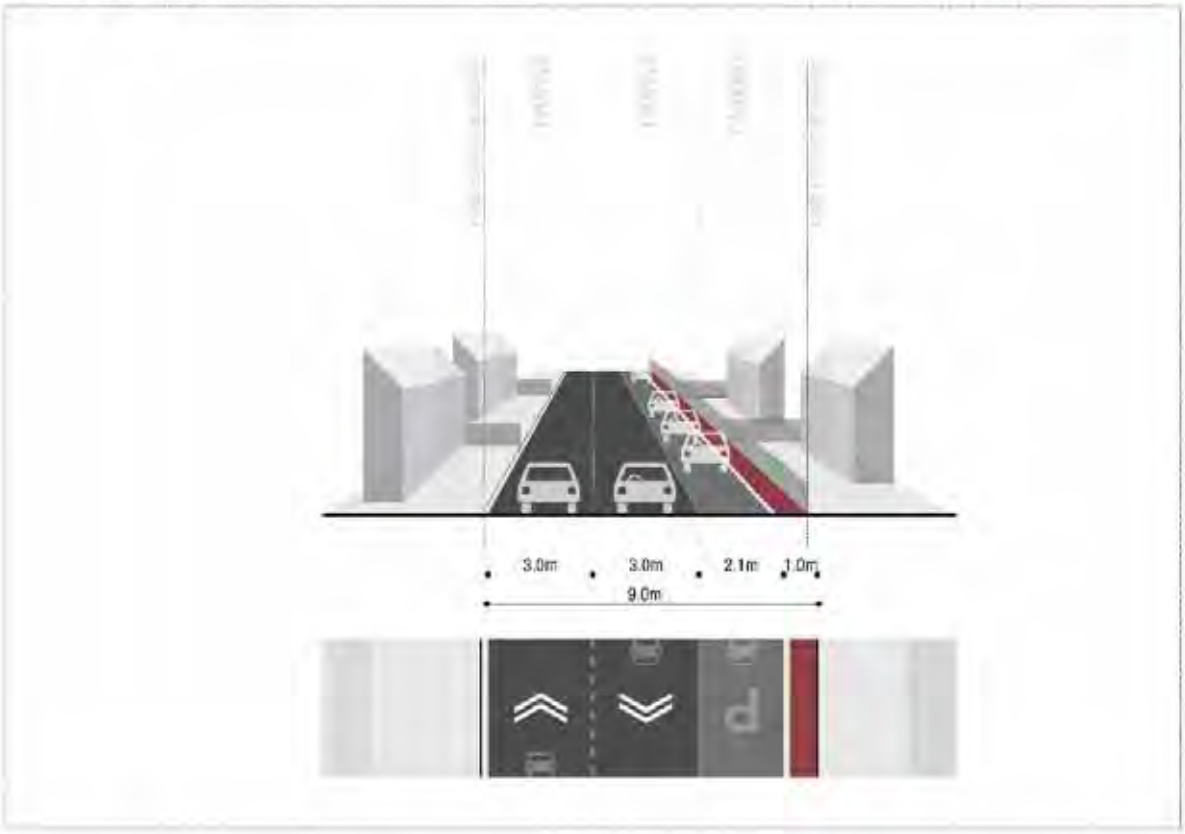


Figure 8 - Laneway



In accordance with promoting alternative transportation mode share, pedestrian paths have been provided on all road reservations within the Structure Plan Area.

2.7.3 Proposed Intersection Controls

Woollcott Avenue / Road 06 (Extension of Arpent Link)

The intersection to Woollcott Avenue is a proposed full movement intersection with Give Way yield.

Roundabout – Intersection Road 06 (Extension of Arpent Link) and Road 07

A roundabout is proposed at the above intersection.

6.0 metre Kerb Radii

As previously mentioned in Section 2.5 – we believe that 6.0 metre kerb radii (as per Liveable Neighbourhoods) discourages reckless driving therefore it would be prudent to allow for 6.0 metres curb radii for all Laneway intersections to Access Street C and D roads. All other intersections for Access Street C roads shall be 9.0m in accordance with City of Swan requirements.

Give Way Yields

We propose a Give Way yield at the t-intersection of Road 06 (Extension of Arpent Link) and Road 15, given its proximity to the intersection of Woollcott Avenue and Road 06 (extension of Arpent Link). Given the low likely

volume of right turns into Road 15, we do not believe a right turn deceleration lane is required on the northbound approach in Road 06 (extension of Arpent Link).

Staggered T-Intersections Requiring Median Islands to Prevent "Cutting Across Intersections"

We do not believe any of the proposed staggered t-intersections in the proposed Structure Plan offer motorists the ability to cut across intersections as if they are staggered 4-way intersections, therefore we do not believe that median splitter islands are required at any intersection to prevent vehicle creep into opposing lanes.

2.8 Public Transport Access

This section describes the accessibility to public and alternative modes of transportation. KCTT have reviewed Transperth and Walk Score for the information found below.

2.8.1 Transperth Bus Routes

The following public transport routes are within proximity of the subject site. The key information provided below includes: -

- Bus route number;
- Description of the bus route; and
- Their indicative peak and off-peak frequencies.

These bus routes are available within a 2km radius of the subject landholdings: -

- To the North: Bus routes 335, 955 and 956;
- To the South: Bus routes 335, 955 and 956;

Table 11 - Bus Routes and Frequencies

Bus Route	Description	Peak Frequencies		
		Monday to Friday	Saturday	Sunday
335	Ellenbrook – Midland Railway Station	3 per day (school days only)	No service	No service
955	Ellenbrook North – Morley Bus Station	6 minutes	30 minutes	60 minutes
956	Ellenbrook North – Bassendean Station	6 minutes	30 minutes	60 minutes

2.8.2 Accessibility to Public Transportation

The following table highlights the proximity of the various bus routes to the subject site and highlights the "walkability" to alternative transport modes. This information has been sourced from "Walk Score" at http://www.walkscore.com

Table 12 - Bus Route Description and Walkable Distance to / from the Subject Site

Bus Route	Description	Distance from Subject Site
335	Ellenbrook – Midland Railway Station	2.0km
335	Midland Railway Station – Ellenbrook	2.0km
955	Morley Bus Station – Ellenbrook	1.5km
956	Bassendean Station – Ellenbrook	1.5km

Transperth are planning for improved bus services through the region as urban development expands. Generally, the service provision today could be described as low, however in the future the service provision will improve as patronage rates begin to increase along Lord Street.

Public transport planning for the Albion District Structure Plan is proposed currently to have a bus transit system to serve the Albion and Ellenbrook areas until at least 2030 and potentially much longer in lieu of the postponed Ellenbrook Light Rail project.

The indicative network envisaged in the Albion District Structure Plan has incorporated the following key principles:

- The highest demand for travel will be towards Perth and the inner suburbs, with a potential secondary demand to the regional centre of Midland.
- The indicative service structure would incorporate a major link to the Midland rail line, connecting at Guildford or Bassendean.
- Partridge Street and Youle-Dean Road would be important bus routes, both requiring high levels of activity and integrated bus stops at 400 m intervals.
- Local services would also require a supportive road network and land use density.

In recent years the surrounding area has undergone a major transformation from generally rural to urban. PTA confirmed that it is reasonable to expect an upgrade in the existing bus service through the area given the growth of the population and the increased demand, providing us with the following information: -

1. *It appears that Road 06 (Extension of Arpent Link) traversing in a north-south direction through the local structure plan area forms the proposed alignment for a bus route service connecting Gnangara Road and Youle-Dean Road. It is a desirable alignment due to its central location between Partridge Street and Murray Road. This enables the PTA to provide a service within a 500 metre walkable distance of all residents through direct bus route services aligned parallel to each other in a north-south direction.*
2. *It is imperative that Road 06 (Extension of Arpent Link) be designed to accommodate a bus route service. The street should provide for a desirable traffic running lane of 3.5 metres (minimum of 3.2m) and a desirable minimum turning circle of 14.0 metres (minimum of 12.5m). Further, traffic-calming devices on this street should be avoided and, for where they are necessary, buses must be able to manoeuvre through them. For example, the PTA opposes the use of traffic-calming devises on this street such as narrowed throats and raised pavements, mini roundabouts/chicanes, physically tight intersections, and trees close to street kerbs.*

KCTT have developed a standard cross section for Road 06 (Extension of Arpent Link) which provides: -

- A 4.5 metre width verge on the eastern side of the road reservation (including 2.3m Dual Use Path and 2.1m width embayments for parking, with 0.1m offset between parking embayments and DUP);
- 3.6 metre width lanes;
- The remainder of the 18 metre width reservation, 6.1 metres is dedicated for the swale, 1.8 metre width footpath and provision of bus shelter where nominated below: -
    - approximately 150m north of Woollcott Avenue, coinciding with a potential crest in the road design.
    - Two bus stops are proposed on the eastern side of the road reserve, namely opposite the one on the western side described above and another one approximately 120 metres south of Palfrey Street.

The above design ethos means that the swale can be designed with a maximum width of 4.3 metres and will require localised reduction at Bus Stations to allow for the increased width required for the shelters. This design allows for 3.6 metre width lanes which is in accordance with the information provided below. The design also fits existing design widths for Arpent Link directly to the north of the subject site. The centreline for Arpent Link may need to be adjusted from the intersection of Road 16 at the northern boundary of the Structure Plan, as the KCTT cross-section shows the centreline of the road is offset to the east of the road reserve centreline. This has been done to increase the width of available verge on the western side of the road for the purposes of the swale. The design also allows for the following Austroads requirements for buses: -

'Bus travel lanes' on bus routes should be wide enough to provide a high level of safety and comfort for the driver and bus passengers. As buses are 2.5 m wide (bus body) and generally travel in the left lane of roads, the desirable width of kerbside lanes on bus routes is desirably larger than that for general traffic lanes. Modern buses often have fairly large side mirrors that extend well beyond the body of the vehicle, up to 0.3 m each side. Lane widths must account for these protuberances, particularly where buses run in adjacent lanes in opposing directions, or objects are located immediately behind kerbs.' (Guide to Road Design Part 3: Geometric Design, Austroads, page 77)

The map of existing public transportation routes is provided in Appendix 2.

2.9 Pedestrian and Cyclist Access

There are no existing footpaths adjacent to the Structure Plan Area, however the local environment will change significantly as land development continues in the Albion DSP area. The locations for pedestrian paths and Dual Use Paths in this report is provided on the basis that there may be some minor fluidity in design by the civil engineer. Footpaths and Dual Use Paths should provide direct connection to paths that are constructed and / or designed by others on adjoining boundaries to the proposed Structure Plan. Footpaths and Dual Use Paths should generally be located as follows: -

- 2.3 metre width Dual Use Paths are used where higher volumes of pedestrian activity are expected. For example, higher volumes of pedestrian activity are expected on the eastern side of Road 06 and the southern side of Road 07.
- 1.8 metre width Footpaths are used in all other situations including, behind parking embayments and on the side of the road that features a higher number of allotments for Access Road C and D roads, where only one footpath is required.
- 1.8 metre width footpaths will be provided in areas of POS on alignments to be determined by the landscape consultant.

The proposed Access Streets C through the Structure Plan Area are good riding environments due to their low traffic volumes. Pedestrian paths will be provided on all road reservations except for laneways within the Structure Plan Area.

Pedestrian and Cyclist Provision – Albion District Structure Plan

Walking and cycling have an important role within the overall transportation system of an urban area. When integrated with compatible land uses, a strong walk/cycle network can: -

- Reduce private car dependency for residents;
- Increase accessibility to employment and other urban activities for residents;
- Reduce the adverse environmental impacts of vehicular and motorised transport;

- Increase resource efficiency in a multi-modal transport system; and
- Reduce transport-related crashes or injuries.

The objective of a pedestrian and cycle network is to provide for the convenient and safe movement of pedestrians and cyclists through and between urban cells, having regard for the need to service schools, shops, recreation and other land uses as well as public transport access points.

The Albion District Structure Plan aims to maximise pedestrian and cyclist connections to the local and regional pedestrian / cycle network and to provide a safe, comfortable and convenient walking and cycling environment within the structure plan area.

The potential for shared paths and other linkages through open space and development areas is subject to lot layouts, environmental constraints and landscaping design. The neighbourhood centres and primary schools would be easily accessed on foot from most of the development cells within the Albion District Structure Plan. Pedestrian/cyclist movements between the cells will be along the neighbourhood connectors and district distributors, including Partridge Street, Woollcott Avenue, Youle-Dean Road and Henley Brook Avenue.

It is proposed to accommodate on-street cycle lanes and off-street shared paths on all neighbourhood connectors and district distributors. Shared use paths should be provided on at least one side of key routes to schools.

Figure 9 - Existing pedestrain paths at Fairmount Access / Egress (source: Google Maps)

Figure 10 - Existing pedestrian paths at Partridge Street Access / Egress (source: Google Maps)

Summary – Provision of Pedestrian and Cyclist Infrastructure

KCTT have reviewed our proposed cross-sections and provision of pedestrian and cyclist infrastructure, and we have compared these against the goals in the Albion District Structure Plan as described in the previous pages. We have therefore provided infrastructure which meets the goals of the Albion District Structure Plan, as follows: -

On-Road Cycle Lanes

- Woollcott Avenue

Dual Use Paths

- Road 06 (Extension of Arpent Link) (north-south connectivity)
- Road 07 (east-west connectivity); and
- Road 15 (east-west connectivity adjacent to the southern POS)

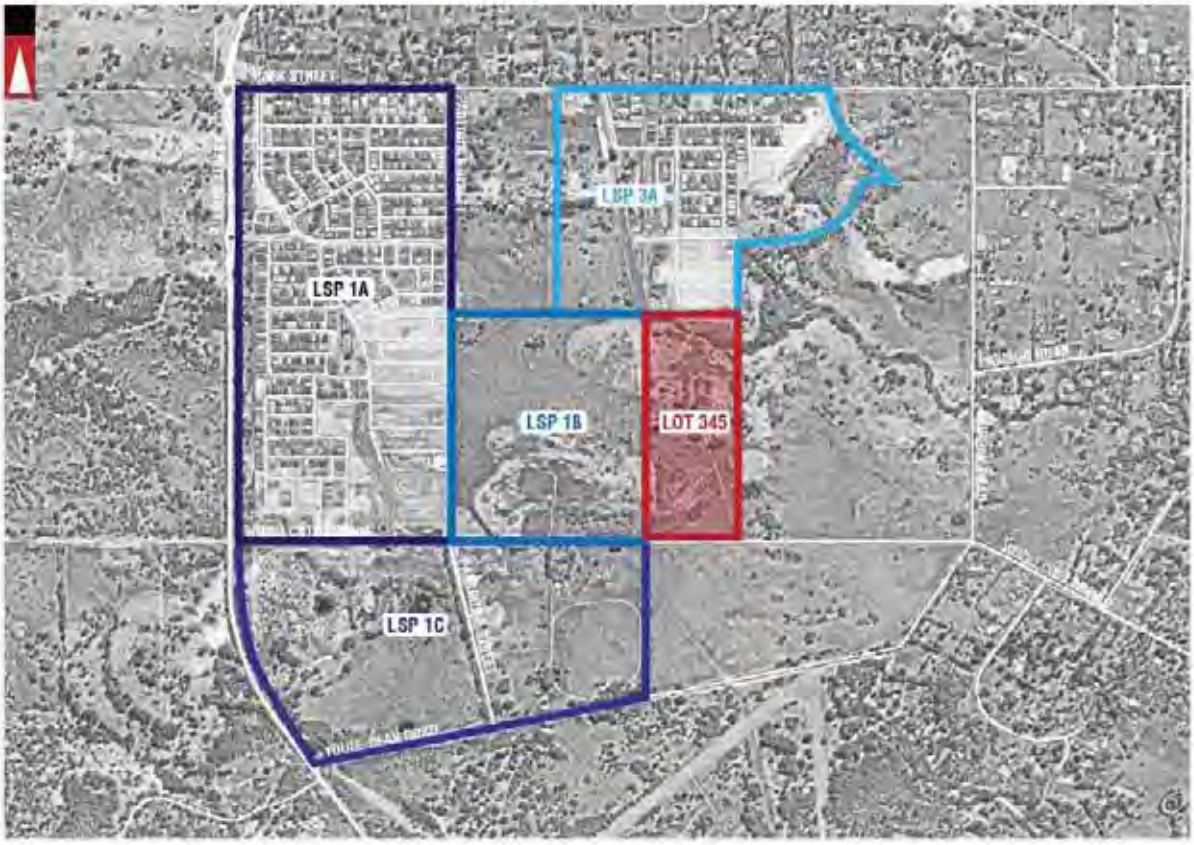
Footpaths

- All other roads (except Laneways)

2.10 Regional Modelling (Paramics)

The location of the subject site (Lots 345) is illustrated in Figure 12 – The Subject Structure Plan Area and the surrounding LSP areas below. KCTT have run a general model in Paramics to determine likely future Levels of Service from the Local Structure Plan network below and the impacts on Youle-Dean Road in particular to the south. All future projections of traffic flows have been calculated with a 3% per annum average traffic growth rate.

Figure 11 - The Subject Structure Plan area and the surrounding LSP areas



Major Road and Pedestrian Network

The road network described below is consistent with the sub-regional Planning and Transport outcomes (APP for DPI and City of Swan, January 2008) with the exception of the Perth to Darwin National Highway which we understand is to be realigned as part of the current Northlink Tonkin Highway projects.

The road network has been developed and agreed in principle through a collaborative approach to the sub-regional planning process with the City of Swan, DPI, PTA and MRWA. The key features of the ultimate road network are described below. This includes a classification of the road network outside of the District Structure Plan area for completeness. The network described is consistent with the subregional planning outcomes.

External to the District Structure Plan area

- The existing Lord Street will be retained in part as a district distributor road. It is expected that by 2025 Lord Street will be upgraded to a four lane carriageway.
- Partridge Street will provide access to Lord Street via Youle-Dean Road and Park Street, which in turn will provide access to Reid Highway. This connection is needed to maintain and enhance connectivity for traffic and buses.
- Partridge Street to the north will allow for connection to Lord Street via Park Street, providing an important connection to Henley Brook and Ellenbrook.
- Henley Brook Avenue forms the eastern boundary and is reserved as an Other Regional Road under the MRS. It will be a four lane dual carriageway with an operating speed of 60km/hr and connect through to Gnangara Road (in the north) and Reid Highway (in the south) via the existing West Swan Road. It is considered a potential future bus route.

- Reid Highway will be upgraded to freeway standard, with full grade-separated access control with Henley Brook Avenue and Lord Street.
- West Swan Road would connect with Henley Brook Avenue.
- Lord Street will be realigned through Dayton into the former PDNH alignment to the west of the existing Lord Street alignment. The existing Lord Street alignment south of Youle-Dean Road will be downgraded to a Neighbourhood Connector providing direct connection between Brabham and Dayton.

Internal to the District Structure Plan area

- Partridge Street is proposed to become the alignment for a north-south district distributor (B) providing for district level movements both within Albion and through to Ellenbrook in the north and Caversham to the south.
- Youle-Dean Road is proposed as an Other Regional Road under the MRS. West from the intersection with Partridge Street, Youle-Dean Road will be a four lane single carriageway, with an operating speed of 60 km/hr, designed to District Distributor B standards. East of Partridge Street Youle-Dean Road will be a two lane carriageway. The intersection of Youle-Dean Road and Lord Street will be configured as a signalised intersection.
- Woollcott Avenue will be upgraded to an urban road, designed as a Neighbourhood Connector A/B, with an operating speed of 50 km/hr.

3. Transport Impact Assessment Checklist for a Structure Plan

The following is the summary / checklist for a Transport Impact Assessment as shown in the Department for Planning and Intrastructure's Transport Assessment Guidelines – Part 2: Structure Plans.

Item	Status	Comments / Proposals
Summary	Y	The Structure Plan proposes 323 lots (residential land use) and 1 grouped housing.
Introduction / Background	Y	KCTT have completed a Transport Impact Assessment using the data from the Structure Plan Area. We have completed this report and all supporting graphics in accordance with the full requirements of the WAPC Guidelines for the preparation of a Transport Impact Assessment – Part 2 (Structure Plans).
Structure Plan Proposal		
Regional Context	Y	The proposed Structure Plan fits within the general regional context. It is a part of the Albion District Structure Plan.
Proposed Land Uses	Y	Lot 345 Woollcott Avenue, Brabham is a homogeneous residential area. It comprises of 324 lots (323 individual lots (residential land use) and 1 grouped housing lot). Total Area of the subject area is 11.35 ha.
Table of Land Uses and Quantities	Y	Refer Appendix 1 of this report for a detailed plan of the proposed land uses and yields. Refer Section 2.1 of this report for the summary of the quantities of the proposed uses.
Major Attractors / Generators	Y	The major trip generators in this locality will be: • Residential - morning and afternoon peaks are likely to be around 7:00am to 8:00am and 5:00pm to 6:00pm during work days. No trip attractors - residential land use only.
Specific Issues	Y	KCTT have reviewed the impact of the proposed development on the local and regional road network and have found the impact of the development is in accordance with the proposed road hierarchies and their cross-sectional capacities.
Existing Situation		
Existing Land Uses Within the Structure Plan Area	Y	The existing land zoning is residential.
Existing Land Uses Within 800 metres of the Structure Plan Area	Y	Residential and remnant rural land use.
Existing Road Network Within the Structure Plan Area	N/A	N/A

Existing Pedestrian / Cyclist Network Within the Structure Plan Area	N/A	N/A
Existing Public Transport Services Within the Structure Plan Area	N/A	N/A
Existing Road Network Within 800 metres of the Structure Plan Area	Y	Key desire lines: - • Murray Road • Woollcott Avenue • Park Street • Partridge Street • Youle-Dean Road • Henley Brook Avenue (future) • Lord Street (both existing Lord Street alignment and the proposed realignment of "New Lord Street" into the former PDNH)
Traffic Flows on Roads Within the Structure Plan Area (including AM / PM peak flows)	Y	Refer Section 2.3.1 for the proposed traffic flow onto the proposed roads within the subject site.
Traffic Flows On Roads Within 800 metres of the Structure Plan Area	Y	Refer Section 2.2 for the existing traffic flows on the adjacent road network.
Existing Pedestrian / Cycle Paths Within 800 metres of the Structure Plan Area	Y	There is Pedestrian Path in some parts of Partridge Street.
Existing Public Transport Routes Within 800 metres of the Structure Plan Area	N/A	N/A
Proposed Internal Transport Networks		
Changes / Additions to existing road network or proposed road network	Y	Refer Section 2.7
Road reservation widths	Y	Refer Section 2.7
Road cross sections and speed limits	Y	Refer Section 2.7
Intersection controls	Y	All the proposed intersections are designed to have full unrestricted movement of vehicles.

Pedestrian / cycle networks and crossing facilities	Y	Internal pedestrian networks have been considered along all internal roads within the subject site. **On-Road Cycle Lanes** • Woollcott Avenue **Dual Use Paths** • Road 06 (Extension of Arpent Link) (north-south connectivity) • Road 07 (east-west connectivity); and • Road 15 (east-west connectivity adjacent to the southern POS) **Footpaths** • All other roads (except Laneways)
Public transport routes	N/A	N/A
Changes to External Transport Networks		
Road Networks	N	No change proposed.
Intersection Controls	N	No change proposed.
Pedestrian Cycle Networks and Crossing Facilities	N	Existing and future cycle networks have been noted. Connectivity to future pedestrian and cycle networks has been flagged in this report.
Public Transport Services	Y	Existing bus services nominated, with potential relocation of bus services into Road 06 (Extension of Arpent Link).
Integration with Surrounding Area		
Trip Attractors / Generators Within 800 metres of the Structure Plan Area	Y	Two Primary Schools are proposed to the North-East and North-West of the Structure Plane Area which would work as trip attractors within 800 metres of the Structure Plan Area.
Proposed Changes to Land Uses Within 800 metres of the Structure Plan Area	Y	Proposed suburban residential development to the south, north, east and west of the Structure Plan Area.
Travel Desire Lines from the Structure Plan Area to Trip Attractors / Generators Within 800 metres of the Structure Plan Area	Y	• Woollcott Avenue for travel to the east and west (toward West Swan Road and to Youle-Road for access to Lord Street, or to Partridge Street for access to Lord Street); • Partridge Street and Murray Road provide connectivity to the north (Park Street and Lord Street) and south (Youle-Dean Road).

Adequacy of External Transport Networks	Y	The existing external transport networks are suitable for the proposed Structure Plan Area. The Structure Plan Area has strong connectivity to major road networks including West Swan Road, Henley Brook Avenue and Lord Street.
Deficiencies in External Transport Networks	N/A	N/A
Remedial Measures to Address These Deficiencies	N/A	N/A
Analysis of Internal Transport Networks		
Assessment Year(s) and Time Period(s)	Y	Traffic assessed as a base case, based on 2015 traffic volumes from MRWA. No formal staging of the Structure Plan Area has been considered in this assessment. It is expected that the development would be completed by 2018.
Structure Plan Generated Traffic	Y	Refer Table 5 - Section 2.3.1
Extraneous (Through) Traffic	Y	Through Traffic modelled for the following land uses: - • Existing traffic volumes on Park Street from West Swan Road to the north of the Structure Plan Area. • Existing traffic volumes on Woollcott Avenue from West Swan Road to the south of the Structure Plan Area. • Estimated traffic from the proposed LSP areas adjoining the proposed Structure Plan area.
Design Traffic Flows (i.e. Total Traffic)	Y	Proposed Local Structure Plan area traffic flows + existing Main Roads WA data provides the likely total vehicular flows for the current Structure Plan assessment. Refer Section 2.3.
Road Cross-Sections	Y	Refer Section 2.7
Intersection Controls	Y	Refer Section 2.7
Access Strategy	Y	Refer Section 2.7
Pedestrian / Cycle Networks	Y	Pedestrian and cycle networks have been considered in detail in this report.
Safe Routes to Schools	Y	Pedestrian and cycle networks to future school locations have been considered with a hierarchy for Dual Use Paths and footpaths provided throughout the Structure Plan area, considering future linkages to schools.
Pedestrian Permeability and Efficiency	Y	All roads except laneways feature footpaths and / or Dual Use Paths on at least one side of the road reservation. The Structure Plan will be linked at all corners to existing and / or future path networks, ensuring a permeable and efficient network.

Access to Public Transport	Y	Existing bus service routes 955 and 956 (along Lord Street) and 335 (along West Swan Road) approximately 1,500 metres to the west and 2,000 metres to the East of the subject site. This access will be improved once the road networks internally within the Albion District Plan area are upgraded suitably.
Analysis of External Transport Networks	Y	Review of road and transportation networks undertaken to within an 800m radius of the Structure Plan Area.
Conclusions	Y	The development of the subject site does not adversely impact the future designated road network. The internal roads have been sized to cater for their respective daily vehicular flows and to suit minimum requirements of the City of Swan, as well as stormwater drainage requirements on the western side of Road 06 (Extension of Arpent Link). Intersection improvements / controls have been nominated for all intersections requiring additional traffic intervention (i.e roundabout, signage etc.)

Appendix 1

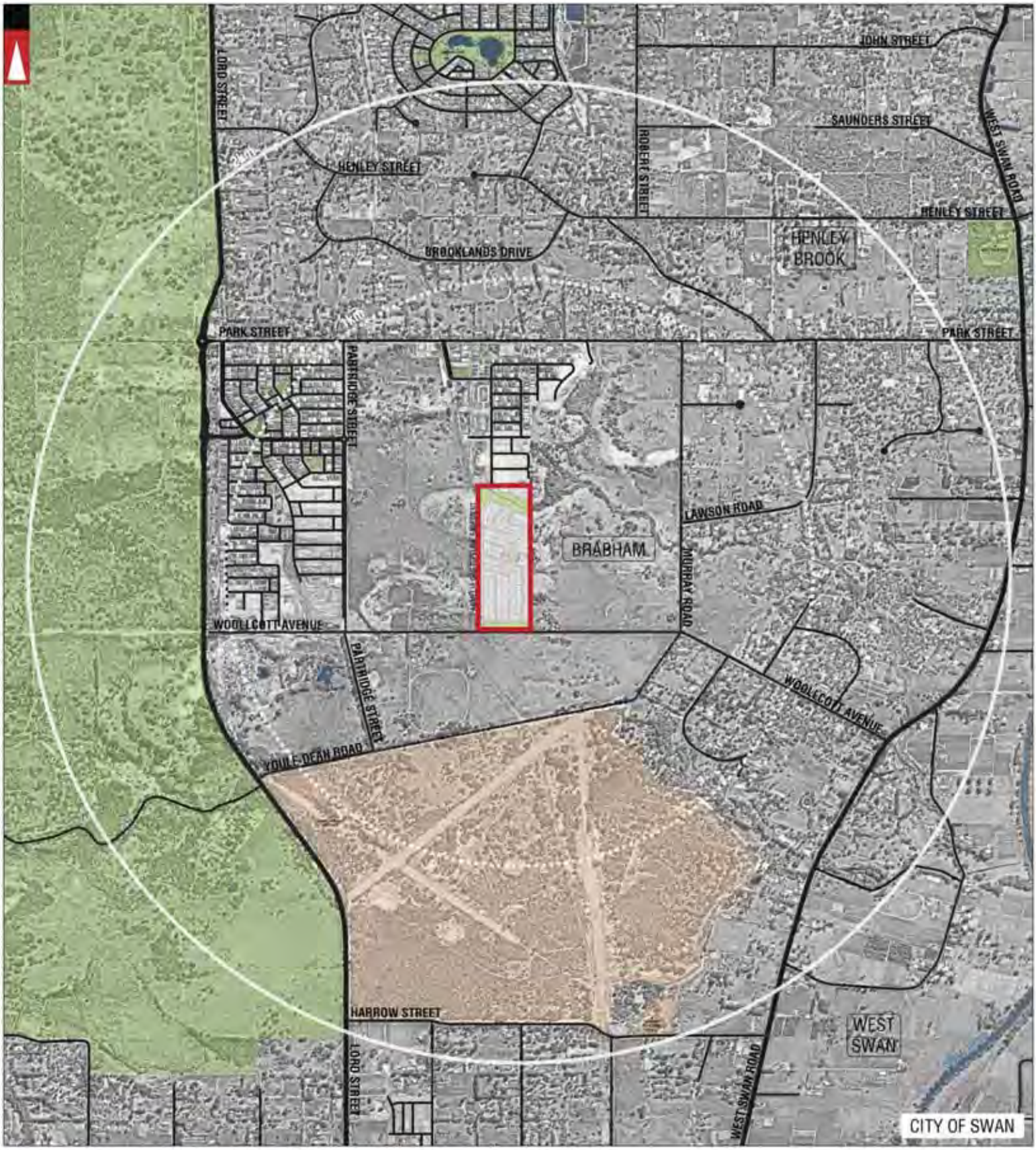
Layout of the proposed development

CONCEPT PLAN
Lot 345 Woollcott Avenue, Brabham
City of Swan

plan no: 3403-09F-01
scale: 1:2500@A3, 1:1250@A1
date: 09.03.2016

Appendix 2

Transport Planning and Traffic Plans



BRABHAM

WOOLLCOTT AVE

LEGEND

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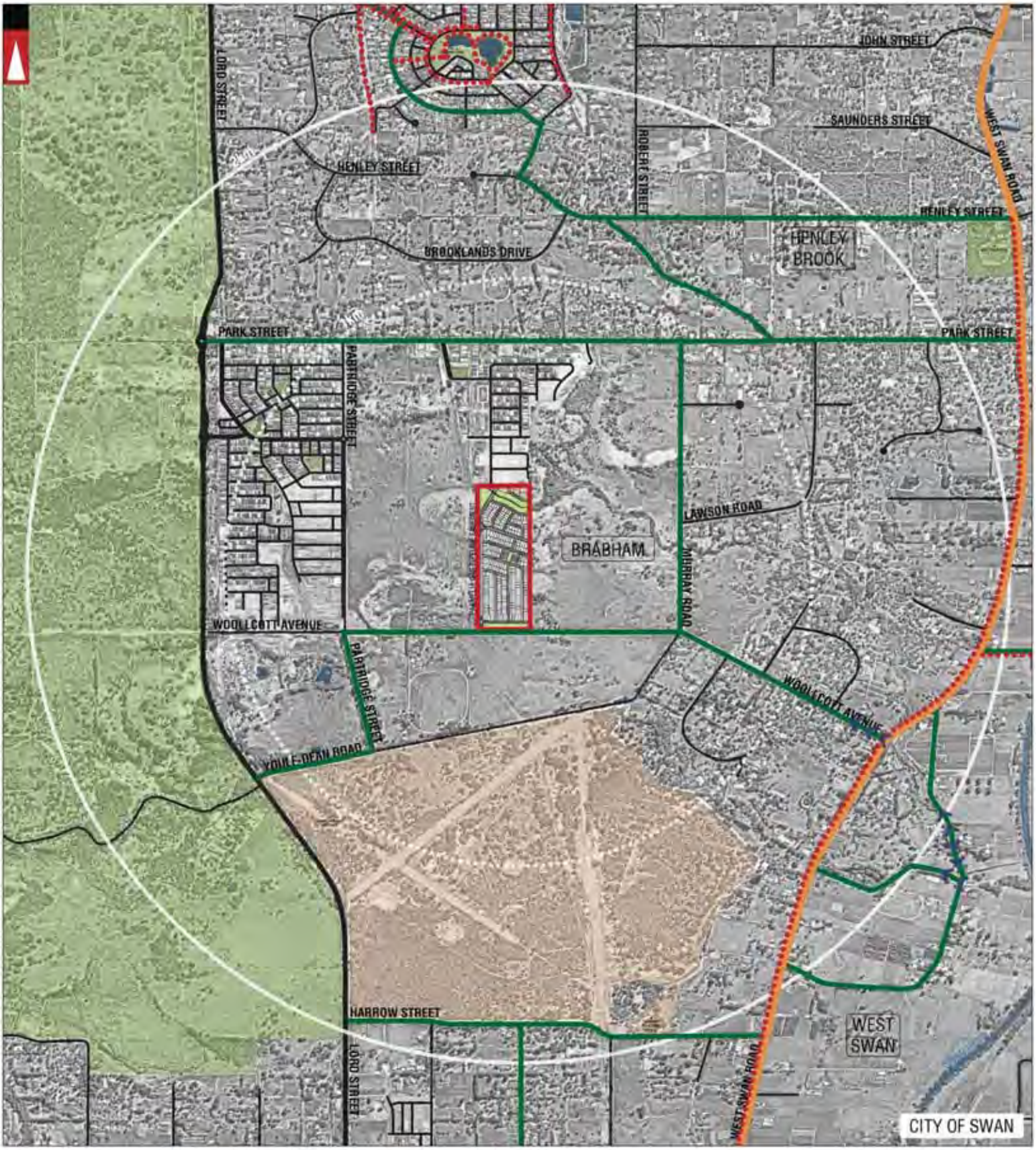
B	01-04-2016	PROPOSED LAYOUT AMENDED	TITLE: LOCALITY PLAN - 2KM RADIUS	A.N.	
A	30-07-2015	ISSUED FOR REVIEW	DRAWING NUMBER: KC00337.000_S01		
No	DATE	AMENDMENT			



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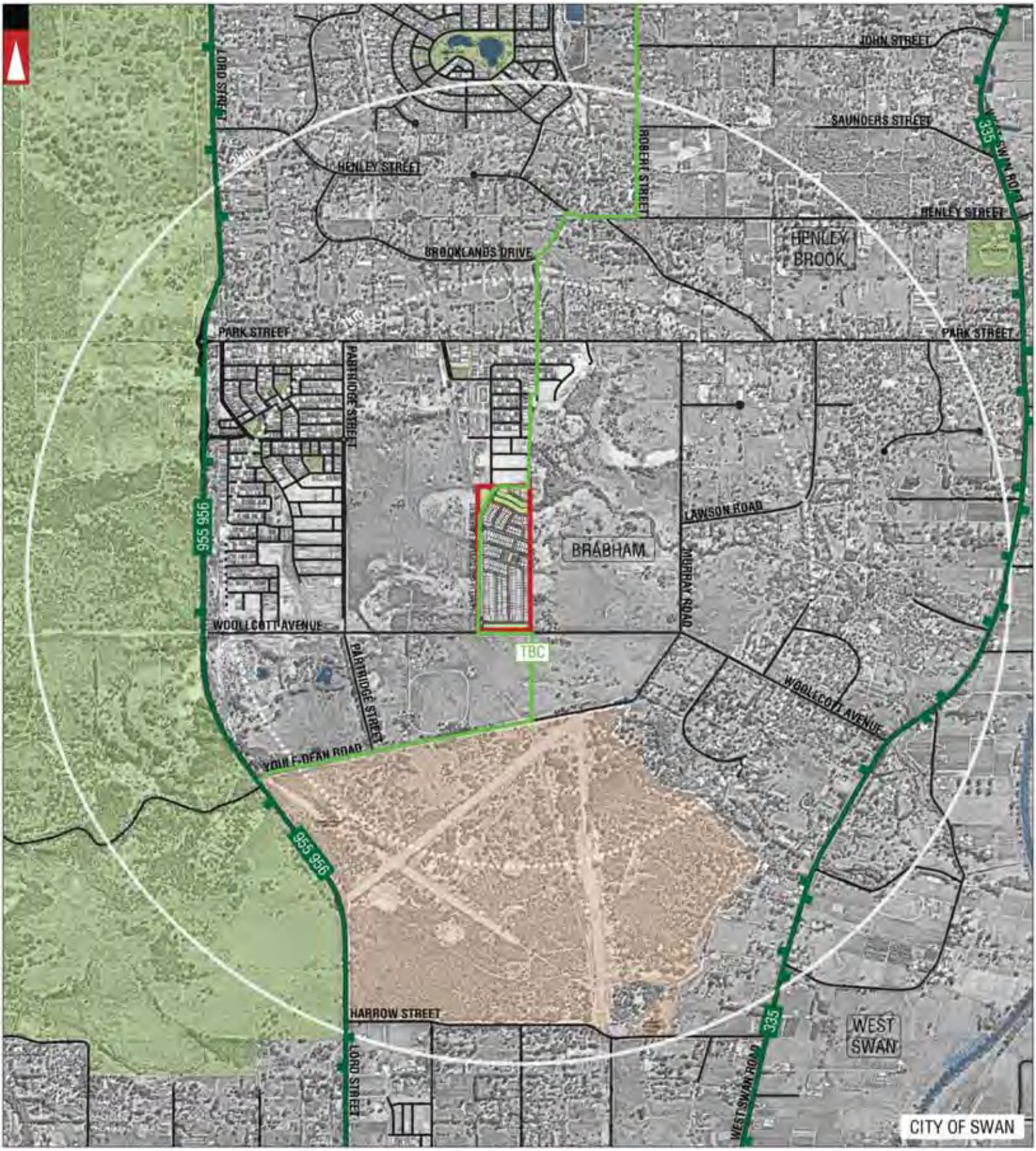
B	01-04-2016	PROPOSED LAYOUT AMENDED	TITLE: BICYCLE NETWORK PLAN - 2KM RADIUS	A.N.	
A	30-07-2015	ISSUED FOR REVIEW	DRAWING NUMBER: KC00337.000_S02		
No	DATE	AMENDMENT			



No	DATE	AMENDMENT
B	01-04-2016	PROPOSED LAYOUT AMENDED
A	30-07-2015	ISSUED FOR REVIEW

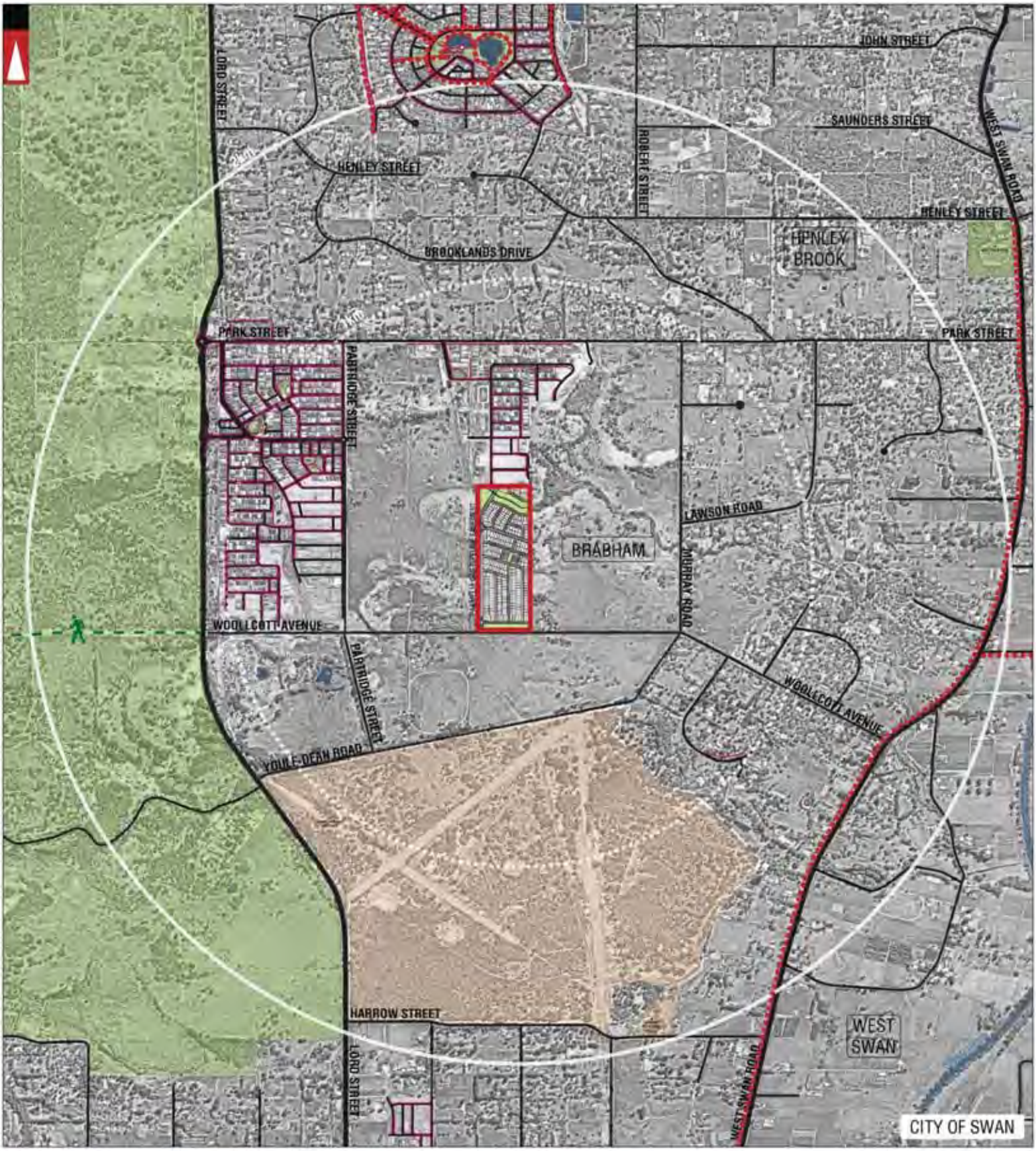
PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: PUBLIC TRANSPORT PLAN - 2KM RADIUS

DRAWING NUMBER: KC00337.000_S03

DRAWN BY: A.N.

kctt



LEGEND

No	DATE	AMENDMENT
B	01-04-2016	PROPOSED LAYOUT AMENDED
A	30-07-2015	ISSUED FOR REVIEW

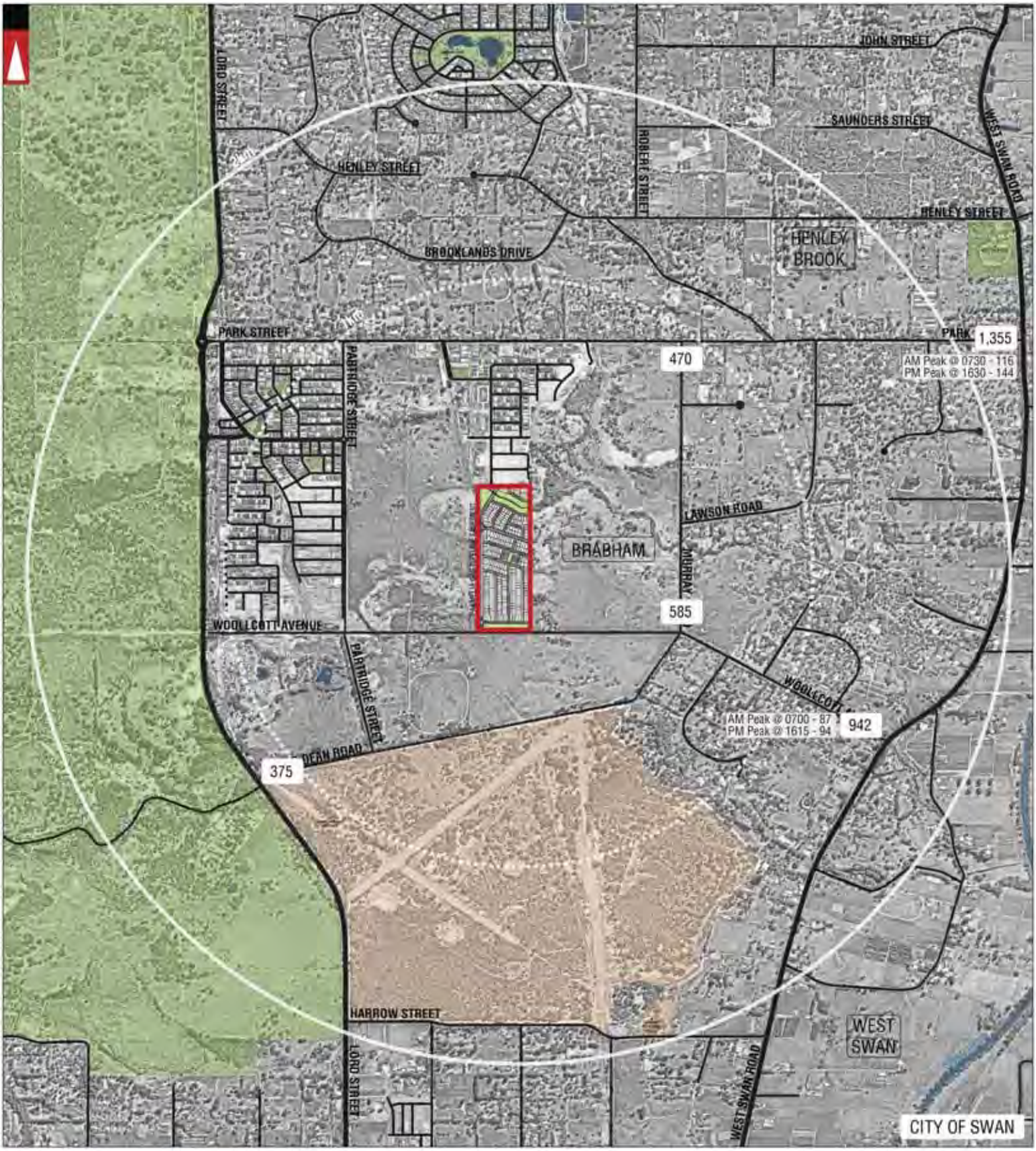
PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: PEDESTRIAN PATHS PLAN - 2KM RADIUS

DRAWING NUMBER: KC00337.000_S04

DRAWN BY: A.N.

kctt



LEGEND

No	DATE	AMENDMENT
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A	30-07-2015	ISSUED FOR REVIEW

PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: EXISTING TRAFFIC COUNTS - 2KM RADIUS

DRAWING NUMBER: KC00337.000_S05

DRAWN BY: A.N.

kctt

LOCATION BOUNDARY

RAILWAY

740 / 1,230 DEVELOPMENT VPD

BRABHAM LOCAL GOVERNMENT NAME

ROAD (VARIED WITH ROAD WIDTH)

TRAFFIC FLOW IN DIRECTION

TRAFFIC FLOW OUT DIRECTION

WOOLLCOTT AVE ROAD NAME

LEGEND

No	DATE	AMENDMENT
C	01-04-2016	PROPOSED LAYOUT AMENDED
B	01-03-2016	ROAD HIERARCHY AMENDED
A	30-07-2015	ISSUED FOR REVIEW

PROJECT:
LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE:
TRAFFIC FLOW DIAGRAM

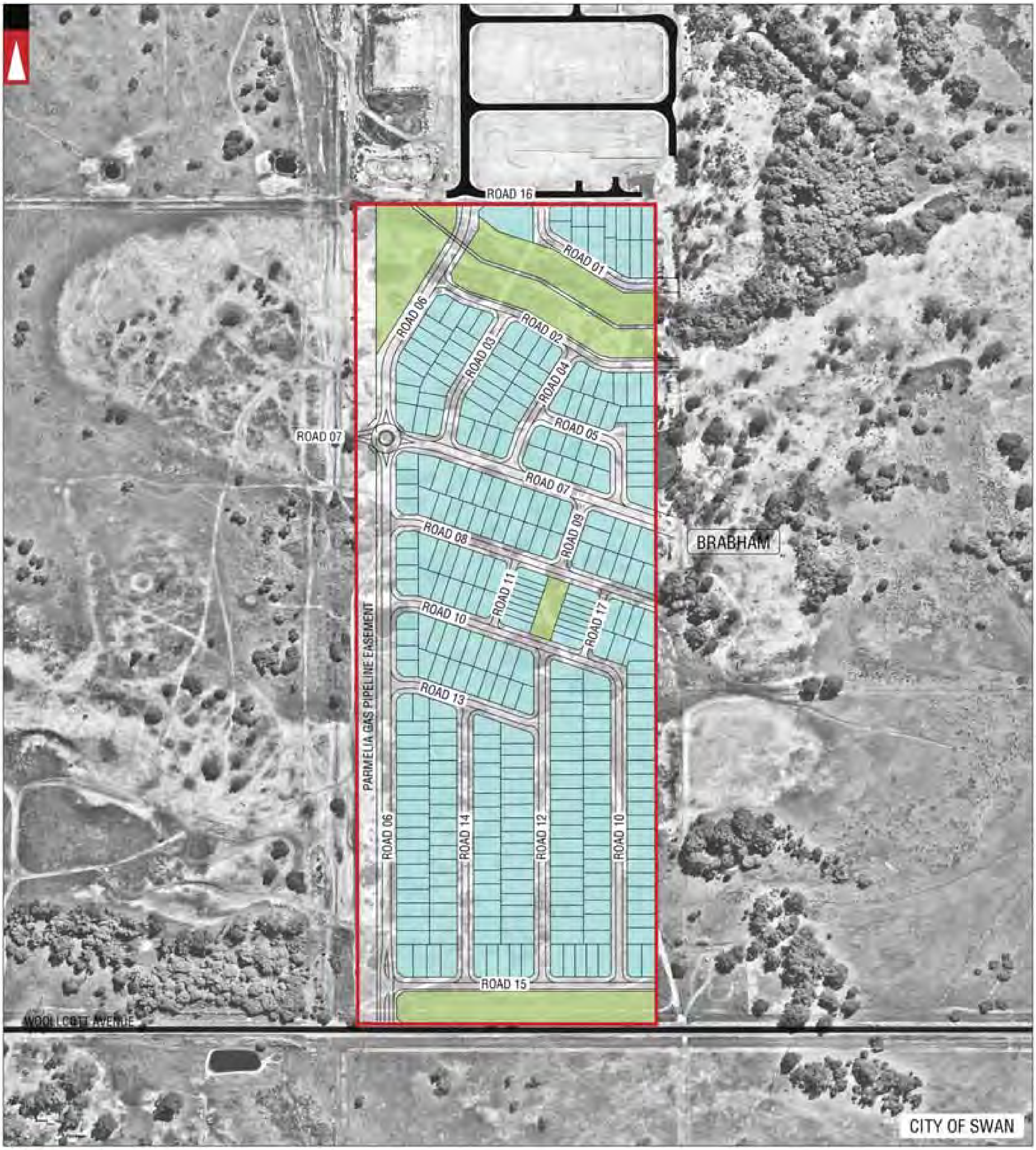
DRAWING NUMBER:
KC00337.000_S06

DRAWN BY: A.N.

kctt

			PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP	DRAWN BY:	
C	01-04-2016	PROPOSED LAYOUT AMENDED			
B	01-03-2016	ROAD HIERARCHY AMENDED	TITLE: TRAFFIC FLOW DIAGRAM AM / PM PEAK	A.N.	
A	30-07-2015	ISSUED FOR REVIEW			
No	DATE	AMENDMENT	DRAWING NUMBER: KC00337.000_S07		

kctt



LOCATION BOUNDARY

BRABHAM — LOCAL GOVERNMENT NAME

RAILWAY

ROAD (VARIED WITH ROAD WIDTH)

WOOLLCOTT AVE — ROAD NAME

LEGEND

No	DATE	AMENDMENT
C	01-04-2016	PROPOSED LAYOUT AMENDED
B	01-03-2016	ROAD HIERARCHY AMENDED
A	30-07-2015	ISSUED FOR REVIEW

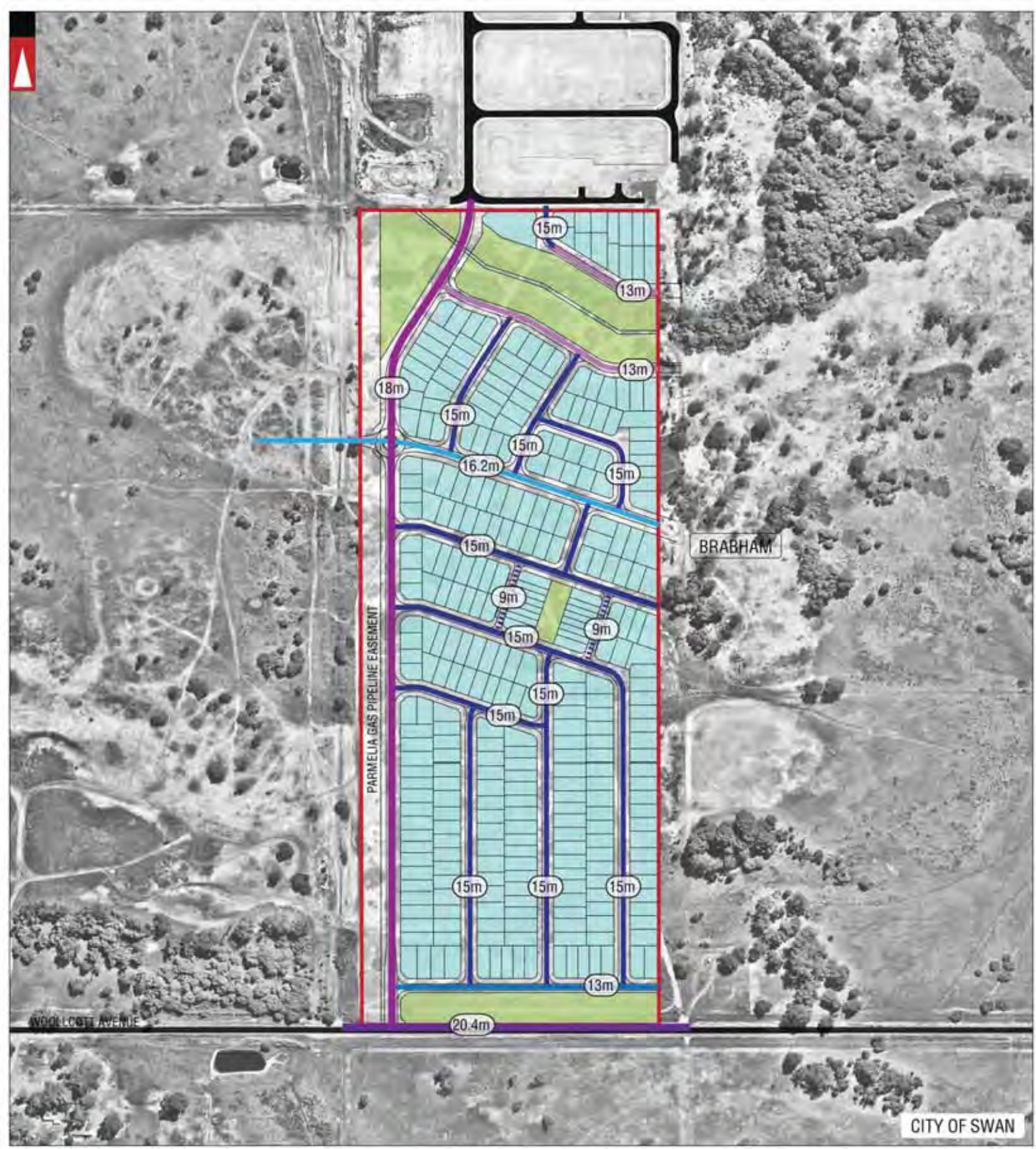
PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: ROAD NAMING CONVENTION

DRAWING NUMBER: KC00337.000_S10

DRAWN BY: A.N.

kctt



LOCATION BOUNDARY

BRABHAM LOCAL GOVERNMENT NAME

FAIRWAY

ROAD (VARIES WITH ROAD WIDTH)

WOOLLCOTT AVE ROAD NAME

15m WIDTH OF ROAD RESERVATION

ACCESS STREET D

ACCESS STREET D MODIFIED

LANE WAY

LEGEND

No	DATE	AMENDMENT
C	01-04-2016	PROPOSED LAYOUT AMENDED
B	01-03-2016	ROAD HIERARCHY AMENDED
A	30-07-2015	ISSUED FOR REVIEW

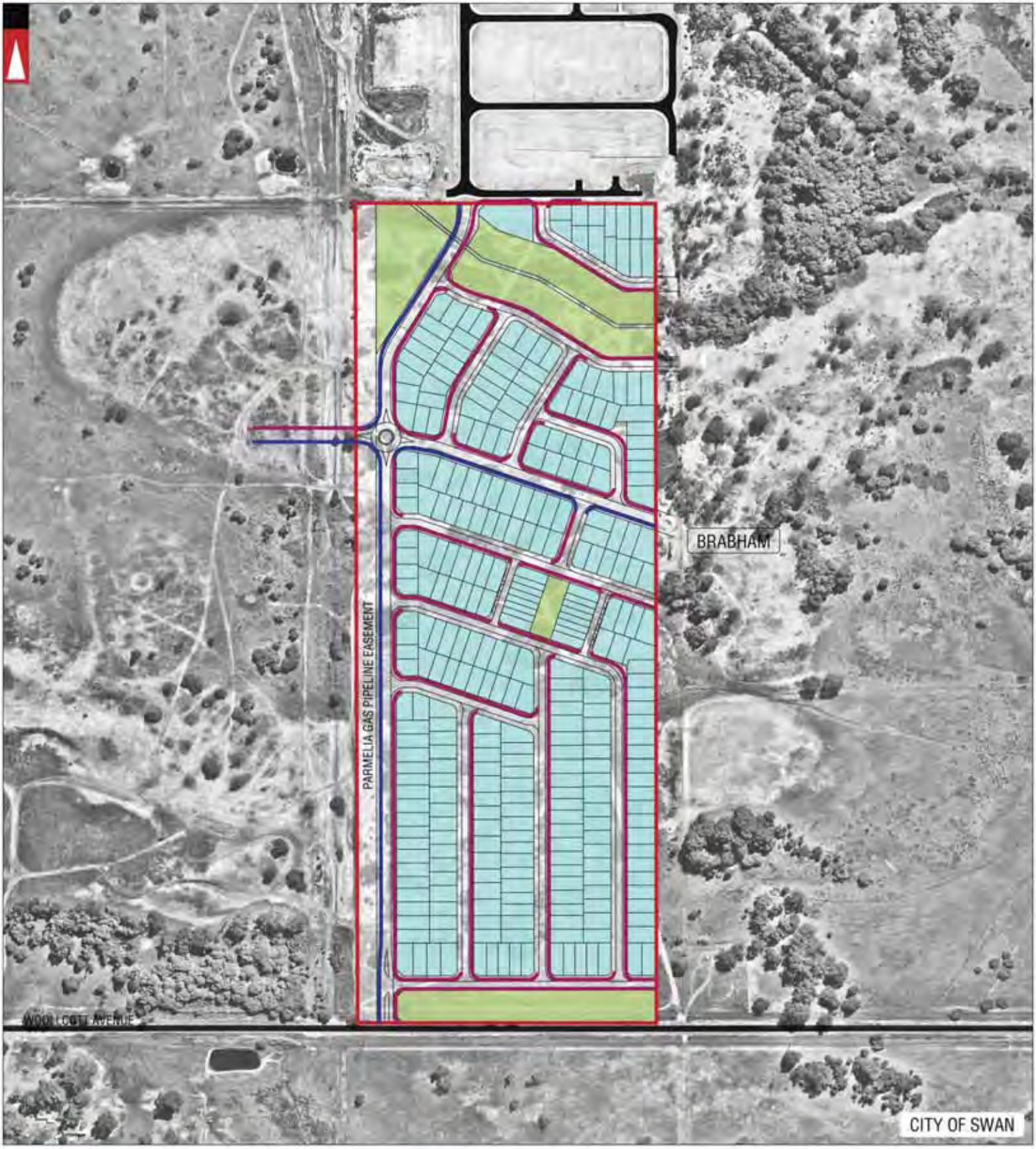
PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: ROAD HIERARCHIES SKETCH

DRAWING NUMBER: KC00337.000_S11

DRAWN BY: A.N.

kctt



LEGEND

No	DATE	AMENDMENT
C	01-04-2016	PROPOSED LAYOUT AMENDED
B	01-03-2016	ROAD HIERARCHY AMENDED
A	30-07-2015	ISSUED FOR REVIEW

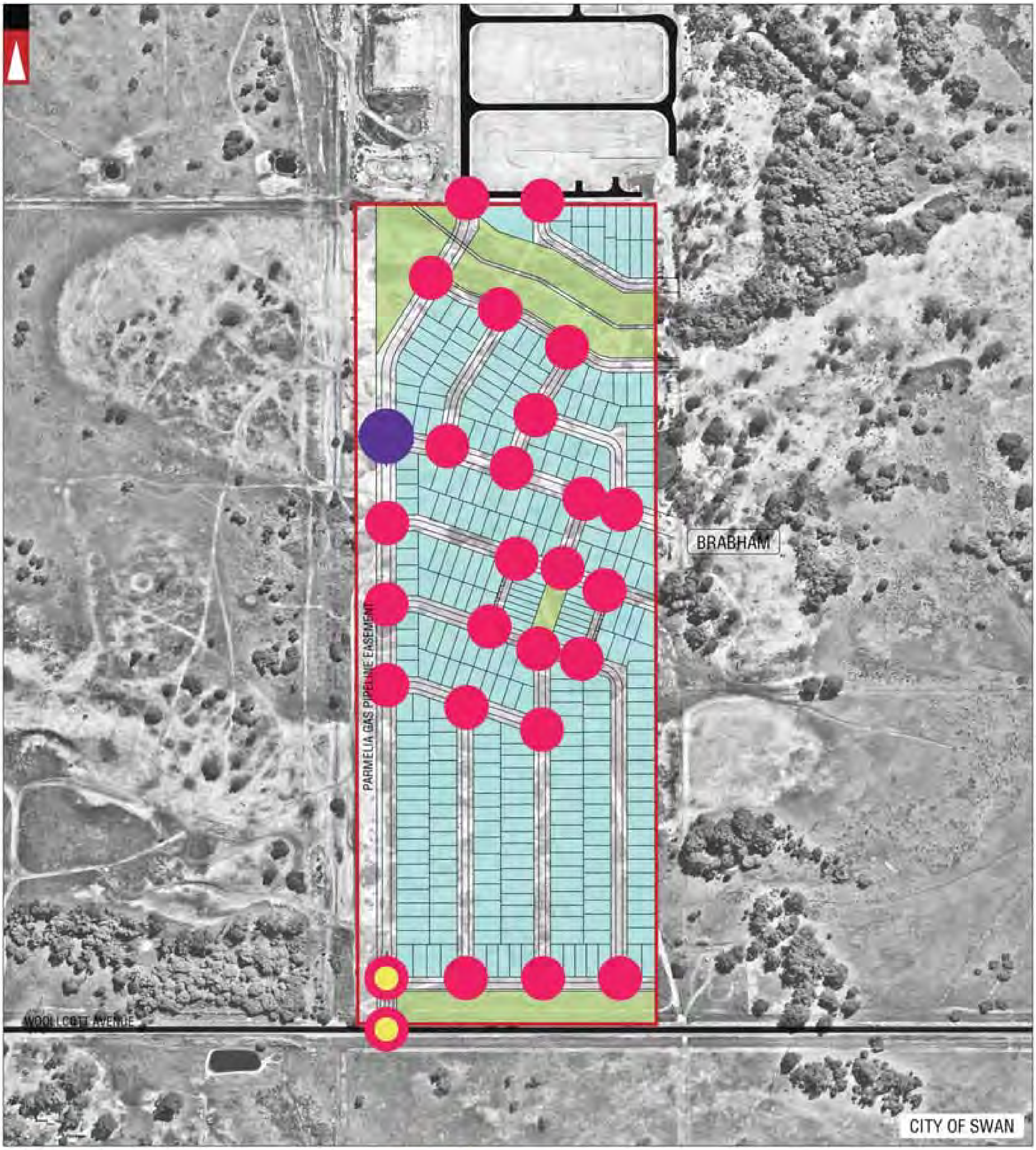
PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: PROPOSED PEDESTRIAN PATHS

DRAWING NUMBER: KC00337.000_S12

DRAWN BY: A.N.

kctt



LEGEND

(red outline)	LOCATION BOUNDARY
(hatched line)	RAILWAY
BRABHAM	LOCAL GOVERNMENT NAME
(dark bar)	ROAD (VARIED WITH ROAD WIDTH)
WOOLLCOTT AVE	ROAD NAME
(purple circle)	ROUNDABOUT
(pink circle with yellow centre)	T-INTERSECTION - GIVE WAY WITH MEDIAN SPLITTER ISLAND
(pink circle)	T-INTERSECTION YIELD STREET

No	DATE	AMENDMENT
C	01-04-2016	PROPOSED LAYOUT AMENDED
B	01-03-2016	ROAD HIERARCHY AMENDED
A	30-07-2015	ISSUED FOR REVIEW

PROJECT: LOT 345 WOOLLCOTT AVENUE BRABHAM LSP

TITLE: INTERSECTION TREATMENTS

DRAWING NUMBER: KC00337.000_S13

DRAWN BY: A.N.

kctt