Western Australian Planning Commission

Your Ref: ODP-161/D Enquiries: Ms Joslin Colli
Our Ref: SPN/0113/1
Enquiries: David Carter (Ph 6551 9280)

Chief Executive Officer
City of Swan
PO Box 196
MIDLAND WA 6936

Attention: John Elliott

Dear Sir/Madam

MODIFICATION – CAVERSHAM NORTH LOCAL STRUCTURE PLAN

I refer to your letter dated 29 April 2014, regarding the abovementioned matter.

The Western Australian Planning Commission has resolved to endorse the modified Caversham North Local Structure Plan in accordance with Clause 5A.1.10 of the City of Swan Local Planning Scheme No. 17, adopted by the City of Swan on 29 April 2014.

Please find enclosed, two endorsed copies of the modified Local Structure Plan.

Should you wish to discuss this matter further, please contact the assigned planning officer listed above.

Yours faithfully

T Hillyard

Tim Hillyard
Secretary
Western Australian Planning Commission
18 August 2014

cc: RobertsDay, 130 Royal Street, East Perth WA 6004

Enclosures: Two copies of Local Structure Plan together with two copies of supporting document "2.4.4 Urban Growth Policy"

2.4.4 Urban Growth Policy

The CNLSP Plan has been prepared having due regard to the requirements of this Policy. In particular, the requirement to meet the Policy's density target of 22 dwellings per hectare (du/ha) was taken into consideration during the design process. The CNLSP has managed to achieve the density target of 22.2du/ha. Calculations to achieve this density are follows"

Area of residential zoned land -	20.61ha
Proposed number of dwellings -	459 dwellings
Proposed density -	22.2 du/ha

Whilst the proposed density falls just short of the City's Policy by 0.02du/ha, the proposed density is considered acceptable for the following reasons:

- Element 1 R3 of Liveable Neighbourhoods states that: Neighbourhood structure should have the following characteristics:

  Size and shape generally defined by a five-minute walk from the neighbourhoods centre to its perimeter, typically 400m (average residential density 22 dwellings per site hectare) to 450m (average residential density 20 dwellings per site hectare).

  The Caversham North Local Structure Plan meets the above Liveable Neighbourhoods requirements;

- The Caversham North Local Structure Plan is the first structure plan for the Caversham Urban Cell. A structure plan for the remainder of the Caversham Urban cell is currently being finalised. The density for the overall Caversham Urban Cell, as advised by the main landowner consultant, is approximately 24du/ha;

- The mix and balance of lots sizes and dwelling types is vital for the success of a greenfield subdivision on the periphery of the Perth urban area. The proposed mix of lot types is considered appropriate for the site. If the overall density of the CNLSP was increased this would compromise this balance and would also result in a poorer urban design outcome via the creation of lots with lower amenity. This current mix of dwelling types is as follows:

R-CODE DENSITY	DWELLING YIELD	% OF DWELLINGS
R10	1	0.2%
R20	226	51%
R25	86	19%
R30	91	17.8%
R50	55	12%
TOTAL	459	100%

- The provision of density in greenfield residential developments does not generally occur until such time that retail, educational and community facilities are provided. Conversely the provision of these facilities does not occur until there si a critical mass of residents. It is therefore typical that the first stages of greenfield developments, such as the Caversham North Local Structure Plan, commence development with a lower density. As the population grows and more facilities are provided then the density is increased. This is demonstrated by the proposed increased densities around the proposed neighbourhood centre, primary school and community centre on the southern side of Suffolk Street.

CITY of SWAN
APPROVED STRUCTURE PLAN
No: ODP-161/D
Date: 29 APR 2014
Coordinator, Statutory Planning

ENDORSEMENT OF MODIFICATION TO CAVERSHAM NORTH LOCAL STRUCTURE PLAN

The Western Australian Planning Commission resolved on 15 August 2014 to endorse the modified Local Structure Plan as a guide for future development and subdivision within the locality.

Signed for and on behalf of the Western Australian Planning Commission

an officer of the Commission duly authorised by the Commission pursuant to section 24 of the *Planning and Development Act 2005* for that purpose in the presence of:

M Wiecla Witness 18-8-2014 Date

Date of Expiry: 19 October 2030

ODP 161/D
29 04 2014
Construction

Notes

1. The Caversham North Local Structure Plan has been prepared in accordance with Part 5A of Local Planning Scheme No. 17. The Local Structure Plan is to be used to guide subdivision and development of the subject land. Land use permissibility within the Local Structure Plan area is to be determined by using the zones and reserves identified on the Local Structure Plan and assessing them against the permissibility's in the Zoning Table within Local Planning Scheme No. 17.
2. Completion of Suffolk Street west of Arthur Street to connect to the roundabout intersection with Bennett Street be constructed before or at subdivision clearance of deposited plan that generates the 230th lot (unit of equivalent demand). This will be constructed to a boulevard treatment as the Figure 6.1; Suffolk Street Cross Section in Appendix 12 to the western boundary of the Caversham DCA. Landowners will be required to contribute to the Suffolk Street extension and its intersection treatment proposed with Lord Street to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
3. Although the Caversham North Structure Plan area contributes to the need for Lord Street between the Reid Highway and Benara Road, the development itself is not of sufficient size to warrant construction. The trigger for construction will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the Lord Street extension and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
4. A right turn pocket at the intersection of West Swan Road and Suffolk Street to be constructed to Type CHR standards as defined in Austroads' Guide for Traffic Engineering Practice: Part 5 - Intersections at Grade (including lighting to the Australian standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the Early Release Area. The trigger for construction of the ultimate arrangement of this intersection will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the West Swan Road/Suffolk Street intersection and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
5. A right-turn pocket at the intersection of West Swan Road and Arthur Street to be constructed to Type CHR standards as defined in Austroads' Guide for Traffic Engineering Practice: Part 5 - Intersections at Grade (including lighting to the Australian standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the Early Release Area. The trigger for construction of the ultimate arrangement of this intersection will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the West Swan Road/Arthur Street intersection and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
5. At the commencement of development outside the Early Release Area (10s lots) Suffolk Street is to be upgraded to a rural standard from the intersection of Suffolk Street and Arthur Street through to West Swan Road, with a carriageway width of 7.4 metres. This upgrade can only be viewed as an interim solution, for which an offset would only be appropriate under the proposed Development Contribution Plan if the extant works are able to form part of the final road treatment. The trigger for upgrading Suffolk St to urban standard, between Arthur St and West Swan Road, will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the ultimate Suffolk Street upgrade and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
6. The trigger for construction of the community facilities will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to development of the proposed community facilities and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
7. The trigger for construction of the shared use oval will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to development of the proposed oval and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
8. The following notification will be placed on the Certificates of Title of all lots created within the Caversham North Local Structure Plan:
Notice: This Lot is situated in the vicinity of major transport corridors. Residential amenity may be affected by noise from current or future traffic activity within these corridors. As a result, there may be a need to incorporate appropriate features in the design and construction of buildings to mitigate against any noise impacts, with special consideration given to noise attenuation measures for two storey dwellings. Further information about quiet house design standards for traffic noise affected property is available on request from the City of Swan.

Legend

- Subject Lot
- Approximate 132Kv Powerline Easement
- 2.4m High Acoustic Wall

Local Scheme Reserves

- Local Road
- Public Purposes (Temporary Sewer Pump Location)
- Recreation

Metropolitan Region Scheme Reserves

- Other Regional Roads

Zones

- Residential

Other

- R20 RCodes

Public Open Space Provision

POS	Function	Area
1	POS/Drainage	0.2429ha
2	POS	0.2398ha
3	POS/Drainage	3.0152ha
4	POS	0.3935ha

Estimated Residential Lot Yield

R10	1
R20	226
R25	86
R30	89
R50	1
Total	403

QUBE

Local Structure Plan
Caversham North
City of Swan

DEPARTMENT OF PLANNING
- 1 MAY 2014
FILE SPN/0113

ENDORSEMENT OF MODIFICATION TO CAVERSHAM NORTH LOCAL STRUCTURE PLAN

The Western Australian Planning Commission resolved on 13 August 2014 to endorse the Modified Local Structure Plan as a guide for future development and subdivision within the locality.

Signed for and on behalf of the Western Australian Planning Commission

an officer of the Commission duly authorised by the Commission pursuant to section 24 of the Planning and Development Act 2005 for that purpose in the presence of:

M.Ribello Witness 15.8.2014 Date

robertsday

FEBRUARY 2014

CAVERSHAM NORTH
LOCAL STRUCTURE PLAN

QUBE PROPERTY GROUP PTY LTD | robertsday

TITLE:	Caversham North Local Structure Plan
PROJECT:	Caversham North
PREPARED FOR:	QUBE Property Group + Premium Developments
REFERENCE:	QUB CAV
STATUS:	Final
VERSION:	9
DATE OF RELEASE:	February 2014
AUTHORS:	R. Darby
GRAPHIC DESIGN:	I. Franich
APPROVED BY:	D. White

CITATON

This document should be cited as follows:

Darby, R (2013). Caversham North Local Structure Plan - QUBE Property Group. City of Swan. Roberts Day Pty Ltd. February 2014

ABN 53 667 373 703, ACN 008 892 135

www,robertsday.com.au

CONTENTS

1.0 Introduction & Background

1.1 Introduction

The Caversham North Local Structure Plan (CNLSP) has been prepared to guide the subdivision and development of a group of lots known as Caversham North (the 'site'). The site is located within the Caversham Urban Cell of the Swan Urban Growth Corridor, which has an estimated potential population of 33,000 residents. The site has been appropriately zoned for urban development for a number of years but its subdivision and development has been delayed due to regional issues relating to the coordinated provision of services, integrated design and the resolution of developer contribution issues. A majority of these issues have now been addressed via the preparation of the Swan Urban Growth Corridor Sub-Regional Structure Plan and the draft Caversham Structure Plan, which encompasses the entire Caversham Urban Cell, including the site.

The design of the CNLSP aims to create a vibrant and sustainable extension to the Swan Urban Growth Corridor comprising a mix of lot sizes and dwelling types. The CNLSP proposes a highly interconnected street and path network, with linkages to the proposed urban development to the north, the proposed retail and education facilities to the south and the Swan Valley to the east. The design and layout of the CNLSP is sympathetic to the topography and landscape values of the site.

The CNLSP has been prepared based on a comprehensive review of relevant town planning, environmental and engineering considerations. The design proposes the creation of approximately 395 residential lots, with densities ranging from R20 (700m^2) through to an R50 grouped dwelling site.

The CNLSP has been prepared in accordance with Part 5A of the City of Swan's Local Planning Scheme No. 17.

The purpose of a Local Structure Plan is to guide the subdivision and development of appropriately zoned land.

In accordance with clause 5A 1.4 City is not to

- consider recommending subdivision; or
- approve development

of land within a Structure Planning are unless there is a structure plan for the area that adequately defines required to guide orderly subdivision and development for urban land use.

1.2 Site Description

1.2.1 Location

The subject land is located approximately 5 kilometres north-west of the Midland Sub-Regional Centre and approximately 14 kilometres north-east of the Perth CBD. Vehicle access to the property is provided from Arthur Street to the east and Suffolk Street to the south. Reid Highway forms the northern boundary of the site and Land Street road reserve forms the western boundary. Suffolk Street and Arthur Street are accessed directly from the West Swan Road, which provides access to Reid Highway. Great Northern Highway and Guilford Road.

The site has a total land area of 35.72 hectares and comprises of the following properties:

Please note that Suffolk Street was previously known as Patricia Street. Any reference to Patricia Street in this report or the supporting appendices shall be considered to be Suffolk Street.

Table 1 - Lot Details

LOT NUMBER	CERTIFICATE OF TITLE	AREA
2	Volume 502 Folio 51A	2.011ha
88	Volume 2078 Folio 5	5.49ha
89	Volume 1113 Folio 641	7.91ha
94	Volume 1242 Folio 337	3.96ha
96	Volume 2186 Folio 42	4.7ha
123	Volume 1079 Folio 978	2.7063ha
213	Volume 1461 Folio 4	4.454ha
214	Volume 1461 Folio 5	4.454ha

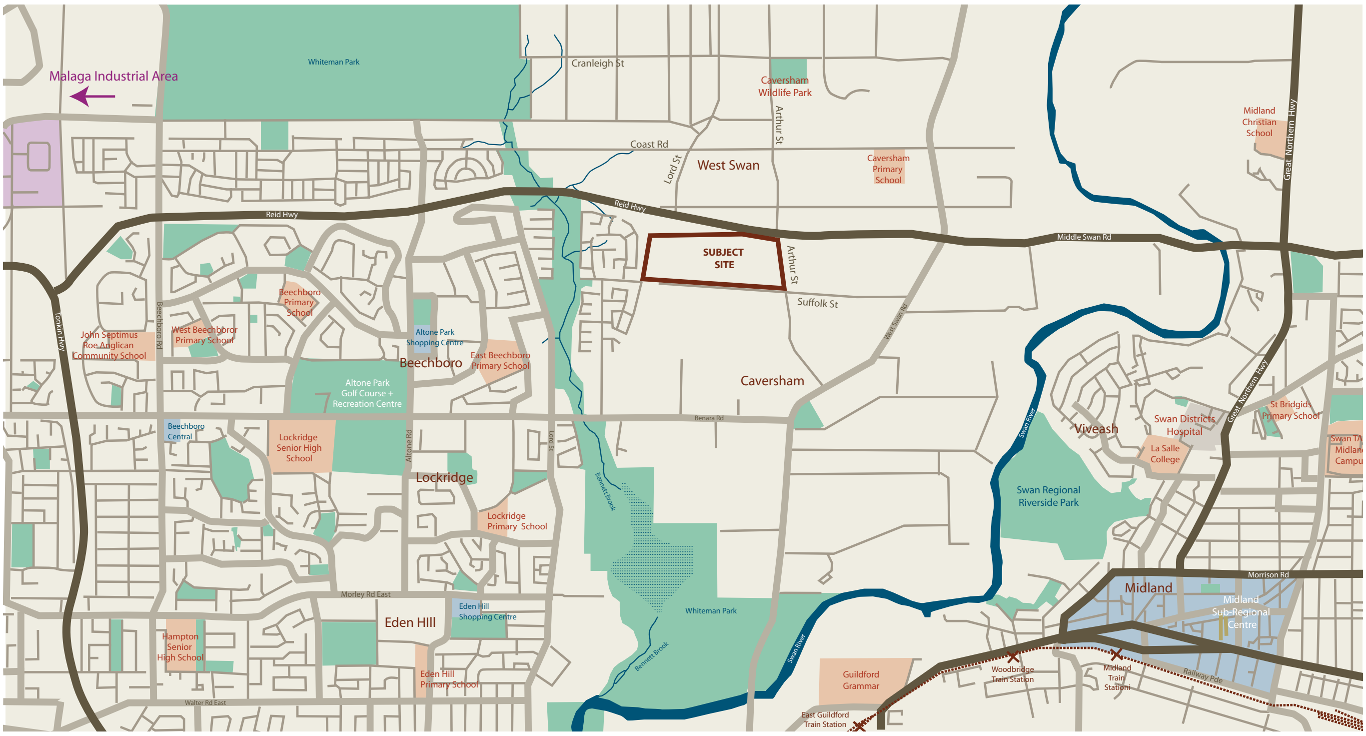
The subject land is in the ownership f Caversham Land Development Pty Ltd with the exception of Lot 96 which is currently owned by the Western Australian Planning Commission (WAPC). The WAPC has advised that they have no objection to a structure plan being prepared over their landholding (refer to Appendix 1).

Aerial Photo

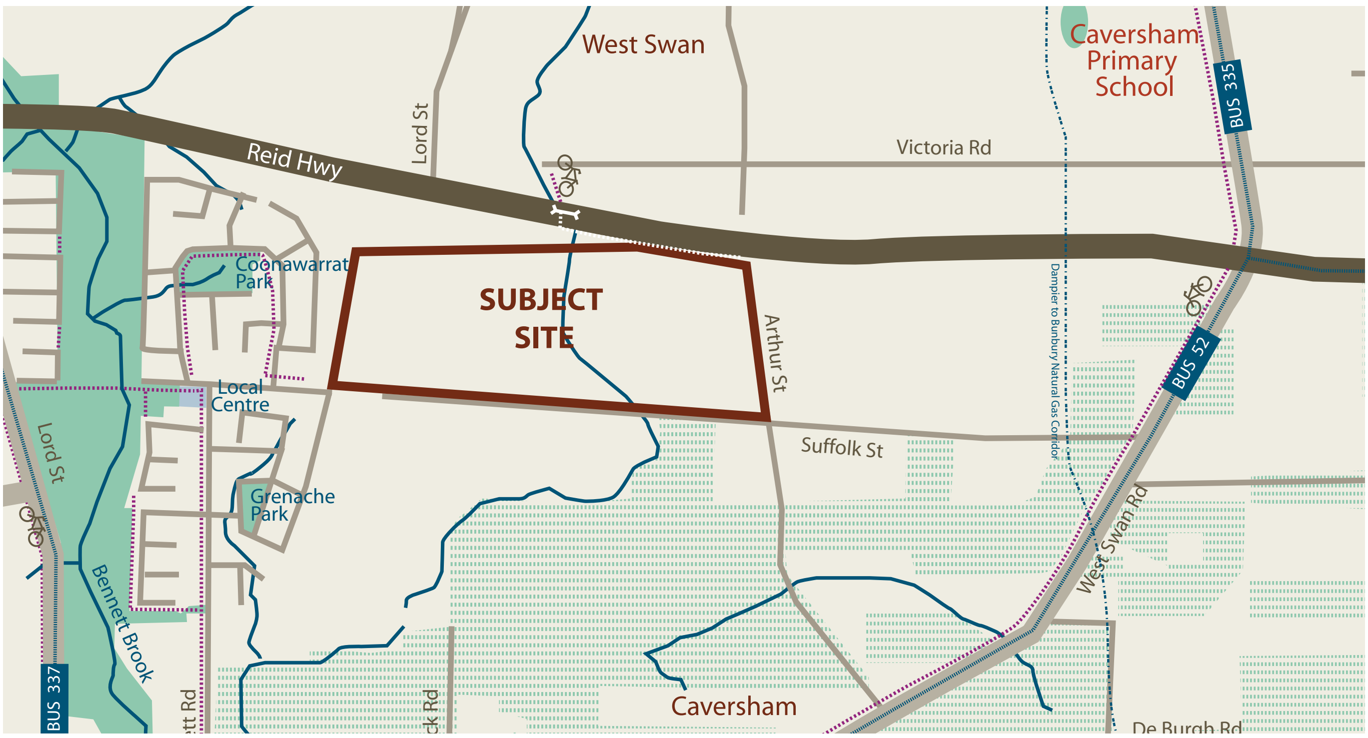
1.2.2 Existing Land Use & Development

The subject site comprises land which forms part of the Swan Coastal Plain and has previously been used to for livestock agistment purposes. There are no buildings constructed on the site and it is predominately cleared of vegetation.

Regional Context Plan



Local Context Plan



1.3 Project Backround

1.3.1 Project Team

The following multi-disciplinary project team, as listed below, have been engaged by QUBE Property Group on behalf of Caversham Land Development Pty Ltd to progress the preparation of a structure plan.

- Cardno - Traffic
- Coffey - Geotechnical Investigations
- Ecoscape - Landscape Architecture
- Emmerson Stewart - Engineering & Civil Engineer
- G Quartermaine - Archaeological
- Lloyd George Acoustics - Acoustics
- R & E O'Connor Pty Ltd - Ethnographic
- Roberts Day Town Planning + Design - Statutory planning & urban design
- RPS Environment - Environmental

1.3.2 Project Objectives

The principle objective of this document is to provide a sound planning basis for the future subdivision and development of land within the Caversham North Local Structure Plan area. More specifically, the objectives of the Local Structure Plan are as follows:

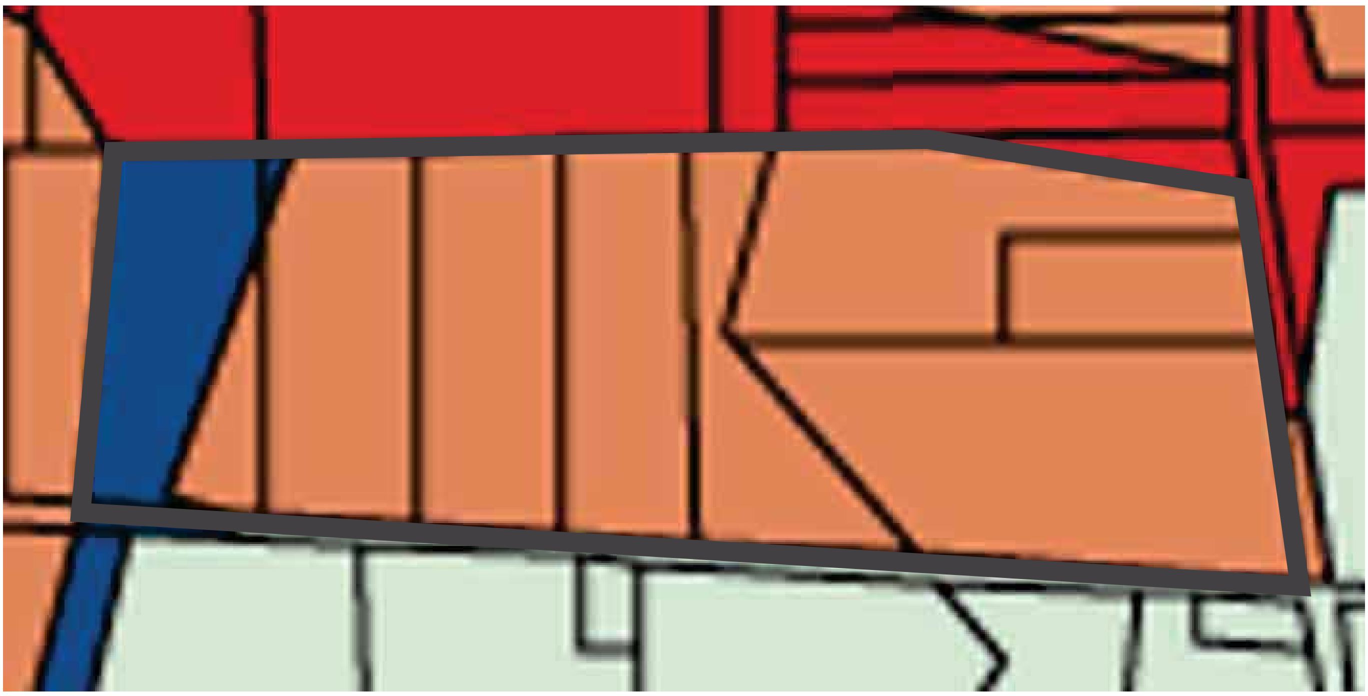
- To create a development that caters to those seeking a Swan Valley lifestyle that has a high standard of residential amenity and integrates well with the surrounding area;
- Provide a range of dwelling types and densities to accommodate a diverse residential community;
- Streets, laneways and open spaces carefully located to maximise views to parkland and to the Darling Scarp;
- An interconnected street system and pathway network, enabling residents that real choice of being able to walk / cycle to facilities and services;
- To create a new urbane-style neighbourhood through modern and contemporary built form, quality landscaping, mix of lot sizes and an increase in residential densities;
- To optimise the retention of trees and vegetation; and
- Address the requirements of the City of Swan Local Planning Scheme No. 17 and associated strategic documents.

2.0 Contextual Analysis/Existing Statutory Framework

2.1 Metropolitan Region Scheme

The site is currently zoned 'Urban' and reserved 'Other Regional Road' under the Metropolitan Region Scheme (MRS). The remainder of the Caversham Urban Cell to the east and south of the site is currently in the process of being rezoned to 'Urban' under MRS.

MRS Map



MRS LEGEND

RESERVED LANDS

ROADS
PRIMARY REGIONAL ROADS
OTHER REGIONAL ROADS

ZONES

URBAN
URBAN DEFERRED
CENTRAL CITY AREA
INDUSTRIAL
SPECIAL INDUSTRIAL
RURAL
RURAL - WATER PROTECTION

N

2.2 City of Swan Local Planning Scheme No. 17 (District Zoning Scheme)

The site is zoned 'Residential Development' and reserved 'Other Regional Road' under the City of Swan Local Planning Scheme No. 17 (LPS 17).

Pursuant to clause 4.1.14 of LPS No. 17 the objectives of the 'Residential Development' zone are:

a. *provide for the coordinated development of future residential areas through the application of a comprehensive plan to guide subdivision and development to be known as a "Structure Plan";*

b. *provide for predominantly residential development, but including also a range of compatible services, consistent with the needs of an integrated neighbourhood, and planned so as to minimise adverse impacts on amenity*

c. *avoid the development of land for any purposes or at a time when it is likely to compromise development elsewhere in the district or prejudice the future development of land in the Residential Development zone for more appropriate purposes; and*

d. *take account of the need to protect the amenity and on-going use adjacent property owners as well as to provide for the needs of future residents*

'to

Council requires a Structure Plan for any land zoned 'Residential Development' prior to providing recommendations on subdivision applications and determining development applications.

The 'Other Regional Road' reservation relates to the widening of the Lord Street for its intersection with Reid Highway, on the western boundary of the site.

The CNLSP area is listed in Schedule 13 - Developer Contributions Area as Developer Contribution Area No. 3 (Caversham). The Schedule states that:

''Development Contribution Plan provisions will be set as pat of, or an amendment to, the Caversham District Structure Plan, and will constitute a Development Contribution Plan in accordance with Section 5A.6.'

LEGEND

METROPOLITAN REGION SCHEME RESERVES

PRIMARY REGIONAL ROADS

OTHER REGIONAL ROADS

ZONES

RESIDENTIAL

RESIDENTIAL DEVELOPMENT

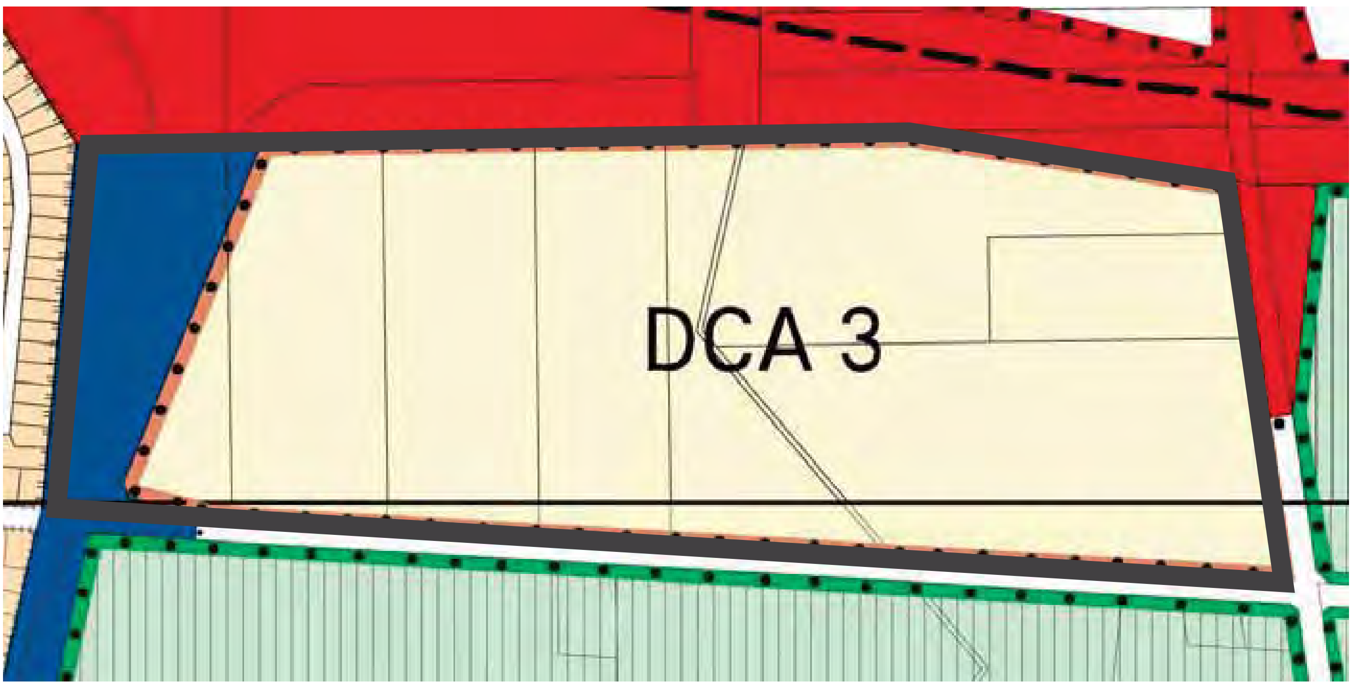
SWAN VALLEY RURAL

OTHER

DCA 1 DEVELOPMENT CONTRIBUTION AREA BOUNDARY (SEE SCHEME TEXT)

N

City of Swan LPS No. 17 MAP



2.3 State Strategies & Policies

2.3.1 State Sustainability Strategy

The State Sustainability Strategy provides an overarching framework for the State Government to respond to the sustainability agenda. The Strategy identifies the following six broad goals and 42 strategy areas intended to fulfil these goals and to guide Government action towards achieving its vision for a sustainable Western Australia:

- Sustainability and governance
- Contributing to global sustainability
- Sustainable natural resource management
- Sustainability and settlements
- Sustainability and community
- Sustainability and business

The policy objectives of the State Sustainability Strategy are incorporated into the planning system through State and Local Government policy and formally applied through planning decisions. The role of sustainability - economic, environmental and social - is fundamental to the planning of the site and is implicitly embodied in the content of the CNLSP.

2.3.2 State Planning Strategy

The State Planning Strategy (1997) was prepared by the WAPC as a whole of Government approach to guide sustainable land use planning throughout the State up until 2029. The Strategy is aimed at developing a land use planning system to help the State achieve a number of key goals. These include generating wealth, conserving and enhancing the environment and building vibrant and safe communities for the enjoyment of this and subsequent generations of Western Australians. The Strategy was lost audited in 2000 - 2001. The CNLSP is consistent with the goals and objectives of the State Planing Strategy.

2.3.3 Liveable Neighbourhoods

Liveable Neighbourhoods Edition 3 (LN 3) was prepared by the WAPC to implement the objectives of the State Planning Strategy and deliver the strategies and actions of Network City. Unlike Edition 2 of LN, which is a voluntary code under which applications may be lodged and assessed, LN3 has recently become a compulsory design code. As an operational policy of the WAPC LN3 guides the design and assessment of structure plans (regional, district and local), subdivision and development for new urban areas. Its aims include promoting the design of walkable neighbourhoods; places that offer community and a sense of place; mixed uses and active streets; accessible and sustainable parks; energy efficient design; and a variety of lot sizes and housing types.

The key initiatives of LN 3 are covered under eight design Elements. The implementation of each of these elements and the fulfilment of the overall principles of LN will fundamental to ensuring that development of the structure plan area and the wider metropolitan region occurs in a thoughtful and sustainable manner. Application of the LN principles is therefore relevant to all levels of planning for the site from the proposed CNLSP through to detailed lot and building design.

2.3.4 Statements of Planning Policy

Development of land must generally be consistent with any relevant Statements of Planning Policy (SPP) which are prepared and adopted by the WAPC under statutory procedures set out in Part 3 of the Planning and Development Act 2005. The WAPC and local governments must have due regard to the provisions of SPPs when preparing or amending regional and district planning schemes and when making decisions on planning matters. Details of the SPPs relevant to the site are provided below.

(i) SPP No 1 *State Planning Framework*

The State Planning Framework unites existing State and regional policies, strategies and statements with a central framework to provide a context for decision making on land use planning and development matters in Western Australia. The Structure Plan is consistent with the primary aim of this overarching policy, which can be surmised as "...to provide for the sustainable use and development of land."

The WAPC and local governemnt will refer to the relevant planning instruments reerred to under SPP No. 1 for all planning deisions, including those concerning the Structure Plan and subsequent planning proposals presented for the site.

(ii) SPP No. 2 *Environment and Natural Resources Policy*

The Environment and Natural Resources SPP sets out a planning response to environment and natural resource management issues within the framework of the State Planning Strategy.

Specific policy areas of relevance to the site include those relating to air quality, soil and land quality, biodiversity, landscapes, greenhouse gas emissions and energy efficiency.

(i) SPP No 3 Urban Growth and Settlement

SPP No. 3, which was gazetted in February 2006, applies to the hole of the State in promoting sustainable and well planned settlement patterns that have regard to community needs and are responsive to environmental conditions. The objectives and principles of Network City and Liveable Neighbouthoods are enshrined in this Policy.

SPP No. 3 recognises that much new development in metropolitan Perth has been in the form of low density suburban growth. This form of development intensifies pressure on valuable land and water resources, imposes costs in the provision of infrastructure and services, increases the dependence on private cars and creates potential inequalities for those living in the outer suburbs where job opportunities and services are limited.

To promote growth that is sustainable, equitable and liveable, SPP 3 encourages a more consolidated urban form. In general terms the proposal for the site is consistent with the high level principles of SPP 3.

The Structure Plan will facilitate:

- access to public transport and existing services;
- provision of suitable access to existing areas of public open space;
- the creation of cohesive and walkable communities through the applications of traditional neighbourhood design principles; and
- a diversity of housing types and lot sizes.

2.3.5 Swan Urban Growth Corridor Sub-Regional Structure Plan

The Swan Urban Growth Corridor Sub-Regional Structure Plan provides a coordianted approach to sub-regional issues such as transport, residential density, community service provision, employment and open space. Policy principles for relevant issues affecting the Swan urban growth corridor are provided in order to guide subsequent planning.

The strategic objectives of the Swan Urban Growth Corridor Sub-Regional Structure Plan are to:

- provide coordination of development, including regional infrastructure within areas of the Swan urban growth corridor marked for urbanisation;
- provide for key transport links throughout the sub-regional structure plan area;
- ensure appropriate provision and equitable access to community facilities, open space areas and employment centres for future residents;
- recognise the importance of environmentally sensitive and important agricultural areas;
- promote an appropriate range of residential densities to suit the needs of the community; and
- provide for development in a manner consistent with Network City principles.

The Policy Principles within this document have been taken into consideration when preparing the CNLSP.

2.4 City of Swan Policies

2.4.1 Urban Growth Policy

The purpose of the Urban Growth Policy is to set out the City's expectations and guidelines for development in urban growth areas to ensure that population growth in the Swan region contributes to sustainable urban communities.

The Policy sets out the City's urban growth objectives and priorities to be achieved through Structure Plans. Development Plans, accompanying Management Strategies and Management Plans, Town Planning Scheme and Metropolitan Region Scheme amendments.

The Policy also requires financial analysis and lifestyle costing of urban development proposals to enable proper consideration of Structure Plans, referred to as a Financial Assessment Report.

A draft Financial Assessment Report has been prepared for the subject CNLSP area (Appendix 2). This report details the potential rates revenue of the Caversham Urban Cell and the ongoing maintenance costs for the proposed public open space areas.

2.4.2 Environmental Planning Policy

The purpose of this Policy is to clearly articulate and set out the City's expectations for the management of the natural environment especially relating to urban growth areas.
This Policy sets out the policy requirements measures and processes for planning, developing and managing the natural environment aspects of urban development areas through Structure Planning (and associated Management Plans) and Associated Town Planning Scheme Amendments.

This Policy requires that structure plans are to be prepared to provide an adequate assessment of environmental constraints and contain a comprehensive framework for their management. Matters to be addressed include:

- Biodiversity;
- Drainage via a Local Water Management Strategy;
- Acid Sulfate Soil assessment;
- Contaminated Sites; and
- Fire Management.

Each of the above matters has been addressed through the CNLSP or via consultant reports. Particular reference should be made to the Environmental Assessment Report (Appendix 3), the Urban Water Management Plan (Appendix 4) and a Fire Management Plan is currently being prepared as part of the overall Caversham Urban Cell Structure Plan and will be lodged with the City shortly.

2.4.3 Community & Economic Planning Policy

The purpose of the Community and Economic Planning Policy is to clearly articulate and set out the policy requirements and processes for community and economic development planning to be carried out in conjunction with the preparation of Structure Plans.

The Policy requires that a Community and Economic Development Plan (CEDP) Must be prepared for a Structure Plan area in collaboration with the City f Swan.

A CEDP has been prepared for the subject Caversham Urban Cell (Appendix 5). The specific areas addressed in the CEDP are:

- The social and economic environments within the Caversham LSP;
- Relevant social and economic opportunities and constraints associated with the development and how they will be addressed;
- Strategies and time frame for the provision of initial community and economic development within the Caversham LSP;
- Identification of potential partnership opportunities;
- Detailed community facilities and infrastructure program; and
- Indicative costing for the provision of community facilities within the Caversham LSP area.

The CEDP is supported by a Caversham Facilities Provision Strategy (Appendix 6).

2.4.4 Urban Growth Policy

The CNLSP Plan has been prepared having due regard to the requirements of this Policy. In particular, the requirement to meet the Policy's density target of 22 dwellings per hectare (du/ha) was taken into consideration during the design process. The CNLSP has managed to achieve the density target of 22.2du/ha. Calculations to achieve this density are follows"

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R50	55	12%
TOTAL	459	100%

- The provision of density in greenfield residential developments does not generally occur until such time that retail, educational and community facilities are provided. Conversely the provision of these facilities does not occur until there si a critical mass of residents. It is therefore typical that the first stages of greenfield developments, such as the Caversham North Local Structure Plan, commence development with a lower density. As the population grows and more facilities are provided then the density is increased. This is demonstrated by the proposed increased densities around the proposed neighbourhood centre, primary school and community centre on the southern side of Suffolk Street.

3.0 Site Analysis Assessment - Opportunities & Constraints

The following identifies the existing conditions of the Caversham North Local Structure Plan area, and the key opportunities and constraints for its development.

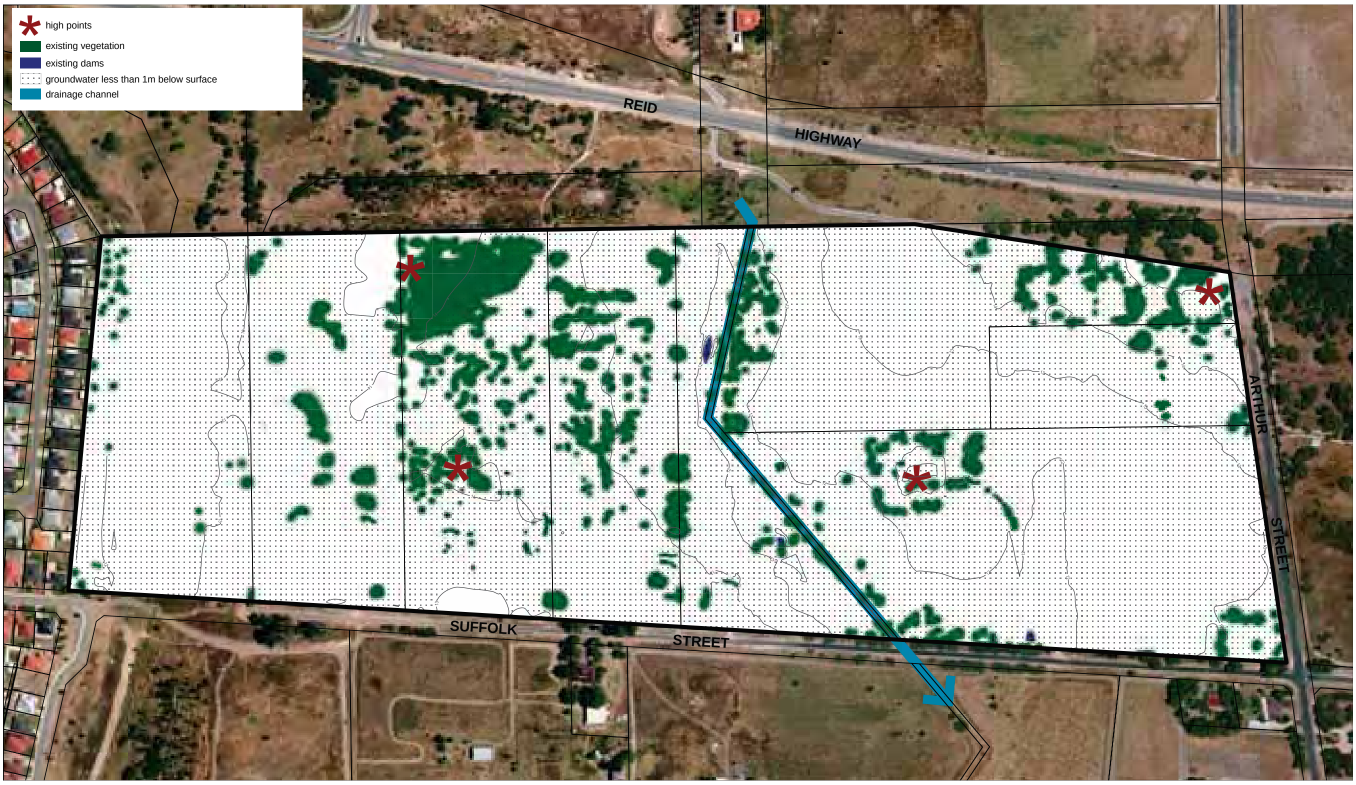
3.1 Surrounding Land Use & Development

The land to the north of the site, on the opposite side of Reid Highway, is zoned 'Special Use (No. 11 West Swan)' under the city of Swan LSP No. 17 and is known as the West Swan Urban Cell of the Swan Urban Growth Corridor. Structure planning is currently underway over this land and there are early release subdivision applications pending.

The land to the east and south is zoned 'Swan Valley Rural' and forms part of the Caversham Urban Cell under the MRS.

A majority of the land is currently utilised for viticultural and rural lifestyle purposes. A structure plan is currently being prepared over this land. The land to the west, on the opposite side of the Lord Street road reserve, is zoned 'Residential' and has been subdivided and developed for residential purposes.

Site Analysis Plan



3.1.1 Interim Buffers To Viticultural Uses

The CNLSP area will be the first precinct within the Caversham Urban Cell to be subdivided and developed. As a result some of the existing viticultural uses will remain in operation within the 500-metre buffer zone, as recommended by the EPA, from the viticultural activities on Lot 2 and 202 Arthur Street. Whilst the CNLSP area is currently affected by this recommended buffer it is only for an interim period until such time that Lots 2 and 202 are developed. The early Release Stage 1 subdivision application, which is affected by the recommended buffer, was referred to the Department for Environment and Conservation (DEC) by the Western Australian Planning Commission for comment. The DEC did not raise the potential land use conflicts with the interim viticultural activities as an issue as part of this referral process and there were no conditions or advice notes included on the subject subdivision approval.

Notwithstanding, it is recommended that notification on titles be required to advise prospective purchasers that vineyards area located within the vicinity and vineyard operations, including spraying, may have impact on the amenity of the area.

3.2 Climate

The study area experiences a warm Mediterranean climate. The summer temperature averages are 18 C (min) to 29C degrees (max). Winter averages are 8C (min) to 18 C (max).

During summer, winds blow from the east in the morning and from the south west in the afternoon, bringing cooling sea breezes created from the temperature differential between land and sea. The most severe winds come from the west and occur during the winter months, although tropical cyclones may occasionally migrate south in the summer to autumn period bringing gale force winds and heavy rains.

Key climatic considerations for the CNLSP and subsequent detailed design include optimising solar orientation and utilising breezes for cooling effects, whilst ensuring that adequate sheltered and wind protected spaces are available where appropriate.

3.3 Landform/Topography

The land gently undulates with elevations generally between 11 metres AHD and 15 meters AHD.

3.4 Hydrology

The Perth Groundwater Atlas shows the average Annual Maximum Groundwater Level (AAMGL) for the site as between 8mAHD and 14mAHD.

The estimated maximum (late winter) groundwater table at the site is generally located close to the surface, varying between 1-2 meters below surface level.

During May, when the groundwater table is at its lowest elevation, the separation distance between groundwater and the surface level at the site is approximately 4 meters.

Exceptions to this occur at the high point of the site where the groundwater is approximately 8 meters below the surface during this period and along the drainage line where the ground water falls to approximately 1-2 meters below the surface.

The site is located on the southeastern edge of the Gnangara Mound, and as such the groundwater flow is in a general southerly direction towards the Swan River.

Further information on groundwater is available in Appendix 3 (RPS Environmental Assessment Report).

3.5 Landscape/Vegetation

Prior to European settlement of the area, the native vegetation within the site was representative of the Southern River Complex, which consists of open woodland of Eucalyptus calophylla- Eucalyptus marginate- Banksia spp. With fringing woodland of Eucalytus rudis- Melaleuca rhaphiophylla along creek beds.

Of the original area of the Southern River Complex on the Swan coastal Plain, 17% currently remains while 10% is proposed for protection, which meets the criteria for levels of protection identified within the Bush Forever documentation. Examination of the earliest available aerial photography, taken in 1953, shows the site was cleared prior, with the exception of one area on the site. Lots 214 and P94 Suffolk Street appear to have been cleared in the mid 1980s and then left to regrow before being cleared once more in the late 1990s.

On-site examination of the remnant native vegetation within Lot 214 Suffolk Street indicates that the vegetation in the northern portion of Lot P214 is in a degraded condition.

3.6 Drainage & Watercourses

One drain traverses the site originating at the north of the site on the opposite side of Reid Highway, through the central portion of the site in a north-south alignment before it enters Bennett Brook to the south of the site.

The drain is ephemeral and becomes dry during the summer. The drain most likely began as a natural watercourse, which was altered to some extent, to drain the surrounding agricultural land.

3.7 Soils

The site is located on the Guildford Formation, which is characterized by soils of alluvial origin, ranging from silty clay to pebbly silt, and is characteristically low lying and poorly drained. Elevated areas of the site contain a thin veneer of overlying Bassesdean sands. The soil across the site is:

Pebbly Silt (Mgs1)- strong brown silt with common, fine to occasionally course grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin. This soil type extends over the majority of the site.

3.8 Conservation & Heritage Values

3.8.1 Aboriginal Heritage

A review of the Department of Indigenous Affairs' Aboriginal Inquiry System was undertaken and indicates that there are no registered sites of significance within the CNLSP area.

There is one registered site to the south of the CNLSP area. The site name is 'Little Creek/One Hundred Year Creek' (DIA Site ID 22159). The subject site follows the alignment of the original creek line which trans versed the land from north to south. The creek line has been formalised into a drainage channel. The subject site is an open mythological site and the waterway is a significant Aboriginal site on the basis of its association with a Waugal myth and because it was formally utilised as a camping area by Nyungars.

The Minister for Indigenous Affairs has advised that based on current knowledge the proposed development on the subject lots will not impact upon any Aboriginal sites within the meaning of section 5 of the Aboriginal Heritage Act 1972. Please refer to Appendix 8 for the Ethnographic Report and Appendix 9 for the Archaeological Survey, which have been prepared for the Caversham Urban Cell.

Vehicular access to the site is gained from Arthur Street in the east and Suffolk Street in the south, which are both accessed from West Swan Road. Reid Highway, which is reserved as a 'Primary Regional Road' under the MRS, forms the northern boundary. There are a number of proposed road upgrades and infrastructure provision which will directly affect the CNLSP area. These upgrades include:

- Reid Highway upgraded to a dual carriageway with the transit corridor to be relocated into the central median;
- Lord Street, north of Reid Highway, will form the start of the Perth Darwin National Highway. Lord Street is planned to be relocated to the east of Bennett Street and the MRS in this area has provision for a grade-separated interchange at this location. It is currently proposed as a standard diamond interchange with Lord Street (connection to south) going over the top of Reid Highway. In the interim, it is likely to be traffic signalised as part of the staging for the development of the road network. The extension of Lord Street south of Reid Highway, adjacent to the CNLSP area, is proposed but is not the in the current construction program. The southern end of the Lord Street extension will tie into the existing roundabout at Bennett Street and Benara Road; and
- An overpass across Reid Highway has been proposed to connect the northern and southern section of Arthur Street. Assuming construction of the Lord Street extension, the flyover is not considered crucial to the Caversham development in traffic terms, however it is considered desirable in terms of overall connectivity in the regional area in the longer term.

As a result of the above upgrades there are potential noise impacts from the road networks on future residences with in the CNLSP area, with Reid Highway and the Perth-Darwin National Highway (Lord Street) representing future major transport corridors. In order to reduce the impact upon the future residents of the CNLSP area the recommended approach to transport noise mitigation is:

- Design and construct noise barriers to achieve the noise *limit* criteria for the first row of houses adjoining the transport corridors and to achieve the best practical outcome across the subdivision;
- Future purchasers to be advised of quiet house design measures to be incorporated into the building design and construction, to achieve satisfactory internal noise levels; and
- Notifications to be placed on the certificates of title by the land developer for all lots identified as being above the noise target criteria.

This issue is addressed in the Noise Impact Assessment in Appendix 10.

3.9 Public Transport

The site is serviced by two bus routes (Route 52 and 337).

Route 52 stops on West Swan Road near to the site and runs from Midland Rail Station to the Morley Bus Depot via Middle Swan and Altone. Route 337 stops on Lord Street and runs from Bassendean Rail Station to Ellenbrook town centre.

In discussions with the Public Transport Authority it has been suggested that a future bus route may operate from Bennett Street (current route for bus 63) along the extension of Suffolk Street towards West Swan Road. Bus routes will be re-assessed when more detailed timing is available for the staged construction of Lord Street and when structure planning for the entire Swan Urban Growth Corridor had progressed further.

4.0 Structure Plan

4.1 Introduction

The CNLSP area comprises of approximately 35.72ha in area and is located within the Caversham Urban Cell of the Swan Urban Growth Corridor.

A majority of the site is currently owned by Caversham Land Development Pty Ltd, which allows total control over the sites future development to ensure a coordinated and high quality-planning outcome. The Western portion of the site is owned by the Western Australian Planning Commission, who have advised that they have no objection to a structure plan being prepared over their landholding. Please refer to Appendix A which is a letter from the WAPC advising of their support.

The proposed CNLSP will create a permeable and vibrant community, which will set a high precedent for residential development within the Caversham Urban Cell and the Swan Urban Growth Corridor, as a whole.

The location of the site, exisiting features, changing lifestyle demand, sustainability considerations, affordability and an overriding objective to satisfy the needs of the community has guided the urban structure and design. The mix of densities and housing types will assist in providing alternative housing options for existing City of Swan residents and attract new residents to the area.

4.2 Land Use Permissibility

Land use permissibility within the Local Structure Plan (LSP) area is to be determined by using the zones and reserves identified on the LSP and accessing them against the permissibility in the zoning Table within Local Planning Scheme No. 17.

4.3 Guiding Principles/Design Philosophy

Five guiding principles have been common drivers throughout the design process, as documented below:

- Integration with surrounding land;
- Permeability through the site;
- Diverse density and housing type;
- Creation of amenity; and
- Solar passive design

4.3.1 Integration With Surrounding Development

The development of the site provides an opportunity to ultimately connect to the existing residential development within Caversham to the west, once Lord Street has been constructed, and the proposed residential development to the east and south within the remainder of the Caversham Urban Cell. The site is strategically located in respect to proposed community services, commercial uses, recreation areas and educational facilities. Taking the above into consideration it is important that the CNLSP is designed to acknowledge and integrate with the existing and proposed surrounding development.

The CNLSP design proposes a graduation in densities from medium density development along the Suffolk Street activity corridor and opposite the proposed neighbourhood centre to the south down to low-density development adjoining the Reid Highway and Arthur Street road reserves. This allows the built form to reflect and compliment the proposed surrounding development and to reduce the potential for traffic noise and pollution to affect the amenity of residents.

The design proposes to establish an appropriate relationship with the proposed residential and commercial development to the south via the provision of rear loaded lots with narrow frontages, which allows for 'urban' residential built form. This built form will be reflected on the southern frontage of Suffolk Street.

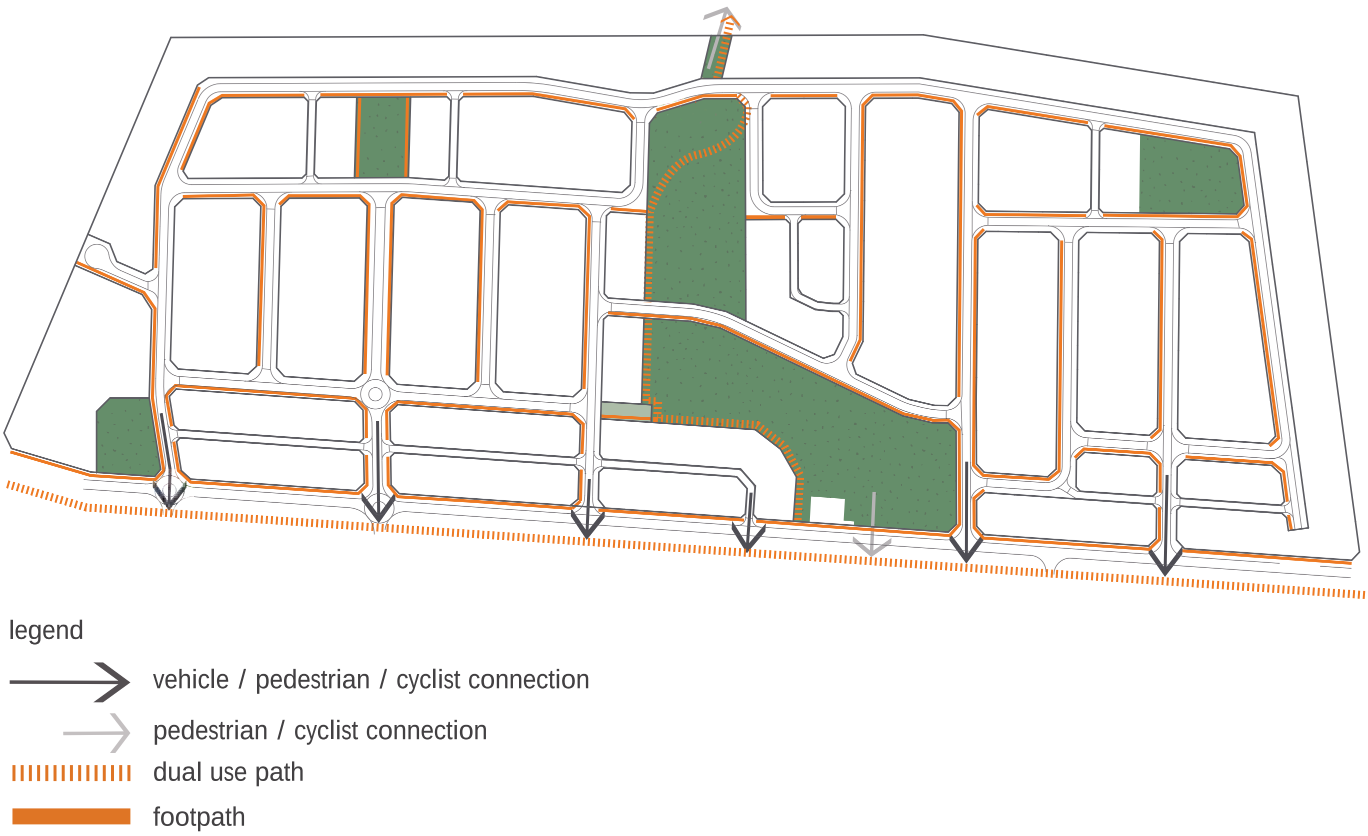
Surrounding Proposed Development Plan

4.3.2 Permeability Through The Site

As a result of the sites proximity to the proposed commercial, community, educational and recreational facilities to the south of the CNLSP area the permeability for pedestrians and cyclists through the site is considered important for new residents. The design includes strong north-south connections allowing residents convenient and formalised access to the neighbourhood centre facilities located on the opposite side of Suffolk Street as well as a route to the proposed primary school and community site.

The CNLSP design includes east-west connections through the site creating multiple access points to the proposed public open space reserves and associated recreational facilities resulting in easy access for the new residents of the CNLSP site.

Connections Plan



4.3.3 Diverse Density And Housing Type

The site is located in close proximity to proposed community facilities, commercial uses, educational facilities and recreational facilities. In light of this it is considered important to take advantage of the site's strategic location by providing for medium density residential developments in appropriate areas of the site such as the southern area fronting onto Suffolk Street, adjacent to the proposed public open space. The provision of medium density sites, including a one hectare grouped dwelling site which has the potential to be developed for aged person's accommodation, will allow for the development of alternative housing stock that is not currently available within the Caversham locality and its surrounds.

Lower density areas are located abutting the Roe Highway and Arthur Street road reservations to reduce the potential for vehicular noise and odour issues affecting the amenity of residents.

Lot Types Plan

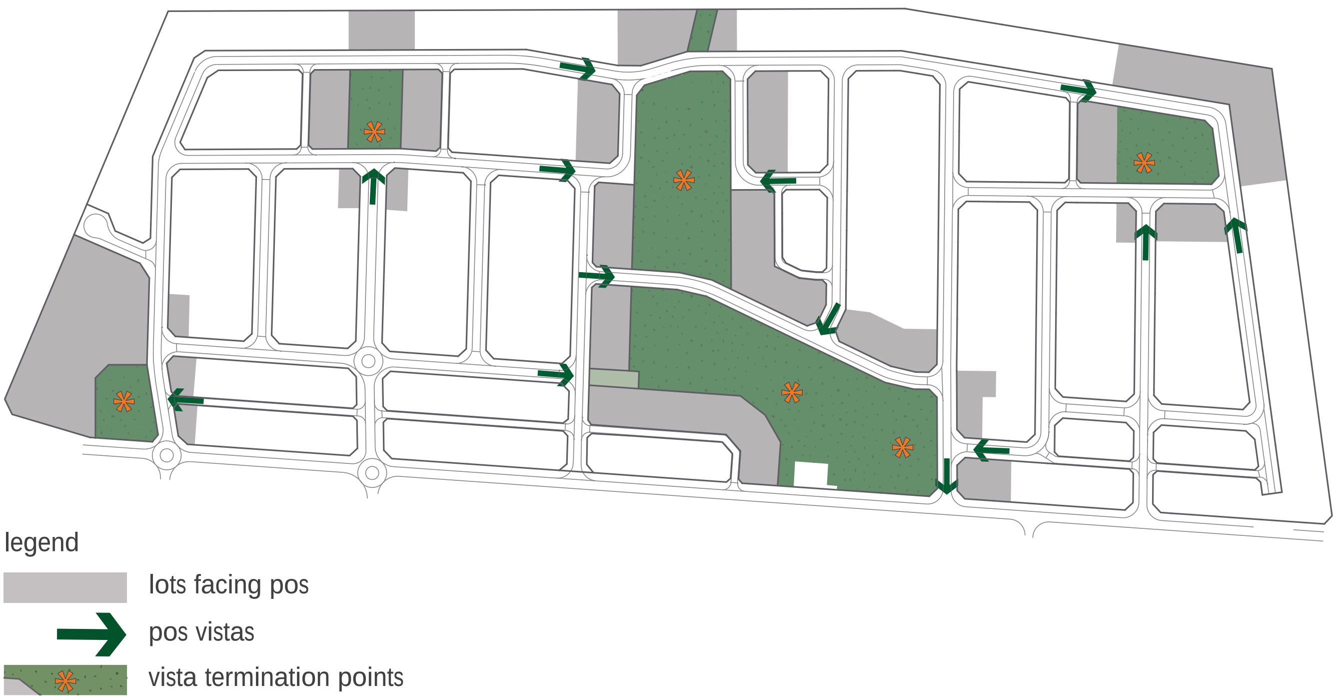
legend

- traditional
- park front traditional
- rear - loaded traditional
- cottage
- park front cottage
- grouped dwelling

4.3.4 Creation Of Amenity

The creation of amenity for future residents was an important element of the local structure plan design. Being located adjacent to the Swan Valley it was considered important to provide strategically located green spaces in an attempt to retain some of the rural character of the locality. The location of the public open space areas and strategic lot design has resulted in over a fifth of all proposed lots having direct frontage to green spaces, therefore providing amenity for residents. The proposed roads have also been configured to ensure that they terminate at public open spaceareas to create pleasant vistas and focal points for pedestrians, cyclists and motorists.

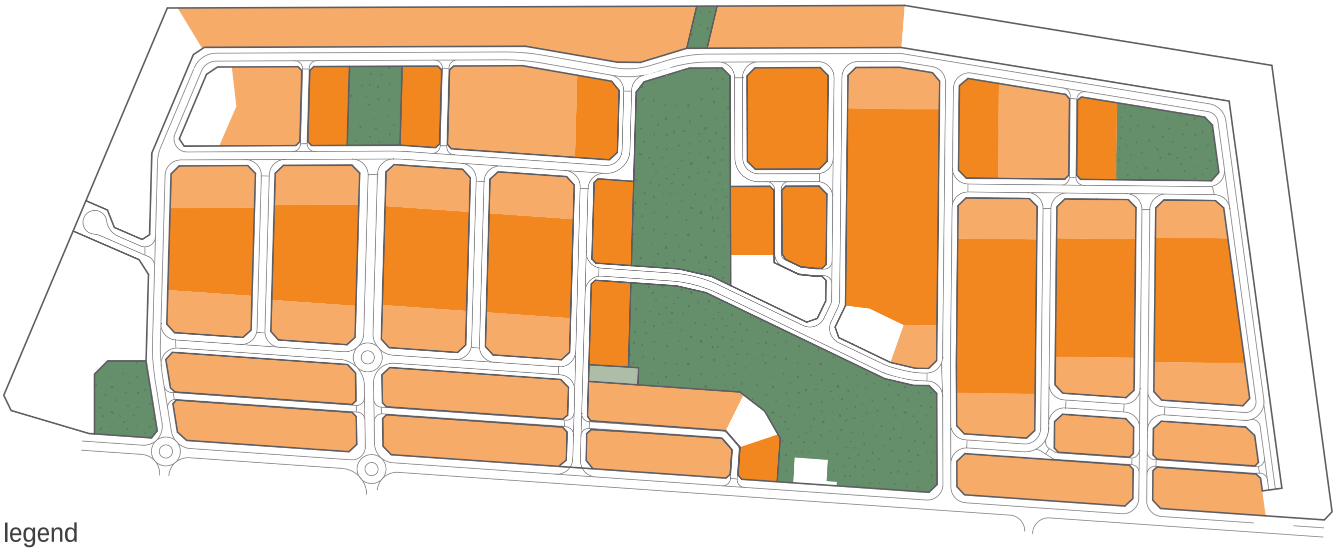
Public Open Space Views & Vistas Plan



4.3.5 Solar Passive Design

The road network provides for a north south-east west orientation connecting the individual cells within the CNLSP and allowing a framework which provides for lots to be orientated north-south and east-west, in line with solar design principles. As well as lot orientation the built form and layout of dwellings is also considered important. Building layout to meet solar passive design principles will be addressed via Detailed Area Plans over strategic areas within the CNLSP area.

Lot Orientation Plan



legend

east - west

north - south

4.4 Lot Yield & Mix

Australian's have become more discerning and selective in their preferred choice of urban environment for living, working, learning and recreating. Combined with this is the changing demographic of the population in terms of; married status, age, family size and composition. The role and function of suitability located and serviced areas, such as the subject site, are now more varied than in the past as a result of the above. Accordingly, this CNLSP has been designed to offer a range of lot sizes and dwelling types to satisfy a range of lifestyles that are currently accommodated in the surrounding, predominately suburban areas.

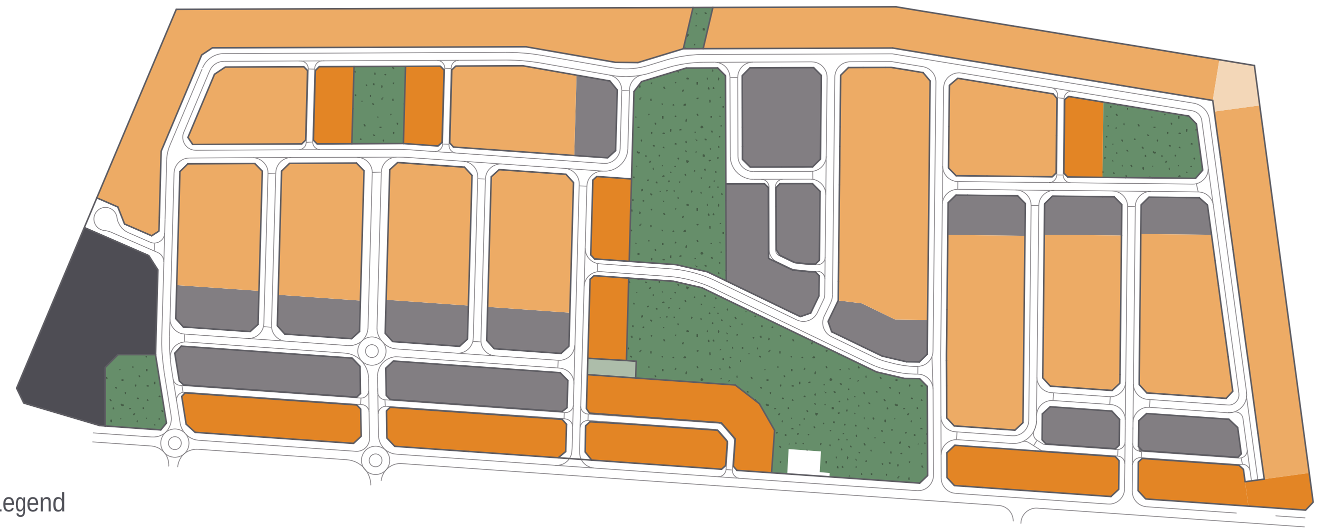
As stated previously the mix of lot sizes allows for the development of alternative housing stock that is not currently available within the Caversham locality. The densities proposed range from R20 adjacent to the Reid Highway and Arthur Street reservations to an R50 grouped dwelling site on the corner of Lord and Suffolk Streets.

Table 2 - Indicative Lot Yield

R CODE	LOTS
R10	1
R20	226
R25	86
R30	89
R50	1*
TOTAL	403

The R50 lot is a grouped dwelling site with the potential to accommodate 55 dwellings.

Residential Densities Plan



Legend

- R10
- R20
- R25
- R30
- R50

4.5 Servicing Infrastructure

4.5.1 Sewer

The Water Corporation sewer planning indicates that a Regional Pump Station (Type 180) is required at Bennett Street and 5.5 kilometres of pressure main to Hollett Road to service the Swan Urban Growth Corridor.

However for the initial stages of 500 lots which include the subject CNLSP area, the following infrastructure will be required:

1. Temporary developer funded Type 40 pump station situated in a public purpose reserve within the central public open area north of Suffolk Street;
2. Developer funded 1100 metre pressure main along Suffolk Street to Bennett Street; and
3. 500 metres of DN375 gravity sewer along Suffolk Street from the pump station to Arthur Street.

4.5.3 Water Reticulation

The Water Corporation water planning indicates that a prefunded DN600 Water Distribution Main from Altone Road is required to service the Swan Urban Growth Corridor. The DN600 Water Distribution Main from Altone Road is required to service the Swan Urban Growth Corridor. The DN600 water main will run from Altone Road, along Benara Road, Bennett Road and then northerly along Vorvina Place. Carignan Avenue to Patricia Street. A DN250 reticulated water main is also required from the DN600 Water Distribution Main, along Suffolk Street to Arthur Street to service the CNLSP area.

4.5.3 Power

There are existing 22kV HV aerial power lines along Suffolk Street and Arthur Street which is capable to service the structure plan area. Western Power jave advised that the whole of CNLSP area can be serviced by connecting into the 22kV lie at the corner of Arthur Street and Suffolk Street by a HV cable and a switchgear.

An easement relating to the 132kV power line which traverses the Arthur Street road reserve partially impacts on the proposed lots abutting Arthur Street. The affected lots are 35 metres in depth ro accommodate the easement and negate the potential of dwellings on this easement. Detailed Area Plans will be prepared for these advising that no structures are permitted within this easement.

A notification, pursuant to Section 165 of the Planning and Development Act 2005 will be placed on the Certificate of Title of each of the proposed residential lot(s) abutting Arthur Street advising of the existence of an 132kv transmission line easement to the benefit of Western Power and that this lot is immediately west of the proposed Arthur Street fly-over, which will require existing ground levels to be increased to facilitate its construction.

4.5.4 Gas

Currently there is a 110 PE medium pressure gas main at the corner of Carrignan Avenue and Suffolk Street.

Westnet Energy have indicated the existing 100 PE MP gas main is capable to service the entire CNLSP area. A developer funded extension of the gas main (about 80m) is required along Suffolk Street. This extension will be undertaken and the proposed lots will be fully services with reticulated gas. The extension has the potential to service 420 lots, therefore other developers in the Caversham urban cell will be required to provide their own upgrades in order to provide reticulated gas.

4.5.5 Telecommunications

There are existing telecommunication cables along Arthur Street and Suffolk Street as well as Fibre Optic cables along Arthur Street. These existing cables are able to service the CNLSP area. Service providers, including Telstra, are able to service the estate with Fibre To The Home (FTTH) service. The funding for the provision of FTTH service will be provided by the developer.

4.5.6 Drainage

The following drainage is proposed to service the CNLSP area:

- All lots to install soakwells for the on-site retention and disposal of stormwater;
- 1 year 1 hour ARI flows will be retained and infiltrated in the bio-retention areas which will be located adjacent to the Caversham North Central drain;
- The 5 year ARI flows are to be conveyed predominantly by a conventional pipe network along the road reserves. 5 year ARI flows with generally follow the same flow paths as the 100 year ARI events;
- The peak 5-year ARI flow rate through the 1200 x 450 mm box culvert crossing Suffolk Street will be restricted to 0.37 m3/s, in accordance to the DWMP predevelopment modelling;
- The peak 100 year ARI flow rate through the 1200 x 450 mm box culvert crossing Suffolk Street will be restricted to 1.21 m3/s, in accordance to the DWMP predevelopment modelling; and
- Flood levels within the Structure Plan area will return to minimum levels within 24-48 hrs. after the peak 5 year or 100 year ARI storm event.

Developers will be responsible for post-development drainage monitoring activities in accordance with Council policies (currently for a five year period) for submission to regulatory authorities. If water quality and quantity objectives are not met during this period, the developer is to undertake a review of the system to determine why the objectives are not being met. On completion of the review, the City and developer are to agree on the recommended course of action (s) to be undertaken by the developer to ensure the objectives are met to the satisfaction of the local government. A period less than five years may be negotiated by the developers and City after three years subject to developers being able to technically demonstrate that the system is performing as intended and will continue to do so.

Please refer to the Servicing Report (Appendix 11) and Urban Water Management Plan (Appendix 4) for further information.

4.6 Road Network & Parking

The CNLSP area proposes an internal road network predominantly consisting of 15-meter road reserves and 6-meter laneways. The design does include 13-meter road reserves abutting public open space areas, as a result of a reduced area required for services. A 20 meter road reserve has been provided linking the CNLSP area with the neighbourhood centre to the south.

Footpaths will provide on at least one side of each road and dual use path will be constructed within the central public open space corridor linking the existing dual use path and Reid Highway underpass to Suffolk Street and the remainder of the Caversham Urban Cell.

On-street parking will be provided in strategic locations adjacent to public open space and in close proximity to the medium density areas. The proposed road reserves widths are suitable to accommodate on-street parking, footpaths and landscaping.

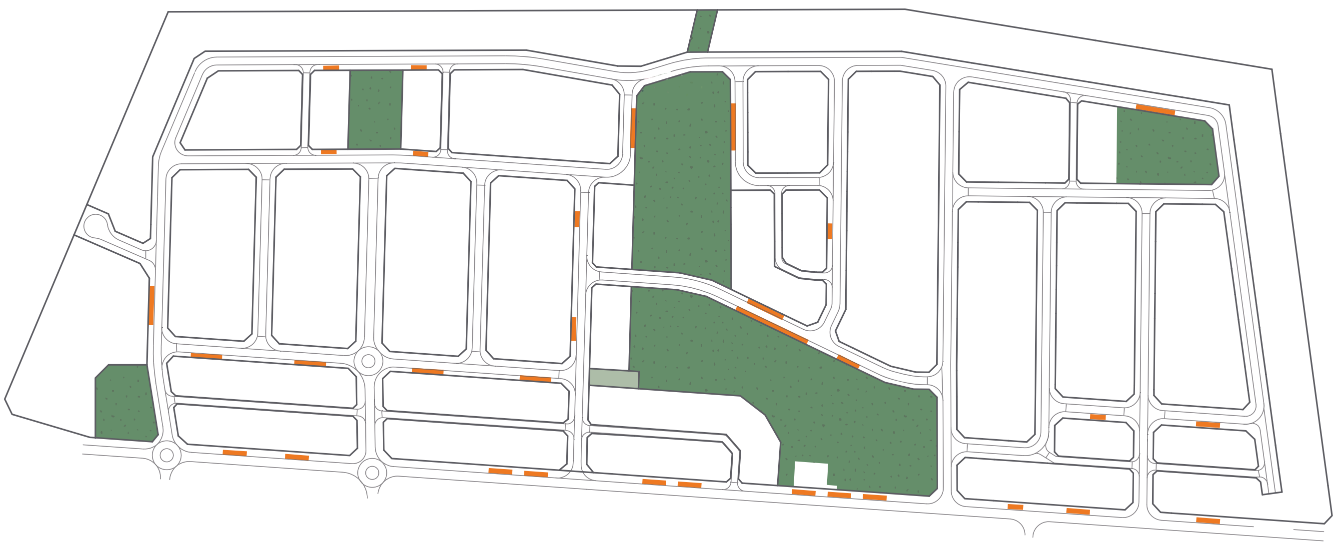
Following negotiations with the City of Swan, the upgrade of roads and intersections will be conducted as follows:

- Suffolk Street will be initially upgraded from Arthur Street west to the Early Release Stage 1 access road to accommodate traffic associated with construction and Stage 1 residents.
- Upgrade of Suffolk Street will be undertaken periodically in advance of lot clearances progressing west toward Bennett Street.
- Completion of Suffolk Street west of Arthur Street to connect to the roundabout intersection with Bennett Street to be constructed before or at subdivision clearance of deposited plan that generates the 250th lot (unit of equivalent demand). This will be constructed to a boulevard treatment as the Figure 6.1: Suffolk Street Cross Section in Appendix 13 to the western boundary of the Caversham DCA. Landowners will be required to contribute to the Suffolk Street extension and its intersection treatment proposed with Lord Street and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common from capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS in the absence of an approved DCP.
- Although the Caversham North Local Structure Plan area contributes to the need for Lord Street between the Reid Highway and Benara Road, the development itself is not of sufficient size to warrant construction. The trigger for construction will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan Landowners will be required to contribute to the Lord Street extension and to secure these payments a deed of agreement shall be entered into by the landowners within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common form capable of being executed is sent out to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LSP 17 in the absence if an approved DCP.
- A right-turn pocket at the intersection of West Swan Road and Suffolk Street to be constructed to Type CHR standards as defined in Austroads' Guide for Traffic Engineering Practice: Part 5- Intersections at Grade (including lighting to the Australian Standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the early release area. The trigger for construction of the ultimate arrangement at this intersection will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the West Swan Road/Suffolk Street intersection and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, which ever is the later in order to satisfy Cl 5A.2.7.3 of LSP17 in the absence of an approved DCP.

- A right- turn pocket at the intersection of West Swan Road and Arthur Street to be constructed to Type CHR standards as defined in Austroroads' Guide for Traffic Engineering Practice: Part 5- Intersections at Grade (including lighting to the Australian Standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the Early Release Area. The trigger for construction of the ultimate arrangement at this intersection will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Contribution Plan. Landowners will be required to contribute to the West Swan Road/Arthur Street intersection and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LSP17 in the absence of an approved DCP.
- At the commencement of development outside the Early Release Area (106 lots) Suffolk Street is to be upgraded to a rural standard from the intersection of Suffolk Street and Arthur Street through to West Swan Road, with a carriage width of 7.4 meters. This upgrade can only be viewed as an interim solution, for which an offset would only be appropriate under the proposed Development Contribution Plan if the extant works are able to form part of the final road treatment. The trigger for upgrading Suffolk Street to urban standard, between Arthur St and West Swan Road, will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the ultimate Suffolk Street upgrade and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

Please refer to the Transport Assessment (Appendix 13) for further information.

On-street Parking Plan



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on street parking

4.7 Cycle & Pedestrian Network

Footpaths will be provided on at least one side of each road and a dual use path will be constructed within the central public open space corridor linking the existing dual use path and Reid Highway underpass to Suffolk Street and the remainder of the Caversham Urban Cell.

Cycle/Footpath Plan

4.8 Detailed Area Plans

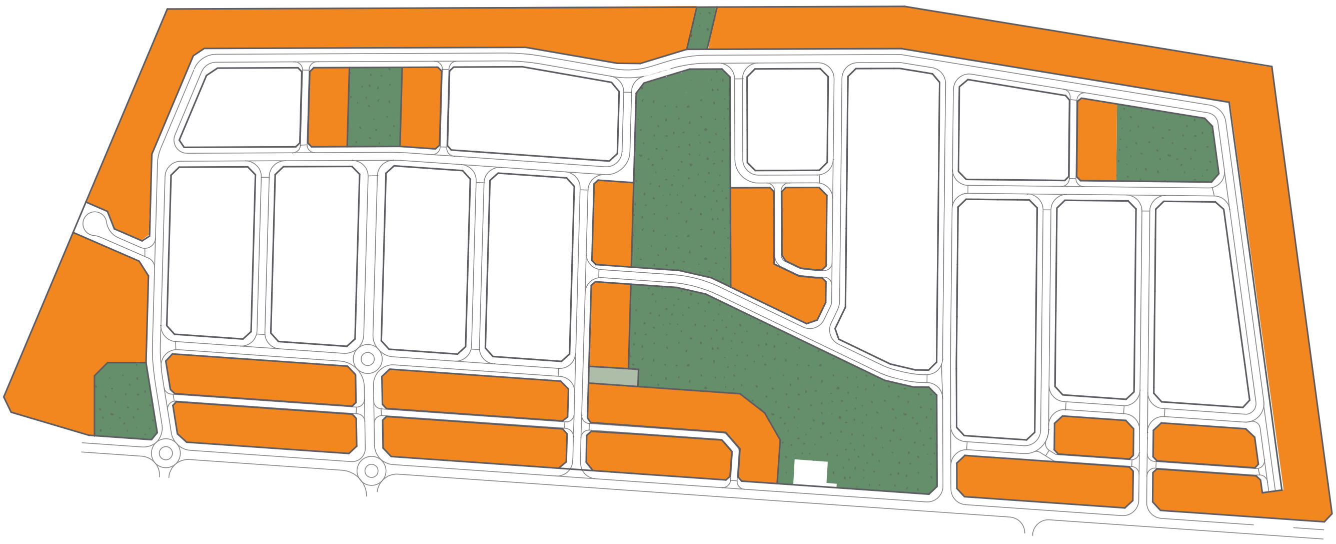
In order to adequately control built form and development within particular areas of the CNLSP it is proposed to prepare and lodge Detailed Area Plan's (DAP's) in accordance with Cl.5A.1.15 of Local Planning Scheme No. 17. The DAP's will be required for the following:

- Lots accessed by a laneway
- Lots directly abutting public open space;
- Grouped dwelling sites; and
- Lots with an acoustic wall on their boundary.

The DAP's will provide guidance on the following, but not limited to:

- Building setbacks;
- Location of acoustic walls along the periphery of the site relating to noise amelioration. DAP's to advise of height of walls to a minimum height of 2.4 meters;
- Detailed the requirement for acoustic assessments for multi-storey development on affected lots;
- Fencing;
- The location of the 132kV power line easement adjacent to Arthur Street and the requirement for no structures permitted within this easement;
- Garage locations to ensure appropriate access;
- Private open space for cottage lots
- Vehicular access; and Building orientation to ensure passive surveillance over public open space and public thoroughfares.

Detailed Area Plan Locations



legend

lots that require DAPs

4.9 Public Open Space

The WAPC generally requires that 10% of the net subdivisible residential area is proposed as Public Open Space (POS).

The following POS area is proposed:

- Central Park 2.8195ha
- Pocket Park East 0.3935ha
- Pocket Park North- West 0.2398ha
- Pocket Park South- West 0.2429ha

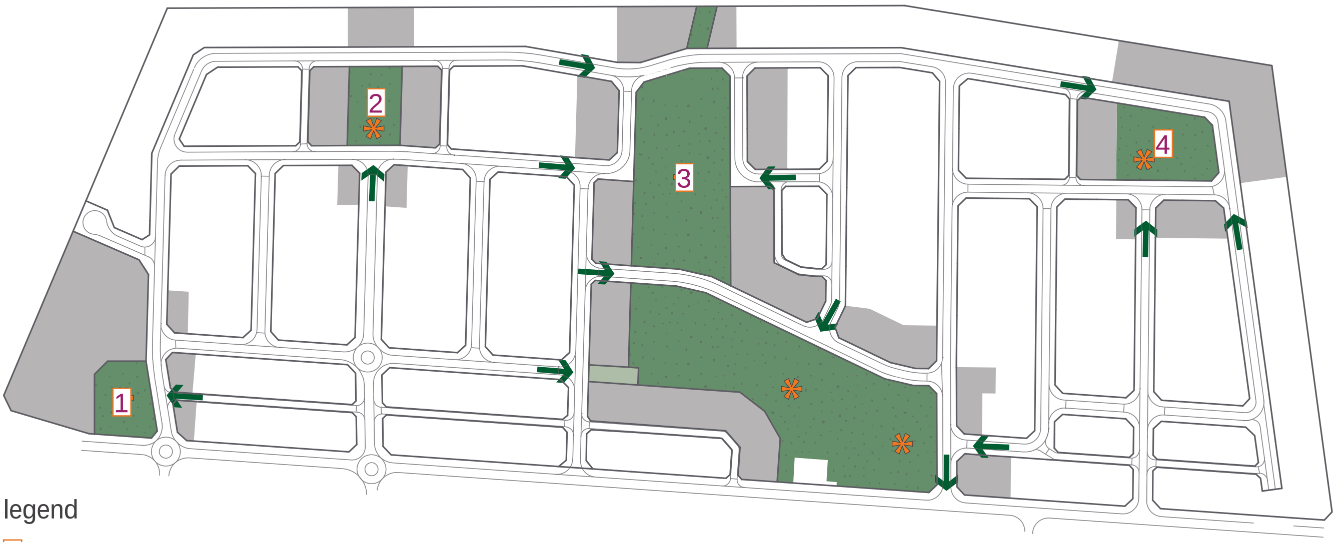
The CNLSP provides 10.2% POS as detailed below.

The requirements for restricted and unrestricted public open space were calculated in accordance with the liveable Neighbourhoods. Further details on drainage with the public open space reserves can be found in the Urban Water Management Plan (Appendix 4). The drainage channel, which traverses the Central Park, has not been included in the public open space calculations.

Table 3 - Public Open Space Schedule

Local Structure Plan Area (Site Area)		35.72ha
Total Net Site Area		35.72ha
Deductions		
Other regional Road Reservation		3.57ha
Gross Subdivisible Area (GSA)		32.15ha
Public Open Space requirement @10% of GSA		3.215ha
Public Open Space provision on Caversham North Local Structure Plan		3.6957ha minus 0.2672ha = 3.4285ha
Public Open Space Contribution		
May comprise: Minimum 80% Unrestricted Public Open Space Maximum 20% Restricted Public Open Space (based on 3.215ha)		 2.572ha 0.643ha
Unrestricted Public Open Space Sites		
Central Park (not impacted by drainage) Pocket Park East Pocket Park North-West Pocket Park South-West (not impacted by drainage) Total Unrestricted Public Open Space	1.975ha 0.3937ha 0.2399ha 0.0275ha	1.975ha 0.3935ha 0.2398ha 0.0275ha 2.6358ha
Restricted Public Open Space Sites		
Total restricted use public open space contribution (less than 20% of total POS) Drainage area in Central Neighbourhood POS (subject to inundation greater than 1 year AR1 rainfall interval but more frequently than 5 year ARI rainfall event i.e. between 1 and 5 year rainfall event Central Park Pocket Park South-West Total Unrestricted Public Open Space However on 20% can be included as Restricted Public Open Space	 0.6170ha 0.1758ha 0.643ha	 0.6170ha 0.1758ha 0.7928ha 0.643ha
Total Public Open Space Provision		3.2788ha
POS Oversupply		0.0638ha

POS Plan



legend

1 pocket park south-west
2 pocket park north-west (formal park)
3 central park
4 pocket park east (neighbourhood park)

4.10 Landscaping

The proposed public open space reserves within the CNLSP area will be landscaped to the City of Swan's standards. The following points identify the major features of each public open space reserve. Concept Plans of the public open space reserves are located in Appendix 12.

Central Waterway Pos (Central Park)

- Shaded picnic areas adjacent sand pit and play equipment at access nodes
- Mounded grassed and planted areas to offer relief to flat site
- Drainage capacity accommodated in planted areas
- Larger turfed areas for kick about and active play
- Low seating height walls adjacent sand pit and picnic tables
- Larger (max 12m) WA trees to street frontage and wetland species to watercourse edges
- Paved frontage to lots fronting POS
- Local WA groundcovers and low shrubs to garden beds
- Bollards to minimise unwanted vehicular activity in POS

Formal Park (Pocket Path North-West)

- Formalised picnic area to central space with hard shade structure
- Wide ramps through lower terraces for maintenance vehicle access
- Paving steppers through beds to allow maximum tree root development zones
- Letterboxes and visually permeable fencing incorporated to lots fronting POS
- Low seating height terraces create localised stormwater retention capacity
- Smaller (max 4m), non-fruiting, deciduous tress to lot frontages
- Larger (max 8m) WA trees to street frontage
- Paved frontage to all POS edges
- Local WA groundcovers to garden beds
- Bollards to minimise unwanted vehicular activity in POS
- NEIGHBOURHOOD PARK (POCKET PARK EAST)
- Shaded picnic area to central space adjacent sand pit and play equipment
- Mounded grassed areas to offer relief to flat site
- Larger turfed area for kick about active play
- Low seating height walls adjacent sand pit and picnic tables
- Smaller (max 4m), non- fruiting, deciduous trees to central area
- Larger (max 12m) WA trees to street frontage and edges
- Paved frontage to lots fronting POS with some garden bed softening to this edge
- Local WA groundcovers to garden beds
- Bollards to minimise unwanted vehicular activity in POS

Pocket Park South-West

- Modified ground plane to grassed and planted areas to offer relief to flat site
- Drainage capacity accommodated across POS with low point to planted areas
- Turfed area for kick about and active play
- Low seating height walls adjacent picnic tables to offer maintenance edge and extra seating
- Larger (max 12m) WA trees to western edge and wetland species to low-lying areas
- Paved frontage to grouped dwelling lot fronting POS
- Local WA groundcovers and low shrubs to garden beds
- Bollards to minimise unwanted vehicular activity in POS
- Screens adjacent Suffolk Street to minimise active play spilling onto street

4.11 Home Based Business

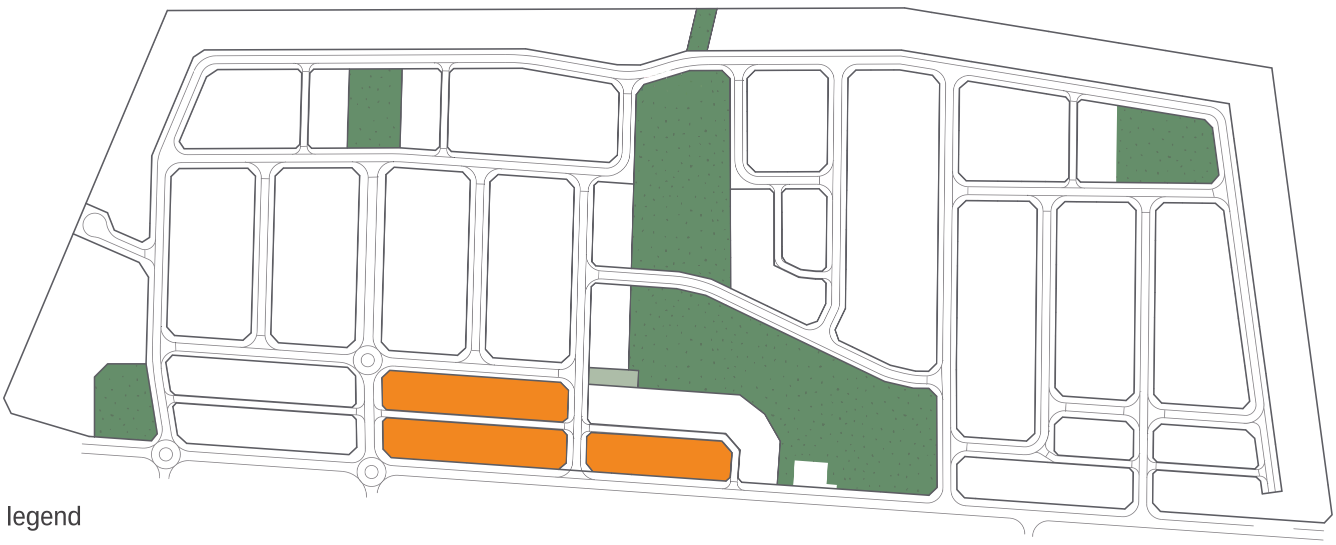
Liveable Neighbourhoods states that structure plans should identify sites suitable for home-based businesses. These sites should have good traffic exposure on arterials and neighbourhood connectors, sites in neighbourhood centres, suited to home workshops and trades businesses, and live work opportunities in centres and/or in areas with high amenity. Liveable Neighbourhoods requires a minimum of 5% of all residential lots should be identified for home-based businesses.

The plan below highlights the sites which are considered suitable for home-based businesses. The sites are considered suitable for the following reasons:

- Exposure to neighbourhood connector, Suffolk Street;
- Proximity to neighbourhood centre; and
- Variety of densities al allow for different types of businesses

In order to provide incentives and flexibility it is proposed to designate the use of 'Home Based Business' as a 'Permissible' use in Local Planning Scheme No. 17 via a Detailed Area Plan.

Home Based Business Lots Plan



legend

home based busienss lots

4.12 Bushfire Protection

As the CNLSP site is likely to be the first precinct of the Caversham Urban Cell to be developed , the surrounding land, in the interim, will remain as rural land. As a result of the surrounding land remaining rural in the interim it is considered important to assess the potential for bush fires to affect the CNLSP area.

The land surrounding the CNLSP site has been assessed in accordance with the Department of Planning's and FESA's 'Planning for Bushfire Protection Policy'. The vegetation within surrounding land is predominantly classified as Grassland in accordance with the Policy with the exception of a portion of land located to the north-east of the site which is classified as Open Woodland.

The surrounding land has a slope less than 100 and is located a distance over 15 meters from the CNLSP site. Therefore, in accordance with the Planning for Bush Fire Protection Policy, the surrounding land has a Bush Fire Hazard Assessment Level of 'Low'. As the surrounding land is rated as 'Low' it is not considered to be a bush fire prone area in accordance with the Policy. Accordingly, the CNLSP is not required to be assessed in accordance with the 'Planning for Bush Fire Protection Policy'.

It is noted that the City's Environmental Planning Policy requires two emergency access points in the first stage of subdivision. The first access point will be from the constructed first stage access road from Suffolk Street and the second access will be via a limestone based trafficable track which will access the site from Arthur Street.

Bush Fire Assessment Plan

4.13 Developer Contributions

Land owners within the Caversham North Local Structure Plan area will be required to pay for shared infrastructure costs as defined in the final Development Contribution Plan covering the area.

It is expected that some subdivision will occur prior to finalisation of the DCP. Preliminary contributions will be calculated using one of the following mechanisms:

- The final Development Contribution Plan; or
- In the absence of the final DCP, a Council endorsed Infrastructure Strategy for Development Contributions (ISDC); or
- In the absence of a Council endorsed ISDC, Council's consultants to provide the costs based on the most current draft of the relevant Policy and/or Strategy (ISDC).

In addition to the preliminary contributions calculated as per three above, developers will be required to provide an additional security to the value of 50% of that contribution.

Any landowner wishing to subdivide their land prior to adoption of the final DCP, will be required to enter into a Deed of Agreement with the City of Swan within 28 days after approval of the CNLSP for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, which ever is the later. The Deed, while in form similar to the early release subdivision deeds is to require payment of contributions, which may be reduced below the previous contribution rate having regard to the latest cost estimates for the DCP. The Deed is to act as a financial security to secure payment of any monies owed (to either party) under the final DCP.

A financial Assessment Report (Appendix 2) has been prepared for the Caversham Urban Cell in accordance with City Policy POL-C-102. The Financial Assessment Report addresses the following:

- Levels of infrastructure provision and timeframes for delivery;
- Asset management programs; and
- Priorities for staging of Urban Development

Specifically the following items are to be accounted for:

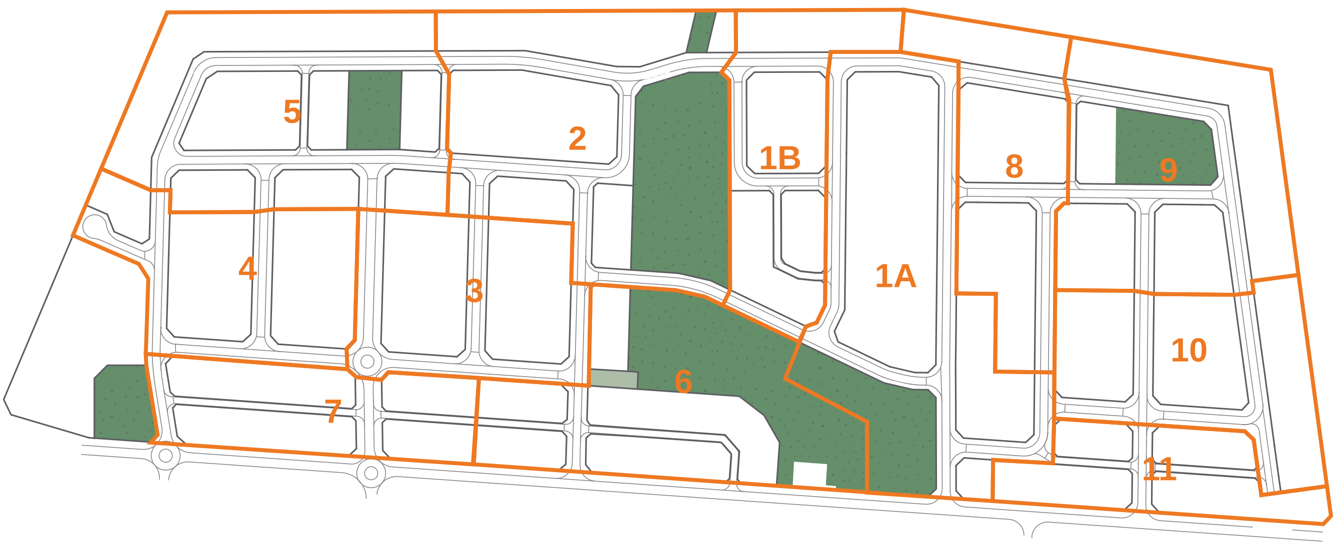
- Public and civic open space systems;
- Environmental and water management systems;
- Transport networks and pathways;
- Community facilities and services;
- Public utilities; and
- Associated follow up studies

4.14 Staging

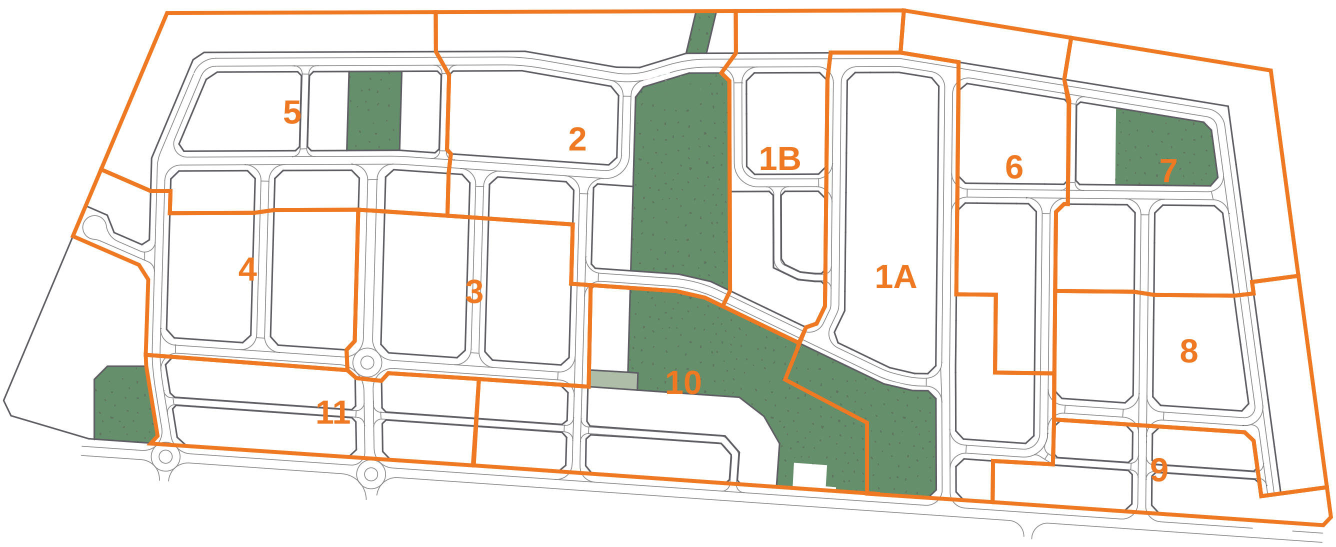
Two staging plans have been prepared for the Caversham North Local Structure Plan as a result of the interim mushroom farm buffer. Staging Plan 1 will be implemented should the interim mushroom farm buffer not be removed by the time that Stage 5 is finalised. Staging Plan 2 will be implemented should the interim mushroom farm buffer be removed by the time that Stage 5 is finalised.

The release of lots for sale will follow the numerical order of the relevant staging plan. The timing of the release of lots will depend on sale rates.

Staging Plan 1



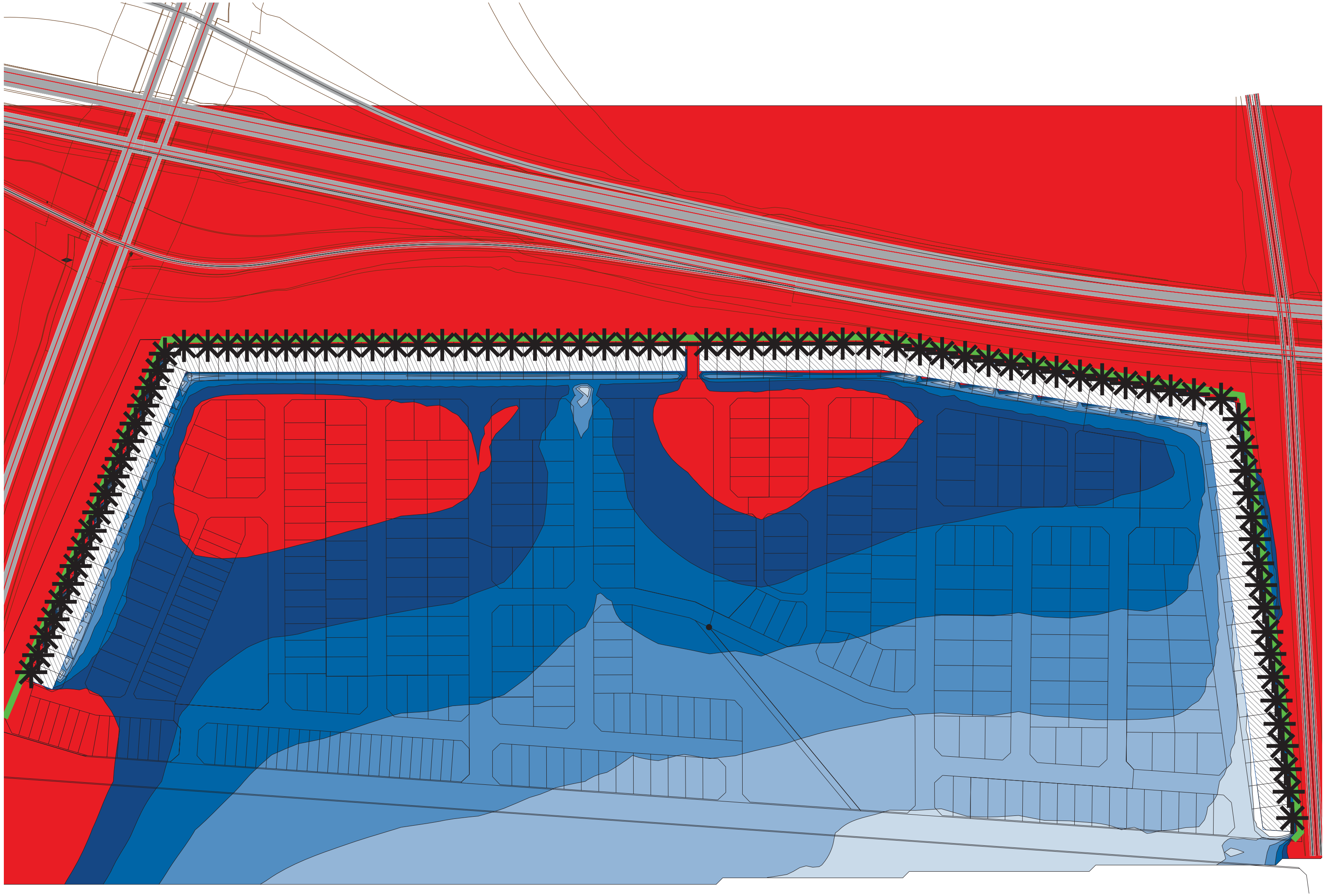
Staging Plan 2



robertsday

Caversham North - Qube Property Residential Development
LAeq,Night Noise Level Contours - Standard 1.8m High Property Fences

Figure 4.1



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	

N

Signs and symbols

Road Source
Surface
Building
Wall
Point receiver

21 May 2009

Length Scale 1:5000

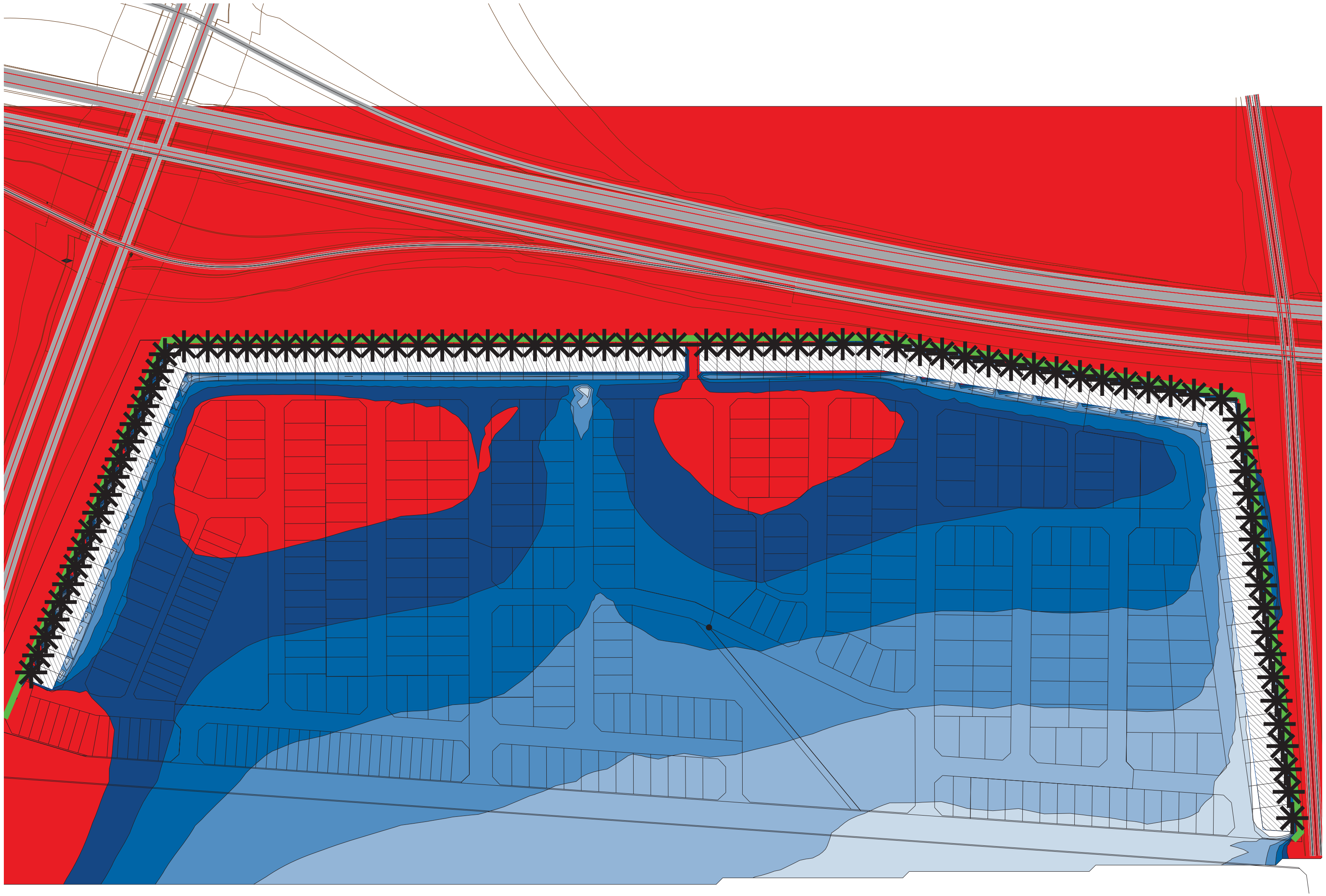
0 25 50 100 150 200 m

Lloyd George Acoustics
by Michael Cake
mike@lgacoustics.com.au
(08) 9245 3223

Figure 4.2

Caversham North - Qube Property Residential Development

LAeq,Night Noise Level Contours - Noise Barriers at Property Boundary



Noise levels
LAeq,Night dB

	< 50
50 <=	< 51
51 <=	< 52
52 <=	< 53
53 <=	< 54
54 <=	< 55
55 <=	

Signs and symbols

- Road Source
- Surface
- Building
- Wall
- Point receiver

21 May 2009

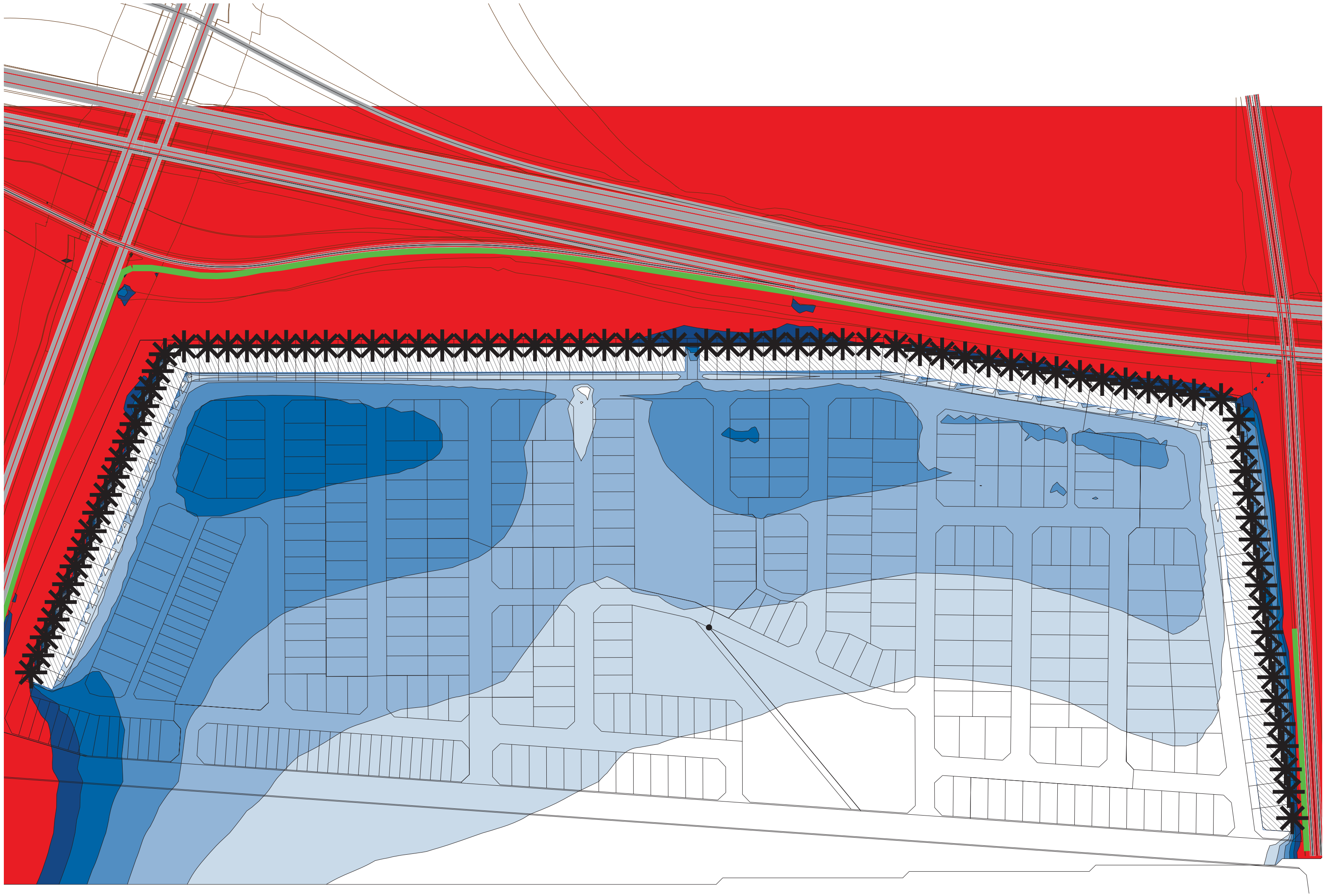
Length Scale 1:5000

Lloyd George Acoustics
by Michael Cake
mike@lgacoustics.com.au
(08) 9245 2332

Caversham North - Qube Property Residential Development

LAeq,Night Noise Level Contours - Noise Barriers Alongside Roadway

Figure 4.3



Noise levels
LAeq,Night dB

		< 50
50 <=		< 51
51 <=		< 52
52 <=		< 53
53 <=		< 54
54 <=		< 55
55 <=		

Signs and symbols

- Road Source
- Surface
- Building
- Wall
- Point receiver

21 May 2009

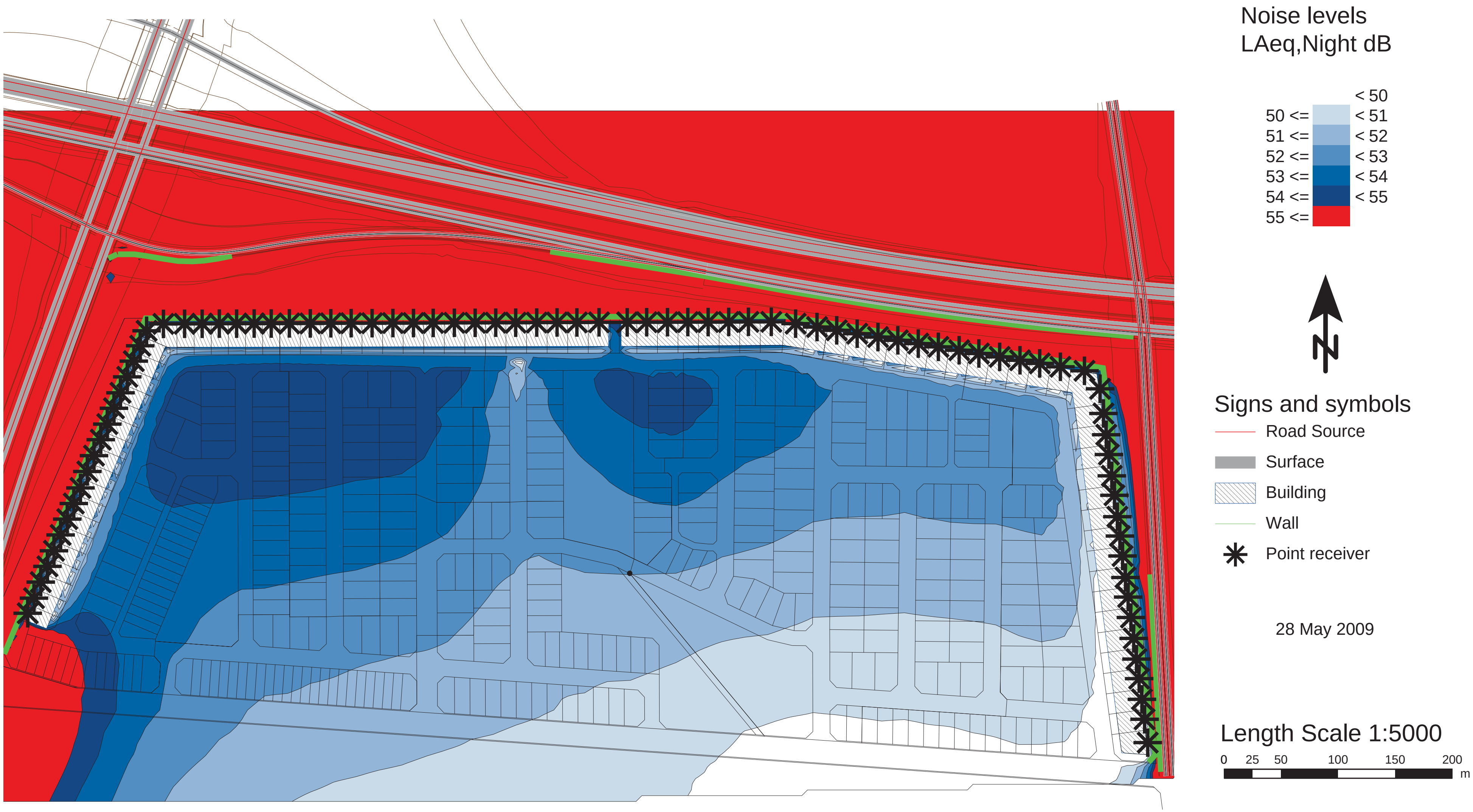
Length Scale 1:5000

0 25 50 100 150 200 m

Lloyd George Acoustics
by Michael Cake
mike@lgacoustics.com.au
(08) 9245 3223

Caversham North - Qube Property Residential Development
LAeq,Night Noise Level Contours - Dual Barriers
2.4m High Wall at Property Boundary and Customised Barrier Alongside Roadway

Figure 4.4



Lloyd George Acoustics
by Michael Cake
mike@lgacoustics.com.au
(08) 9245 3223

Western Australian Planning Commission

Your ref:
Our ref: dpi/807/2/21/320
Enquiries: Tim Ryan (Tel: 9264 7544)

- 7 JUL 2009

Mr Mark Hector
Managing Director
QUBE Property Group Pty Ltd
PO Box 1161
NEDLANDS WA 6009

RE: LOCAL STRUCTURE PLAN - CAVERSHAM NORTH

Thank you for your letter dated 29 May 2009 concerning the preparation of a structure plan affecting the WAPC's land at Lot 96 (10) Patricia St Caversham. Please accept my apologies for the delay in response.

An amendment to the MRS affecting Caversham is currently being considered. This amendment includes the exclusion of land from the urban rezoning adjacent to Lord Street, pending investigation by PTA for a transit corridor. This land however lies to the south of Patricia Avenue and will not affect the WAPC's Lot 96. As a result the WAPC as an affected landowner has no objections to the proposal.

Please note that the aforementioned comments reflect the views of the WAPC Property Branch as an affected landowner only and are not intended to represent the views of the Department of Planning or the WAPC, both of which will assess the plans during the formal statutory process.

Should you have any queries concerning the above I would be pleased to discuss and can be contacted on 9264 7544.

Yours sincerely,

T. Hillyard

Tim Hillyard
Manager
WAPC Property Management Services
Western Australian Planning Commission
1 July 2009

City of Swan, Caversham Cell - 20 Year Plan

Year	2010 Year 1	2011 Year 2	2012 Year 3	2013 Year 4	2014 Year 5	2015 Year 6	2016 Year 7	2017 Year 8	2018 Year 9	2019 Year 10	2020 Year 11	2021 Year 12	2022 Year 13	2023 Year 14	2024 Year 15	2025 Year 16	2026 Year 17	2027 Year 18	2028 Year 19	2029 Year 20
Vacant Land	80% s.lot	70% s.lot	60% s.lot	50% s.lot	40% s.lot	30% s.lot	20% s.lot	0	0	0	0	0	0	0	0	0	0	0	0	0
Units			70	70	70	70	70	350	350	350	350	350	350	350	350	350	350	350	350	350
Houses	120	240	410	448	370	204	23	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
Total dwellings	**120**	**360**	**840**	**1358**	**1798**	**2072**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**	**2165**
Actual Rates - avg																				
Vacant land rate	886	921	958	997	1036	1078	1121	1166	1213	1261	1311	1364	1419	1475	1534	1596	1659	1726	1795	1867
Unit	886	921	958	997	1036	1078	1121	1166	1213	1261	1311	1364	1419	1475	1534	1596	1659	1726	1795	1867
House rate	996	1036	1077	1120	1165	1212	1260	1311	1363	1418	1474	1533	1595	1658	1725	1794	1865	1940	2018	2098
Rating Income																				
Super lot income-4% increment each year	$ 135,381	$ 123,197	$ 109,821	$ 95,178	$ 79,188	$ 61,767	$ 42,825	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Unit Dwelling income-4% increment each year	$ -	$ -	$ 67,081	$ 139,528	$ 217,664	$ 301,827	$ 392,375	$ 408,070	$ 424,393	$ 441,369	$ 459,024	$ 477,385	$ 496,480	$ 516,339	$ 536,993	$ 558,473	$ 580,811	$ 604,044	$ 628,206	$ 653,334
House Dwelling income-4% increment each year	$ 119,520	$ 372,902	$ 829,501	$ 1,364,604	$ 1,850,304	$ 2,171,521	$ 2,287,368	$ 2,378,863	$ 2,474,017	$ 2,572,978	$ 2,675,897	$ 2,782,933	$ 2,894,250	$ 3,010,020	$ 3,130,421	$ 3,255,638	$ 3,385,863	$ 3,521,298	$ 3,662,150	$ 3,808,636
Total Rates income	**$ 254,901**	**$ 496,099**	**$ 1,006,402**	**$ 1,599,310**	**$ 2,147,157**	**$ 2,535,115**	**$ 2,722,568**	**$ 2,786,933**	**$ 2,898,410**	**$ 3,014,347**	**$ 3,134,921**	**$ 3,260,317**	**$ 3,390,730**	**$ 3,526,359**	**$ 3,667,414**	**$ 3,814,110**	**$ 3,966,675**	**$ 4,125,342**	**$ 4,290,355**	**$ 4,461,969**
Cumulative rating income	$ 254,901	$ 751,000	$ 1,757,402	$ 3,356,712	$ 5,503,869	$ 8,038,984	$ 10,761,552	$ 13,548,485	$ 16,446,895	$ 19,461,242	$ 22,596,163	$ 25,856,480	$ 29,247,210	$ 32,773,569	$ 36,440,983	$ 40,255,093	$ 44,221,768	$ 48,347,109	$ 52,637,465	$ 57,099,434
MAINTENANCE EXPENDITURE		**Maintained by MLG**										**Maintained by the City of Swan**								
1. Public & Civic Open Space Systems																				
Completed POS Throughout Development Vested to CoS(%)				**20%**	**40%**	**60%**	**80%**													
Parks -maintenance MLG $				$ 27,265	$ 56,712	$ 88,471	$ 122,680	$ 159,484	$ 165,863	$ 172,497	$ 179,397	$ 186,573	$ 194,036	$ 201,798	$ 209,869	$ 218,264	$ 226,995	$ 236,075	$ 245,518	$ 255,338
Cumulative expenditure on parks				$ 27,265	$ 83,977	$ 172,448	$ 295,128	$ 454,612	$ 620,475	$ 792,972	$ 972,369	$ 1,158,942	$ 1,352,979	$ 1,554,776	$ 1,764,646	$ 1,982,910	$ 2,209,905	$ 2,445,979	$ 2,691,497	$ 2,946,835
% park/t.rates income				1.70%	3.91%	6.80%	10.84%	16.31%	21.41%	26.31%	31.02%	35.55%	39.90%	44.09%	48.12%	51.99%	55.71%	59.29%	62.73%	66.04%
2. Environmental & Management Systems		**Maintained by MLG**																		
Drainage -maintenance MLG $				$ 540,276	$ 561,887	$ 584,363	$ 607,737	$ 632,047	$ 657,329	$ 683,622	$ 710,967	$ 739,405	$ 768,982	$ 799,741	$ 831,730	$ 865,000	$ 899,600	$ 935,584	$ 973,007	$ 1,011,927
Cumulative expenditure on drainage				$ 540,276	$ 1,102,164	$ 1,686,526	$ 2,294,264	$ 2,926,310	$ 3,583,639	$ 4,267,261	$ 4,978,227	$ 5,717,633	$ 6,486,614	$ 7,286,355	$ 8,118,086	$ 8,983,085	$ 9,882,685	$ 10,818,268	$ 11,791,275	$ 12,803,203
% drainage/t.rates income				34%	26%	23%	22%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
3. Transport Networks & Pathways		**Maintained by MLG**																		
Roads & Pathways -maintenance MLG $				$ 2,190,566	$ 2,278,189	$ 2,369,316	$ 2,464,089	$ 2,562,652	$ 2,665,158	$ 2,771,765	$ 2,882,635	$ 2,997,941	$ 3,117,858	$ 3,242,573	$ 3,372,276	$ 3,507,167	$ 3,647,453	$ 3,793,352	$ 3,945,086	$ 4,102,889
Cumulative expenditure on transport networks & cycleways				$ 2,190,566	$ 4,468,755	$ 6,838,071	$ 9,302,160	$ 11,864,812	$ 14,529,971	$ 17,301,735	$ 20,184,371	$ 23,182,312	$ 26,300,170	$ 29,542,743	$ 32,915,019	$ 36,422,185	$ 40,069,639	$ 43,862,990	$ 47,808,076	$ 51,910,965
% trasport networks & cycleways/t.rates income				136.97%	106.10%	93.46%	90.51%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%	91.95%
4. Community Facilities & Services		**Maintained by MLG**																		
Community Facilities & Services -maintenance MLG $				$ 119,756	$ 125,145	$ 130,777	$ 136,662	$ 162,626	$ 169,944	$ 177,591	$ 185,583	$ 193,934	$ 202,661	$ 211,781	$ 221,311	$ 231,270	$ 241,677	$ 252,553	$ 263,918	$ 275,794
Cumulative expenditure on community facilities & services				$ 119,756	$ 244,902	$ 375,679	$ 512,340	$ 674,966	$ 844,910	$ 1,022,501	$ 1,208,084	$ 1,402,018	$ 1,604,679	$ 1,816,460	$ 2,037,771	$ 2,269,041	$ 2,510,718	$ 2,763,271	$ 3,027,189	$ 3,302,982
% community facilities & services/t.rates income				7.49%	5.83%	5.16%	5.02%	5.84%	5.86%	5.89%	5.92%	5.95%	5.98%	6.01%	6.03%	6.06%	6.09%	6.12%	6.15%	6.18%
5. Public Utilities		**Maintained by MLG**																		
Public Utilities -maintenance MLG $																				
Cumulative expenditure on public utilities																				
% public utilities/t.rates income																				
6. Studies - Planning & Monitoring		**Maintained by MLG**																		
Studies -maintenance MLG $																				
Cumulative expenditure on Studies - Planning & Monitoring																				
% studies - planning & monitoring/t.rates income																				
7. Other Items		**Maintained by MLG**																		
Other Items -maintenance MLG $																				
Cumulative expenditure on other items																				
% other items/t.rates income																				
Total Maintenance Expenditure				**$ 2,877,864**	**$ 3,021,933**	**$ 3,172,927**	**$ 3,331,168**	**$ 3,516,808**	**$ 3,658,294**	**$ 3,805,475**	**$ 3,958,582**	**$ 4,117,853**	**$ 4,283,537**	**$ 4,455,892**	**$ 4,635,187**	**$ 4,821,701**	**$ 5,015,725**	**$ 5,217,562**	**$ 5,427,528**	**$ 5,645,948**
Total Maintenance Expenditure as a % of Rating Income				179.94%	140.74%	125.16%	122.35%	126.19%	126.22%	126.25%	126.27%	126.30%	126.33%	126.36%	126.39%	126.42%	126.45%	126.48%	126.51%	126.53%
Cumulative Maintenance Expenditure				$ 2,877,864	$ 5,899,797	$ 9,072,724	$ 12,403,892	$ 15,920,700	$ 19,578,994	$ 23,384,469	$ 27,343,051	$ 31,460,905	$ 35,744,442	$ 40,200,334	$ 44,835,521	$ 49,657,222	$ 54,672,947	$ 59,890,509	$ 65,318,037	$ 70,963,985
NET RATING INCOME	**$ 254,901**	**$ 496,099**	**$ 1,006,402**	**-$ 1,278,554**	**-$ 874,777**	**-$ 637,812**	**-$ 608,599**	**-$ 729,875**	**-$ 759,884**	**-$ 791,129**	**-$ 823,662**	**-$ 857,536**	**-$ 892,807**	**-$ 929,533**	**-$ 967,773**	**-$ 1,007,590**	**-$ 1,049,050**	**-$ 1,092,221**	**-$ 1,137,172**	**-$ 1,183,979**
NET RATING INCOME AS A % OF TOTAL RATING INCOME	100.00%	100.00%	100.00%	-79.94%	-40.74%	-25.16%	-22.35%	-26.19%	-26.22%	-26.25%	-26.27%	-26.30%	-26.33%	-26.36%	-26.39%	-26.42%	-26.45%	-26.48%	-26.51%	-26.53%
CUMULATIVE NET RATING INCOME	$ 254,901	$ 751,000	$ 1,757,402	$ 478,848	-$ 395,928	-$ 1,033,740	-$ 1,642,340	-$ 2,372,215	-$ 3,132,098	-$ 3,923,227	-$ 4,746,889	-$ 5,604,425	-$ 6,497,232	-$ 7,426,765	-$ 8,394,538	-$ 9,402,128	-$ 10,451,179	-$ 11,543,400	-$ 12,680,572	-$ 13,864,551

Broad Assumptions

1. Superlot area is based on the total area of the Caversham cell as per the DCP (191 Ha)
2. Assume the development is completed in 7 years and it is pro rata over the 7 years
3. All maintenance expenditure is calculated using the relevant % amount of embelishment or $/sqm as provided by the CoS Financial Departmen
4. Vacant land is the balance of the super lot rated UV
5. Unit rate is assumed to be on par with house rating as rental levels comparable
6. House rate based on average residential ($) rate from the CoS 2009/10 budget, with the addition of a levy of $55/bin for new waste bins (general and recyclables = $110)
7. Annual increment set at 4% - applicable to both income only. Annual increment of 4% - 4.5% for expenditure as per CoS instruction
8. The total spend by the City commences in year 4 based on 09/10 numbers escalated by 4%. It is assumed that as the development progresses, various POS will be vested to the City of Swan in years 4,5,6,& 7 and have been broken into percentage amounts
9. Build out of cell is based on best estimates. Expenditure will be determined by actual population growth
10. Funding of parks and all other infrastructure to be completed and wholly funded by the Developer Contribution Plan

Caversham Local Structure Plan &

Caversham North Local Structure Plan

Caversham Financial Assessment Report

February 2010

Prepared for
Caversham Main Landowners Group

Prepared by

RPS koltasz smith
TOWN PLANNING PROJECT MANAGEMENT URBAN DESIGN DEVELOPMENT CONSULTING

A.C.N. 009 161 139

141 Burswood Road

BURSWOOD WA 6100

Telephone: (08) 9486 2222

Facsimile: (08) 9486 2233

Email: perth@ksap.com.au

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1. OVERVIEW

BACKGROUND

This Financial Assessment Report has been prepared in accordance with the City of Swan's policy POL-C-102 to accompany the Caversham Local Structure Plan and the Caversham North Structure Plan. Together both local structure plans provide for a coordinated approach to the future development of the Caversham Urban Cell consistent with the Swan Urban Growth Corridor Sub – Regional Structure Plan.

Collectively the proponents of both structure plans are referred to as the 'Caversham Main Landowner Group' (referred to as 'MLG' hereafter).

2. PLANNING FRAMEWORK

2.1 STATUTORY PLANNING

2.1.1 Metropolitan Region Scheme: Amendment No. 1153 / 41

In November 2006, RPS Koltasz Smith, on behalf of the Caversham Main Landowners Group, lodged a request to initiate an amendment to the MRS to rezone the portion of the Caversham future urban cell zoned ‘Rural’ to ‘Urban’. An earlier draft of the Caversham Local Structure Plan (LSP) was lodged concurrently with the MRS amendment request to support the request to rezone the land for urban development.

The amendment was supported for final approval by the Hon. Minister for Planning in June 2009 and promulgated by Parliament in September 2009. The amendment was gazetted on the 22nd October 2009.

2.1.2 City of Swan Local Planning Scheme No. 17

Submitted concurrently with the MRS amendment was a proposal to amend the local scheme to include the land within the ‘Residential Development’ zone. The amendment was gazetted in parallel with the MRS amendment.

A requirement of the zone is that structure plans be accompanied by relevant supporting documentation demonstrating the long term financial feasibility of public infrastructure including public open space systems and community facilities.

2.2 POLICY

Policy POL-C-102 (‘the policy’) requires LSP’s to be accompanied by a Financial Assessment Report FAR. The FAR is required to address the following:

- Levels of infrastructure provision and timeframes for delivery;
- Asset management programs; and
- Priorities for staging of urban development.

Specifically the following items are to be accounted for:

- Public and civic open space systems;

- Environmental and water management systems;
- Transport networks and pathways;
- Community facilities and services;
- Public utilities; and
- Associated follow up studies.

2.2.1 Developer Contribution Strategy and Developer Contribution Plan

The Caversham MLG (including the proponents of Caversham North) in association with the City of Swan and its appointed consultant have prepared a draft Developer Contribution Strategy DCS and recently a Developer Contribution Plan DCP for the Swan Urban Growth Corridor including the Caversham Cell. The purpose of both documents is to provide a fair and equitable means of funding key items of infrastructure within the Swan Urban Growth Corridor including the Caversham Cell. The DCS and the DCP identify the following major contributions items within the Cell:

- Patricia Street upgrade
- Waldeck Street upgrade
- Arthur Street upgrade
- Neighbourhood Active Open Space
- Local Community Centre

The DCS and DCP also identify the following district / regional contribution items external to the Cell:

- Construction of Lord Street, including intersection treatments to Reid Highway and Benara Road; and
- District Open Space.

The MLG is currently in negotiation with the City to determine the level or percentage of contribution required for the construction of Lord Street.

2.2.2 Interim Cost Contribution Arrangements

It is expected that some subdivision will occur prior to finalisation of the DCP. Preliminary contributions will be calculated using one of the following mechanisms:

- the final Development Contribution Plan; or

- in the absence of the final DCP, a Council endorsed Infrastructure Strategy for Development Contributions (ISDC); or

- in the absence of a Council endorsed ISDC, Council's consultants to provide the costs based on the most current draft of the relevant Policy and/or Strategy (ISDC).

In addition to the preliminary contributions calculated as per three above, developers will be required to provide an additional security to the value of 50% of that contribution.

Any landowner wishing to subdivide their land prior to adoption of the final DCP, will be required to enter into a Deed of Agreement with the City of Swan within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later. The Deed, while in form similar to the early release subdivision deeds is to require payment of contributions which may be reduced below the previous contribution rate having regard to the latest cost estimates for the DCP. The Deed is to act as a financial security to secure payment of any monies owed (to either party) under the final DCP.

2.3 COMMUNITY AND ECONOMIC DEVELOPMENT PLAN

In April 2009 community consultants, *Creating Communities,* were commissioned by the MLG to prepare a Community and Economic Development Plan (CEDP) for the Caversham LSP. The CEDP recommended a number of initiatives that are required to be accounted for by the FAR. The FAR will be instrumental in outlining how these initiatives are funded and implemented.

The CEDP is extensively referred to throughout this report.

3. INFRASTRUCTURE PROVISION & COST

3.1 PUBLIC OPEN SPACE

The Caversham Local Structure Plan provides for the following public open space (POS) areas:

POS	Description	Embellishment (Indicative)
1.1	Local	Grassed, non equipment play opportunities
1.2	Local	Paths, shade, seating & play spaces
1.3	Local	Paths, shade, seating & play spaces
1.4	Local	Grassed, non equipment play opportunities
2.1	Local	Paths, shade, seating & play spaces
3.1	Local	Paths, shade, seating & play spaces
4.1	Neighbourhood Active	Shared use oval and sports court
4.2	Local	Paths, shade, seating & play spaces
4.3	Local	Paths, shade, seating & play spaces
4.4	Local	Grassed, non equipment play opportunities
4.5	Community Centre	Local Community Centre (refer section 3.4) & CEDP
5.1	Local	Paths, shade, seating & play spaces
5.2	Local	Grassed, non equipment play opportunities
5.3	Local	Grassed, non equipment play opportunities
5.4	Local	Paths, shade, seating & play spaces

All the parks will be enhanced / embellished in accordance with the standards set out in the City of Swan's 'Landscape Guidelines for Streetscape and Public Open Space' and the 'City of Swan / Play Space Strategy'.

None of the public open space areas will contain artificial lakes or other unsustainable wetland features. All POS will be landscaped with drought tolerant species in accordance with the City's guidelines.

3.1.1 Indicative Costs

The following costs have been derived from the CEDP:

POS Element	No. (area)	Rate	Cost (inc contingency)
Landscaping	85,000 sqm	$50 sqm	$4,675,000.00

The rate is inclusive of: earthworks, installation of grass, shade facilities, bollards, minor paths & kerbing.

3.2 WATER MANAGEMENT SYSTEMS

A draft Local Water Management Strategy (LWMS) has been prepared for the Caversham Cell. The LWMS provides for two primary drainage channels (overland paths) and twenty two detention basins.

The draft Developer Contribution Strategy prepared by Integran, estimates the total cost for installing the infrastructure as follows:

Element	Works Cost per unit	No	Total including contingency
Detention / Retention Basins	$500,000.00	11	$6,050,000.00
Detention / Retention Basin	$850,000.00	1	$935,000.00
Detention / Retention Basin	$1,100,000.00	1	$1,210,000.00
Detention / Retention Basin	$1,420,000.00	1	$1,562,000.00
Overland flow path (west)	$1,511,734.00	Na	$1,662,907.40
Overland flow path (east)	$534,258.00	Na	$587,683.80
Total			$12,007,590.00

The above figures will be reviewed upon approval of the LWMS by the Dept of Water.

3.3 TRANSPORT NETWORKS AND PATHWAYS

The development of the Caversham estate will rely upon the installation of a comprehensive network of local, district and regional roads. All road and pathway infrastructure will be constructed in accordance with the City's standards and requirements.

Construction costs are based upon the following advice received from Integran Infrastructure Consultants:

Code	Description	Units	Unit Rate $2009	Comments
	Earthworks and Site Preparation			
1	Site Clearance (Rate based on light shrubs)	m2	$ 0.80	Based on site clearance in light scrub including removal of all vegetation incl. roots and trees
2	Removal of top soil 150mm thick and stockpile for later re-use	m2	$ 3.00	
3	Detailed Excavation & Cartaway / Dispurse Surplus Material	m3	$ 6.00	Assumed excavation to commence at existing ground level (after removal of topsoil)
4	Backfilling of ROC / Working Space	m3	$ 4.20	Based on use of reduced level detailed excavated material.
5	Existing Services Locating	m	$ 25.00	Assume 1 service every 500m on average
	Subgrade Preparation			
6	Preparation, Trim and Compact	m2	$ 2.20	Only measured to areas where concrete / bases are.
	Subbase			
7	275mm compacted thickness limestone subbase course	m2	$ 13.00	
	Road Base			
8	150mm compacted thick Limestone	m2	$ 12.00	
9	Primer Seal (Coat)	m2	$ 3.00	
10	30mm thick black asphalt wearing course	m2	$ 17.00	
	Kerbing			
11	Standard Semi-Mountable Kerb (SMK)	m	$ 15.00	Including horizontal and vertical sides
12	Reinforced Flush Kerb (300mm)	m	$ 30.00	
13	Barrier / Upright Kerb	m	$ 30.00	Including horizontal and vertical sides
	Linemarking and Furntiure			
14	Linemarking and Furniture	m	$ 25.00	Lane and line marking on the roads including traffic signs - i.e. Stop / Give Way marking at intersections, turning arrows etc.
15	Street Signs (Assume 2 per 500m)	No	$ 400.00	Cost comprises galv. sign post, sign plate, concrete footing inclusive of all necessary excavation and backfilling
	Concrete cycleways and Footpaths			
16	Footpath - General (m2)	m2	$ 36.00	Cost includes, $3.00/m2 ground prep, 25 thick sand bedding $5.00/m2, 100 thick in-situ concrete paving , reio. and formowork $25.00/m2 and broom finish to concrete $3.00/m2
	Planting & Vegetation			
17	General landscaping along the verges and medians of the roadway, including provision of topsoil, laying of turf, and planting of roadside trees / shrubs.	m2	$ 50.00	
18	Temporary landscaping / mulch to Subgrade Base	m2	$ 5.00	Stabilisation to formation
	Overhead Lighting			
19	Lighting (assuming 1 per 50m)	No	$7,500.00	Provision of one light every 50m. Cost includes the light standard, luminaire(s), light pole, junction pits & boxes, cabling, foundations & cages. The Unit Rate assumes the same fully absorbed cost for a single luminaire light and a two-arm / luminaire light.
	General Road Drainage			
20	Excavation of Pipe Trenches (2-3m depth)	m	$ 39.00	Rate includes excavation, backfilling and Risk Of Collapse
21	450mm SW Pipework - Supply and Insall	m	$ 165.00	
22	Precast concrete manholes for up to 450mm pipe (1050 Manhole) (assume 1 per 50m	No	$2,800.00	
23	Gully (Side Entry) Pits - Supply and Install (1050mm dia)(assume 1 per 50m)	No	$1,250.00	
24	Sealed Inlets (assume 1 per 50m)	No	$ 300.00	Rate allows for two inlets (one either side)
25	Sub Soil Drainage	m	$ 16.00	Assume 100mm dia Piping
26	Table Drains (Sand)	m	$ 0.75	
27	Table Drains (Gravel or Clay)	m	$ 50.00	
28	Construct Table Drain	m	$ 5.00	
	Other Drainage			
29	Moderate Culvert (assuming 1 per 500m) (1200x300 long RCBC in good Soil)	m	$ 830.00	
30	Culvert End Wall (assuming 4 sqm required per culvert / per side)	No	$1,280.00	
	Traffic Management, Project Overheads and Project Owner's Costs			
31	Traffic Management	%	5%	5% used as Road works predominantly Greenfied.
32	Project Overheads (Indirect Construction Costs)	%	30%	Includes: Establishment, mobilisation, demobilisation, personnel (admin, Management, supervision), security, testing, final survey, quality assurance, enironmental control, etc.
33	Project Owner's Cost (Planning and Design Costs)	%	7.5%	Includes: Contract Administration, Design, Geothech, planning, project management, design survey, etc - Generally 7.5% - 10%

Based upon the above, the costs estimates for road and pathway infrastructure is:

Road Type	Estimated Cost per linear metre (approx)	Approximate Length	Total
Integrator A (Lord Street)	$2,229.25	1609	$3,586,863.20
Integrator B	$2,960.21	954	$2,824,040.30
Neighbourhood Connector A	$2,745.67	2002	$5,496,831.30
Neighbourhood Connector B	$2,591.28	1005	$2,604,236.40
Access Street (B)	$1,845.00	2620	$4,833,900.00
Access Street (C&D)	$1,483.00	16570	$24,573,310.00
Lane	$940.00	4880	$4,587,200.00
		TOTAL	$48,511380.00

In liaison with the City, the Caversham MLG may seek to review the above estimates in response to detailed design / planning and cost analysis.

3.4 COMMUNITY FACILITIES AND SERVICES

A key initiative of the CEDP is the development of a local community centre. The centre comprises the following:

Internal Facility Component	Functionality	Design Details
Entrance Foyer	Main entrance	Vending machine
	Community notice board	
	Display area for local arts	
Large Multipurpose Activity Room	Club/Group functions	
	Social and fundraising activities	
	Yoga/Pilates	
	Tae kwon do/Tai chi	
	Children's drama classes	
	Youth events/discos	
	Seniors activities/active ageing programs	
	School activities and events	
Training Room	Information presentations	Multipurpose
	Community seminars	Secure store room for laptop and digital projection equipment
	Migrant education programs	
Meeting/Counselling Room	Service clubs	Multipurpose
	Community support group meetings	Lockable storage cupboards for group equipment
	Craft groups	
	Women's/mother's groups	
	Outreach social services	

	Outreach financial counselling	
Playgroup Room/Children's Activity Room	Playgroups	Direct access to enclosed outdoor play area
	Before and after school care	Internal store room for arts and craft equipment, games/toys
	Children's holiday activities	External store for outdoor play equipment
	Parenting programs	
Kitchen/Kiosk	Multicultural cooking classes	Commercial kitchen
	Tea/Coffee facilities	Lockable storage cupboards for groups
	Food preparation and heating	Internal and external servery
	Servicing area for functions	
Toilets	Male	Internal access
	Female	As per building standards
	Disabled	
Toilet/Change rooms	Male	Universal design
	Female	No showers required in change room
		Ablutions to include accessible WC
Cleaners Store	Storage for cleaning equipment	
External Sports Equipment store	Storage of sporting equipment	

The development of the centre and associated initiatives is estimated to cost:

Element	**No. (area)**	**Rate**	**Cost (inc contingency)**
Local Community Centre	335 sqm	$2,600.00	$871,000.00
Shared use oval – earthworks, turf, irrigation (4.1 only)	9,912 sqm	$35	$395,229.00
Shared use oval flood lighting	2	$25,000.00	$55,000.00
Shared use sports courts (4.1 only)	4	$71,000.00	$323,548.00
		TOTAL	$1,644,777.00

In addition to the above infrastructure the CEDP also recommends the following community development initiatives to promote social cohesion and community spirit & identity:

- Information welcome packs;
- Local Christmas party;
- Information welcome packs;
- Community news sheets; and
- Community art projects, etc, etc.

The CEDP budgets $400 per lot for the above community activation initiatives.

3.5 Public Utilities

A pump station is proposed to be located in the south western margins of the LSP area. The pump station will be funded by the developers and ultimately vested in the Water Corporation.

4. FUNDING AND MAINTENANCE COSTS

4.1 FUNDING GENERALLY

The majority of infrastructure identified in the previous section will be funded by subdividers directly and or indirectly via contributions raised through the DCP. In some cases, such as regional road infrastructure, funding will also be sourced by various state agencies, for example the Arthur Street flyover.

Maintenance of infrastructure will be funded via rates.

4.2 RATEABLE INCOME

Based upon advice from the City the following assumptions have been made about rateable income:

- Per dwelling income of $886.00 & $996.00 dwelling; and
- Rateable income indexed by 4%.

The total rateable income from the Caversham LSP in 2017 will be approximately $2,722,568.00 based upon a dwelling yield of 2165. The cumulative rate income by 2017 is estimated to be $10,761,552.00 (refer Cost Schedule Appendix A).

4.3 TIMING & STAGING

It is estimated that the subdivision of the cell will be completed in 7 years commencing in 2010. The estimation is a guide only. Timing of actual development will be determined by market forces & regulatory timeframes (refer Cost Schedule Appendix A).

4.4 PUBLIC OPEN SPACE

Provision of local and neighbourhood open space areas and the embellishment thereof will be the responsibility of individual subdividers.

Through the Developer Contribution Strategy and associated Developer Contribution Plan DCP subdividers will also contribute to the development of an area of district open space located outside the Caversham LSP area.

4.4.1 POS Lifecycle Costs

Consistent with standard practice the individual subdividers will be responsible for maintenance of POS for the first three years with the City responsible thereafter. Lot sales are projected to commence in 2010.

The City of Swan has advised that maintenance POS costs generally equates to 4.5% of embellishment cost of the subject POS.

Using the parameters provided by the City, the Cost Schedule attached at Appendix A clearly demonstrates that projected rateable income will be sufficient to meet estimated POS maintenance costs.

4.5 WATER MANAGEMENT SYSTEMS

The development of the Caversham estate will rely upon the installation of a comprehensive drainage network.

The network will be installed entirely at the cost of subdividers.

4.5.1 Lifecycle Costs

The City of Swan has advised that lifecycle cost estimates should represent 4% of replacement cost per annum.

The Cost Schedule attached at Appendix A indicates that maintenance costs are well covered by estimated rateable income.

4.6 TRANSPORT NETWORKS AND PATHWAYS

The development of the Caversham estate will rely upon the installation of a comprehensive network of local, district and regional roads.

The majority of the road and pathway network will be installed at the cost of subdividers. The following roads with be funded via the DCP:

- Patricia Street upgrade;
- Waldeck Street upgrade;
- Arthur Street upgrade; and
- Construction of Lord Street, including intersection treatments to Reid Highway and Benara Road.

4.6.1 Lifecycle Costs

The City of Swan has advised that lifecycle cost estimates should represent 4% of replacement cost per annum.

The attached draft cost schedule indicates that road maintenance costs are projected to exceed estimated rateable income. Recent discussions with the City have indicated that estimated lifecycle costs may be reviewed. Furthermore, estimates of road construction cost are to be reviewed by an engineer appointed by the MLG in liaison with the City.

4.7 COMMUNITY FACILITIES AND SERVICES

The community centre and associated sports courts represent a significant cost that cannot be pre-funded by any one subdivider within the Caversham LSP area. Instead, funding will be via monies raised / accrued through the DCP.

Should the City wish to fast-track the construction of the community centre, ahead of funds accrued via the DCP, the following funding options could be explored;

a) prioritisation of existing DCP funds;

b) state government grants;

c) City of Swan funding; and

d) Combination of a) – c).

The land provided for the centre will be ceded at the time of subdivision free of cost, subject to the subdivider receiving 100% POS credit for the land.

The trigger for construction of the community facilities (including shared use oval) will be determined as part of the progression of the Caversham LSP and associated DCP. Landowners will be required to contribute to development of the proposed facilities and to secure these payments a deed of agreement shall be entered into by landowners prior to application for subdivision in order to satisfy Clause 5A.2.7.3 of LPS No.17 in the absence of an approved DCP.

4.7.1 Community Facility Lifecycle Costs

Creating Communities have advised that maintenance costs for public buildings per annum should represent approximately 4.5 % of the replacement cost of the subject facility.

Based upon this advice the maintenance of the facility could clearly be funded from rateable income (refer Cost Schedule Appendix A).

5. CONCLUSION

The Financial Assessment Report has been prepared in accordance with the requirements of the City's policy.

The report demonstrates that the majority of public infrastructure will be funded by private developers either directly or indirectly via the City's draft Developer Contribution Plan.

It is estimated that the development of the estate will be completed by 2017 assuming commencement in 2010.

The attached Cost Schedule indicates that estimated maintenance costs, for the majority of infrastructure, are well covered by projected rates income. Nevertheless, the attached draft cost schedule indicates that road maintenance costs are projected to exceed estimated rateable income. Recent discussions with the City have indicated that estimated lifecycle costs may be reviewed. Furthermore, estimates of road construction cost are to be reviewed by an engineer appointed by the MLG in liaison with the City.

APPENDIX A

Public & Civic Open Space Systems			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
			$ 1.20	$ 1.25	$ 1.30	$ 1.35	$ 1.40	$ 1.46
				4%	4%	4%	4%	4%
Local Landscaped Parks	85,000	$4,675,000	$102,000	$106,080	$110,323	$114,736	$119,326	$124,099
Shared Use Oval - Earthworks, Turf & Irrigation	9,912	$395,229			$12,865	$13,380	$13,915	$14,471
Shared Use Oval - Floodlighting (Poles)	2	$55,000			$2,704	$2,812	$2,925	$3,042
Local Community Centre Land	4,000	$400,000				$5,399	$5,615	$5,840
			$102,000	**$106,080**	**$125,892**	**$136,327**	**$141,780**	**$147,452**

Environmental & Water Management Systems			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (% of Constr.)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
			4%					
				4%	4%	4%	4%	4%
Drainage		$12,007,590	$480,304	$499,516	$519,496	$540,276	$561,887	$584,363
			$480,304	**$499,516**	**$519,496**	**$540,276**	**$561,887**	**$584,363**

Transport Networks & Pathways			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (% of Constr.)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
			4%					
				4%	4%	4%	4%	4%
Walking & Cycle Paths	2,500	$173,750	$6,950	$7,228	$7,517	$7,818	$8,131	$8,456
Roads (Integrator, Nieghbourhood, Access & Lane)	29,640	$48,511,380	$1,940,455	$2,018,073	$2,098,796	$2,182,748	$2,270,058	$2,360,860
			$1,947,405	**$2,025,301**	**$2,106,313**	**$2,190,566**	**$2,278,189**	**$2,369,316**

Community Facilities & Services			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (% of Constr.)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
			4.5%					
				4.5%	4.5%	4.5%	4.5%	4.5%
Local Community Centre	605	$1,887,600				$96,933	$101,295	$105,853
Shared Use Sports Courts	4	$323,548						
Community Development Funds			$20,000	$20,900	$21,841	$22,823	$23,850	$24,924
			$20,000	**$20,900**	**$21,841**	**$119,756**	**$125,145**	**$130,777**

Public Utilities			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
			$ -	$ -	$ -	$ -	$ -	$ -
				0%	0%	0%	0%	0%
			$0	$0	$0	$0	$0	$0

Studies - Planning & Monitoring			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
			$ -	$ -	$ -	$ -	$ -	$ -
				0%	0%	0%	0%	0%
			$0	$0	$0	$0	$0	$0

Other Items			2010	2011	2012	2013	2014	2015
	Construction	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Area (Sqm)	Budget	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
			$ -	$ -	$ -	$ -	$ -	$ -
				0%	0%	0%	0%	0%
			$0	$0	$0	$0	$0	$0

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ 1.52	$ 1.58	$ 1.64	$ 1.71	$ 1.78	$ 1.85	$ 1.92	$ 2.00	$ 2.08
4%	4%	4%	4%	4%	4%	4%	4%	4%
$129,063	$134,225	$139,594	$145,178	$150,985	$157,024	$163,305	$169,837	$176,631
$15,050	$15,652	$16,278	$16,929	$17,607	$18,311	$19,043	$19,805	$20,597
$3,163	$3,290	$3,421	$3,558	$3,701	$3,849	$4,003	$4,163	$4,329
$6,074	$6,316	$6,569	$6,832	$7,105	$7,389	$7,685	$7,992	$8,312
$153,350	**$159,484**	**$165,863**	**$172,497**	**$179,397**	**$186,573**	**$194,036**	**$201,798**	**$209,869**

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4%	4%	4%	4%	4%	4%	4%	4%	4%
$607,737	$632,047	$657,329	$683,622	$710,967	$739,405	$768,982	$799,741	$831,730
$607,737	**$632,047**	**$657,329**	**$683,622**	**$710,967**	**$739,405**	**$768,982**	**$799,741**	**$831,730**

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4%	4%	4%	4%	4%	4%	4%	4%	4%
$8,794	$9,146	$9,512	$9,892	$10,288	$10,699	$11,127	$11,572	$12,035
$2,455,295	$2,553,507	$2,655,647	$2,761,873	$2,872,348	$2,987,242	$3,106,731	$3,231,001	$3,360,241
$2,464,089	**$2,562,652**	**$2,665,158**	**$2,771,765**	**$2,882,635**	**$2,997,941**	**$3,117,858**	**$3,242,573**	**$3,372,276**

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
$110,617	$115,594	$120,796	$126,232	$131,912	$137,848	$144,052	$150,534	$157,308
	$19,814	$20,706	$21,637	$22,611	$23,629	$24,692	$25,803	$26,964
$26,045	$27,217	$28,442	$29,722	$31,059	$32,457	$33,918	$35,444	$37,039
$136,662	**$162,626**	**$169,944**	**$177,591**	**$185,583**	**$193,934**	**$202,661**	**$211,781**	**$221,311**

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%	0%	0%	0%	0%
$0	$0	$0	$0	$0	$0	$0	$0	$0

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%	0%	0%	0%	0%
$0	$0	$0	$0	$0	$0	$0	$0	$0

2016	2017	2018	2019	2020	2021	2022	2023	2024
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%	0%	0%	0%	0%
$0	$0	$0	$0	$0	$0	$0	$0	$0

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ 2.16	$ 2.25	$ 2.34	$ 2.43	$ 2.53
4%	4%	4%	4%	4%
$183,696	$191,044	$198,686	$206,633	$214,899
$21,421	$22,278	$23,169	$24,096	$25,060
$4,502	$4,682	$4,870	$5,065	$5,267
$8,645	$8,990	$9,350	$9,724	$10,113
$218,264	**$226,995**	**$236,075**	**$245,518**	**$255,338**

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4%	4%	4%	4%	4%
$865,000	$899,600	$935,584	$973,007	$1,011,927
$865,000	**$899,600**	**$935,584**	**$973,007**	**$1,011,927**

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4%	4%	4%	4%	4%
$12,517	$13,017	$13,538	$14,079	$14,643
$3,494,650	$3,634,436	$3,779,814	$3,931,006	$4,088,246
$3,507,167	**$3,647,453**	**$3,793,352**	**$3,945,086**	**$4,102,889**

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)	Escalation (CPI)
4.5%	4.5%	4.5%	4.5%	4.5%
$164,387	$171,784	$179,515	$187,593	$196,034
$28,178	$29,445	$30,771	$32,155	$33,602
$38,706	$40,447	$42,268	$44,170	$46,157
$231,270	**$241,677**	**$252,553**	**$263,918**	**$275,794**

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%
$0	$0	$0	$0	$0

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%
$0	$0	$0	$0	$0

2025	2026	2027	2028	2029
Year 16	Year 17	Year 18	Year 19	Year 20
Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)	Maintenance (sqm)
$ -	$ -	$ -	$ -	$ -
0%	0%	0%	0%	0%
$0	$0	$0	$0	$0

ENVIRONMENTAL ASSESSMENT REPORT

Caversham Urban Cell
Local Structure Plan Area

Prepared by:

RPS

290 Churchill Avenue, SUBIACO WA 6008
PO Box 465, SUBIACO WA 6904

T: 618 9382 4744
F: 618 9382 1177
E: admin02@rpsgroup.com.au
W: www.rpsgroup.com.au

Prepared for:

CAVERSHAM MAIN LANDOWNERS GROUP

c/o RPS Koltasz Smith
PO Box 127
BURSWOOD WA 6100

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Disclaimer

SUMMARY

The Caversham Main Landowners Group has commenced structure planning for land within the locality of Caversham, within the City of Swan ('the site') (Figure 1). The site forms part of the greater Swan Sub-regional Urban Growth Corridor (Figure 2), and is bound by the proposed Lord Street extension to the west, Reid Highway to the north, the Dampier – Bunbury Natural Gas Pipeline (as well as private properties fronting West Swan Road) to the east, and Benara Road to the south (Figure 3).

The site is largely cleared and used for agricultural activities (grazing). Viticulture and other intensive horticultural practices also occur across the site. The site is located within the Swan Valley, a popular wine region of Perth. It lies north-east of Bennett Brook.

Land within the 198ha site is predominantly zoned 'Rural' under the Metropolitan Region Scheme, with land between Patricia Street and Reid Highway zoned 'Urban' (Figure 4). The site is zoned 'Swan Valley Rural' under the City of Swan's Town Planning Scheme No. 9.

This Environmental Assessment Report (EAR) is intended to:

1. Support the Local Structure Plan design and thus the rezoning of portions of the site currently zoned 'Rural' under the Metropolitan Region Scheme and 'Swan Valley Rural' under the City of Swan's Town Planning Scheme No. 9, to 'Urban'.

2. Provide the Environmental Protection Authority (EPA) with sufficient information to assess the rezoning application and set its level of assessment for the project.

The Local Structure Plan (Plan No. 2965-2001g.dgn, Revision G, 3 October 2008) prepared by RPS Koltaz Smith incorporates the following land uses:

- A mixture of residential densities ranging from R15 to R60.
- A lifestyle/retirement village.
- A neighbourhood centre.
- A community site.
- A primary school.
- Public open space (POS).
- Provision for drainage.
- 'Transitional lots' along the southern and eastern site boundaries.

The transitional lots are intended to provide additional protection of future residents from existing and surrounding land uses that may pose a potential impact. The detailed design of these lots and more detail about their objective(s) and purpose is presented in the Transition Lot (Buffer) Management Plan, being prepared jointly by RPS Koltasz Smith and RPS Environment and Planning.

Review of the proposed Local Structure Plan, and comparison with the existing natural environment provides the following key conclusions:

- The site's topography, soils and landforms present no significant obstacles to development. However, fill will be required to facilitate the development for residential purposes.

- No significant remnant native vegetation will need to be cleared, as a majority of the site has limited native vegetation remaining. The areas of remnant native vegetation to the north of Patricia Street will be protected within the Lifestyle/Retirement Village.

- Nutrient export from the site to the Swan River is likely to be reduced as a result of sewered urban development, given best practice urban water management will be incorporated within the urban design. An Urban Water Management Plan will be prepared at subdivision stage, and be in accordance with the principles of the approved *Local Water Management Strategy* (Cardno BSD, August 2007).

- The *Local Water Management Strategy* (Cardno BSD, August 2007) and the yet-to-be-prepared Urban Water Management Plan will ensure protection of the better quality wetland areas adjacent to the site.

- The enhancement of the western most drainage channel, using a 'Living Stream' concept. This drain will be rehabilitated using native species, enhancing biodiversity at the site and providing additional habitat for local fauna. The living stream will be incorporated into the overall stormwater system and will incorporate a treatment train approach, for the treatment of stormwater (for nutrients), prior to discharge off site. The living stream will include various fauna habitats, including:

  - Wide, shallow sections for wading birds.
  - Native trees for bird nesting.
  - Reeds for dragon flies and macroinvertebrate protection.

  Planting with native plant species will also assist with any potential erosion issues. The area will provide a focal point for future residents, with passive recreational benefits.

- The two known Aboriginal Sites will be protected in Public Open Space and the Lifestyle/Retirement Village landscaped areas.

- The site lies outside the 20 ANEF noise contour associated with Perth International Airport.

- The transitional (buffer) lots identified as part of the Transitional Lot (Buffer) Management Plan (RPS Koltasz Smith and RPS Environment and Planning, 2008) provide protection from the negative impacts of noise and spray drift that could potentially be generated from nearby viticultural activities. These lots will incorporate a thick vegetated buffer of native vegetation. As such, these lots will also provide a landscaping screen to neighbouring wineries, thus improving the landscape amenity of the development.

- Noise associated with Reid Highway and the proposed Lord Street extension is addressed in the *Noise Impact Assessment* (Lloyd Acoustics, 2006).

- The Dampier – Bunbury Natural Gas Pipeline lies within the proposed transitional lots along the eastern site boundary.

- Specific design strategies that will be incorporated as part of the development are anticipated to protect and enhance the existing environmental features of the site. Commitments being made by the developer, as part of the Local Structure Plan design process, include:

- Preparation and implementation of an Urban Water Management Plan to guide detailed design of the stormwater system and will ensure protection of the better quality wetland areas adjacent to the site as well as the groundwater resources in the area.

- Undertaking a Preliminary Site Investigation (PSI) to determine the likelihood for on-site contamination. The PSI will be required for all lots which are recognised as having past or present land uses which may have impacted upon soil or groundwater quality. It will be undertaken prior to soil disturbing activities.

- Undertaking a Preliminary Site Assessment (PSA) to determine the presence or otherwise of Acid Sulfate Soils (ASS). This assessment will be undertaken in areas mapped by the WAPC having any risk of ASS within 3m of soil surface, and along the western most drainage channel, given substantial earthworks in this area are likely. The outcomes of the PSA will inform detailed subdivision design, and as such will be undertaken prior to detailed subdivision design.

- Determination with the City of Swan (and potentially the DEC) of the detailed characteristics and species composition for the transitional lots.

Please refer to the *Transition Lot (Buffer) Management Plan* (RPS Koltasz Smith and RPS Environment and Planning, 2008) and the *Noise Impact Assessment* (Lloyd Acoustics, 2006) for more detailed explanations on the transition lot concept and the rationale for proposed buffer distances relating to spray drift and noise management.

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APPENDICES

1.0 INTRODUCTION

1.1 Background and Context

The Caversham Main Landowners Group has commenced structure planning for land within the locality of Caversham, within the City of Swan (‘the site’) (Figure 1). The site forms part of the greater Swan Sub-regional Urban Growth Corridor (Figure 2), which aims to guide residential growth in the north-eastern corridor of the Perth Metropolitan Area.

The Caversham Local Structure Plan LSP seeks to provide the necessary planning framework for a 172ha of land bounded by Benara Road, West Swan Road, Reid Highway and the proposed Lord Street extension on the edge of the Swan Valley within the City of Swan. The LSP has been prepared in accordance with the provisions of Local Planning Scheme No. 17.

1.2 Location and Land Use

The site is located approximately 18km north-east of Perth and is bound by the proposed Lord Street extension to the west, Reid Highway to the north, the Dampier – Bunbury Natural Gas Pipeline (as well as private properties fronting West Swan Road) to the east, and Benara Road to the south (Figure 3). The site lies north-east of Bennett Brook.

The site is largely cleared and used for agricultural activities (grazing). Viticulture and other intensive horticultural practices also occur across the site. The site is located within the Swan Valley, a popular wine region of Perth.

1.3 Zoning

Land within the 198ha site is predominantly zoned ‘Rural’ under the Metropolitan Region Scheme (MRS), with land between Patricia Street and Reid Highway zoned ‘Urban’ (Figure 4). The site is zoned ‘Swan Valley Rural’ under the City of Swan’s Town Planning Scheme No. 9 (TPS No. 9).

1.4 Purpose and Objectives

The purpose of this Environmental Assessment Report (EAR) is two-fold.

Firstly, it supports the Local Structure Plan design and thus supports rezoning of portions of the site currently zoned ‘Rural’ under the MRS and ‘Swan Valley Rural’ under the City of Swan’s TPS No. 9, to ‘Urban’. The EAR will support documentation lodged with the City of Swan and Western Australian Planning Commission (WAPC) to initiate the Scheme Amendments. An 'Urban' zoning will facilitate ultimate development of the site for residential purposes.

Secondly, the EAR provides the Environmental Protection Authority (EPA) with sufficient information to assess the rezoning application. Provision of detailed environmental information is necessary to allow the EPA to set its level of assessment for the project.

The objectives of this EAR are to:

- Detail the key features of the proposed development and Local Structure Plan design.
- Outline the policies and legislation relevant to the proposal;
- Provide an analysis of potential environmental impacts to the site which may result from development for residential purposes.
- Detail the mechanisms or management strategies the client commits to implementing within the structure plan, in order to protect and enhance the natural environment of the site.
- Identify issues which require further investigation at the appropriate stage in the planning process.

1.5 State Environmental Impact Assessment Process

There are a number of options available to progress the proposed rezoning, or Scheme Amendments, through the State environmental assessment process, under Section 48A of the *Environmental Protection Act 1986* (EP Act).

The proposal documentation, including the EAR, is sent through to the EPA to set its level of assessment. Under Section 48A of the EP Act, there are three potential EPA assessment scenarios:

- Informal level of environmental assessment, which could be either 'Not Assessed – Advice Given' or 'Not Assessed – No Advice Given'.
- Formal level of environmental assessment.
- 'Incapable of being made environmentally acceptable'.

The advantage to a project in terms of the time period for approvals of obtaining an informal level of assessment compared to a formal level of assessment is quite substantial. The formal Section 48A process can take anywhere between eighteen months and two years to finalise.

The Environmental Impact Assessment process for scheme amendments under Section 48 of the EP Act is outlined in Appendix 1. This figure represents Figure A2 from the EPA Guidance Statement No. 33, *Environmental Guidance for Planning and Development (May 2008)* [Part A, Chapter A3, page 4].

Early derivation of appropriate management commitments and/or text for the scheme amendment by the project team, at the time of initial documentation, will assist in aiming to achieve an informal level of assessment, although this outcome is never guaranteed.

2.0 RELEVANT LEGISLATION AND GUIDELINES

As further detailed in Section 6, in the case of Caversham, the key potential impacts from existing surrounding land uses relate to:

- Spray drift (from viticultural activities).
- Odour (from Bennett Street poultry farm).
- Noise (from Reid Highway and the vineyards).
- Gas (from viticulture/poultry farm).

Legislation, policies, planning bulletins, codes of practice and guidelines are in place to reduce the risk of the above factors impacting upon residential development proposed adjacent viticultural, agricultural or industrial operations.

Consideration of these documents is important when deriving buffer requirements between residential development and surrounding land uses, and when developing associated measures to manage the interface between the two land uses. Documents relevant to the Caversham development are outlined below.

2.1 *Environmental Protection Act 1986*

Section 53 of the Environmental Protection Act applies to 'occupiers of prescribed premises to be authorised in respect of certain changes leading to discharges of waste or emissions of noise, odour or electromagnetic radiation'.

'Subject to this act, the occupier of any prescribed premises who, if to do so, may cause an emission, or alter the nature or volume of the waste, noise, odour or electromagnetic radiation emitted, from the prescribed premises –

- Alters the method of operation of any trade, or of any process used in any trade, carried on at the prescribed premises;

- Constructs, installs or alters any equipment on the prescribed premises for:

    - The storage, handling, transport or treatment of waste prior to, and for the purpose of, the discharge of waste; or

    - The control of noise, odour or electromagnetic radiation prior to, and for the purpose of, the emission or transmission of noise, odour or electromagnetic radiation,

into the environment commits an offence unless he does so in accordance with;

- A works approval;

- A licence; or
- A requirement contained in a closure notice or an environmental protection notice.'

2.2 *Occupational Health and Safety Act 1984*

The aim of the Occupational Health and Safety Act ('the Act') is to create safer workplaces, eliminate work-related deaths and prevent worker injury and disease. Under the Act, all parties involved have responsibilities for occupational health and safety. The Act is supported by more detailed requirements in the Occupational Health and Safety Requirements 1996. These regulations are statutory and cover specific requirements of the Act.

Aspects of the Act and the Requirements are administered by the Department for Consumer and Employment Protection. The Worksafe division of the department undertakes a wide range of regulatory activities as well as industry and community awareness programs.

Worksafe has produced a document entitled 'Working with Pesticides' which demonstrates how to comply with the Occupational Safety and Health Act and Part 5 of the Occupational Safety and Health Regulations (Department for Consumer and Employment Protection, 2003), when using pesticides in the workplace. These guidelines provide information in relation to hazard identification, risk assessment and guidelines for usage of pesticides.

All agricultural activities are obliged, by law, to operate within accordance of the requirements of the Act, in order to ensure the health and safety of those people employed within the activities. Therefore, by law, future residents of developments adjacent operations utilizing chemical sprays should furthermore be adequately protected from any potential impacts.

2.3 Environmental Protection (Noise) Regulations 1997

The Environmental Protection (Noise) Regulations were gazetted on 31 October 1997, and came into effect on 31 January 1998. These Regulations replaced the Noise Abatement (Neighbourhood Annoyance) Regulations 1979, and Environmental Protection Act 1986 are a 'prescribed standard' under Sections 51, 62 (4), 65, 74 (3) and Clause 22 of Schedule 4 of the Act. Noise emissions which exceed the prescribed standard can be regarded as 'pollution' and 'unreasonable noise' under Section 3 of the Act.

The Regulations make provision for special cases, to allow reasonable amounts of activities that benefit the community. These activities need not meet the assigned levels outlined in Environmental Protection (Noise) Regulations ('the assigned levels'). In each case, however, the activity must comply with conditions set in the Regulations. One of these special cases is agriculture, provided it can be shown that farming vehicles are not unduly noisy, or if used at night, that the work is necessary.

Under the special case Regulation 12, which deals with rural activities, the assigned levels for noise do not apply to noise emitted from a farming vehicle on rural premises at any time between sunrise and sunset if the farming vehicle complies with the noise emission limits in Australian Design Rule 28/01 (ADR 28/01), which sets out noise emission limits for all types of vehicles. The noise limits to which a farming vehicle would need to comply would be those for goods vehicles intended for off road use, of the same mass and engine power.

The assigned levels for noise do not apply to noise emitted from a farming vehicle on rural premises at any time between sunset and sunrise if:

- The farming vehicle complies with the noise emission limits in ADR 28/01; and
- The occupier of the premises can show that it was reasonably necessary for the vehicle to be operated at night time.

If the above conditions are not met, the farming vehicle must meet the assigned levels.

The 'rural premises' to which Regulation 12 applies, exclude premises used for intensive poultry farming. Therefore, in reference to the Caversham development, Regulation 12 is only applicable to the viticulture operations adjacent the proposed development. The nearby poultry operations are governed by the assigned levels discussed above.

2.4 Environmental Code of Practice for Poultry Farms in Western Australia 1999

The Western Australian poultry industry strives to minimise its impacts on neighbours, ecosystems and water resources. Many farms have relocated further away from residential areas, others have incorporated practical measures to manage impacts. The industry is leading the way by promoting best management practices as an industry standard and encouraging farmers to meet this standard.

This Environmental Code of Practice, Environmental Code of Practice for Poultry Farms in Western Australia 1999, replaces the WA Environmental Protection Authority's Environmental Code of Practice for the Poultry Industry 1991.

This key aim of this Code of Practice in reference to adjacent sensitive land uses, relevant to this report is as follows:

- Suggest practical measures for minimising environmental and social impacts.

The document provides recommended minimum buffer distances between poultry farm facilities and existing or proposed future residential zones. The minimum distance recommended between poultry farm facilities and existing or proposed future residential zones is 300m.

2.5 Environmental Code of Practice for the Use of Agricultural and Veterinary Chemicals in Western Australia 2002

A Code of Practice for the use of agricultural and veterinary chemicals in Western Australia was released by the Department of Agriculture (2002).

The Code of Practice provides practical guidance for the safe, responsible and effective use of agricultural and veterinary chemicals. Issues addressed in the Code of Practice include:

- Duty of care.
- Choice, purchase, transport and storage of chemicals.
- Occupational safety and health.
- Environmental protection.
- Management and minimisation of spray drift.
- Minimising residues in agricultural produce.
- Record keeping.
- Responsibilities for owners.

With specific reference to the management of spray drift, the code clearly identifies the responsibilities of the owner/manager and of the spray operator. The code identifies the factors that contribute to spray drift, such as the suitability and accuracy of the application equipment, wind speed and direction, the presence of inversion layers, and the proximity of sensitive areas.

The code suggests the preparation of a ‘Sprayplan’ for all routine spraying operations by the owner/manager, which would include identifying and mapping sensitive areas in the vicinity of the spray source. The code also suggests planting and maintaining vegetation buffers, and notifying neighbours of upcoming spray events.

The owners/managers and operators of activities making use of spray chemicals are responsible for adhering to this Code of Practice clearly, to ensure that spray operations are carried out effectively and spray drift is managed with regard to the potential impacts to adjacent sensitive land uses.

2.6 EPA Guidance Statement No. 3 – Separation Distances Between Industrial and Sensitive Land Uses

The Environmental Protection Authority's Guidance Statement No. *3* (EPA, 2005) is intended to provide advice on generic separation distances between specific industry and sensitive land uses to avoid or minimise the potential for land use conflict.

The objectives of Guidance Statement No. 3 are to:

- Identify the need for specific separation distances or buffer definition studies.

- Provide general guidance on separation distances in the absence of site specific technical studies.

Guidance Statement No. 3 recommends separation distances between industrial and sensitive land uses, in particular, a separation distance for vineyards (viticulture) of 500m and a separation distance for poultry farming of 300–1000m depending on size of operations, from sensitive land uses such as residential development.

The buffer distances are recommended due to the potential for any of gaseous (chemical spray drift), noise, dust and odour impacts from these operations. As such, the recommended buffer distance represents a 'generic buffer' distance. The practice of the EPA is to give consideration to alternative buffer distances or management practices based upon site specific analysis that can be demonstrated to meet the required environmental standards specific to various emissions.

2.7 Environmental Management Guidelines for Vineyards 2002

Environmental management guidelines for vineyard operators were released by the Department of Agriculture, Water and Rivers Commission, Department of Environmental Protection and Wine Industry Association of Western Australia (2002). These principles are not enforceable, but provide a strong guide to effective and appropriate management.

The guidelines cover best management practices for vineyards with reference to the management of spray drift and noise impacts, and acknowledge that conflicts can arise between vineyards and neighbouring land uses.

The guidelines suggest land use conflicts between vineyards and adjacent land uses can be reduced or made more acceptable by the following:

- Establishing effective topographic or vegetative barriers;

- Modifying normal farm practices by adopting effective new technology such as hooded spray equipment, avoiding night-time activities which generate intrusive noise and the use of netting instead of noisy bird scaring devices;

- Conducting an independent study, if there is uncertainty, to demonstrate the likely area of influence of a specific farm practice. This may suggest the need to modify the proposed farm practice or introduce a separation distance or buffer between the potentially conflicting land uses; and

- Consulting neighbours before night-time spraying or harvesting.

2.8 Sub-regional Structure Plan for the Swan Urban Growth Corridor

The Sub-regional Structure Plan for the Swan Urban Growth Corridor – Draft G for Public Comment (Hassell, May 2008) has been prepared to cater for urban development and population growth within the City of Swan's Urban Growth Corridor. The area encompasses the future urban cells of Albion, West Swan and Caversham and is expected to eventually accommodate approximately 33, 000 residents.

The strategic objectives of the Structure Plan are to:

- Provide coordination of development, including regional infrastructure within areas of the Swan Urban Growth Corridor marked for urbanisation.

- Provide for key transport links throughout the Sub-regional Structure Plan area.

- Ensure appropriate provision and equitable access to community facilities, open space areas and employment centres for future residents.

- Recognise the importance of environmentally sensitive and important agricultural areas.

- Promote an appropriate range of residential densities to suit the needs of the community.

- Provide for development in a manner consistent with Network City principles.

3.0 EXISTING ENVIRONMENT

3.1 Topography

The land is generally undulating, and slopes gently from an elevation of 18m AHD in the north-east corner of the site, to an elevation of 8m AHD in the south-west of the site (Figure 5).

3.2 Soils and Landforms

The site is located on the Guildford Formation, which is characterised by soils of alluvial origin, ranging from silty clay to pebbly silt, and is characteristically low lying and poorly drained. Elevated areas of the site contain a thin veneer of overlying Bassendean sands.

Figure 5 indicates the soils across the site comprise:

- Pebbly Silt (Mgs1) – strong brown silt with common, fine to occasionally coarse grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin. This soil type extends over the majority of the site.

- Sand (S10) – very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin. This soil type is found in the dryland area in the north-east of the site and in a small pocket extending along the eastern drainage channel (within Lot 2 Arthur Street).

- Clayey Silt (Mc1) – yellow brown to strong brown, blocky, mottled, soft, with variable clay content, dispersive in part, of alluvial origin. This soil type is found within the south-western portion of the site, extending along the section of the western drainage channel that directs drainage water off site (towards Bennett Brook).

3.3 Wetlands and Hydrology

3.3.1 Wetlands

A large portion of the site is mapped by Hill et al. (1996) at regional scale as a regional sumpland (a sumpland is a seasonally inundated basin).

The sumpland mapped within the site was originally assigned a ‘Resource Enhancement’ management classification by the DoE, however following the reclassification request the wetland was reclassified as ‘Multiple Use’. Following further reclassification requests, a small area of remnant vegetation was reclassified as ‘Dryland’ and removed from the wetland database.

The majority of the area surrounding the site was very recently reclassified by the DoE (now DEC) from 'Resource Enhancement' to 'Multiple Use' management category wetland.

Figure 6 illustrates the extent of the sumpland within the site and the updated management categories assigned by the DEC.

3.3.2 Groundwater

3.3.2.1 Groundwater Levels

The Perth Groundwater Atlas, accessed online on 21 October 2008 at http://www.water.wa.gov.au/idelve/gwa, shows the Average Annual Maximum Groundwater Level (AAMGL) for the site as between 8mAHD and 14mAHD. Figure 6 of this report indicates that the groundwater contours below the site range between 6mAHD and 14mAHD. The source of these groundwater contours is the Department of Water, but the specific reference is unknown.

The estimated maximum (late winter) groundwater table at the site is generally located close to the surface, varying between 1–2m below surface level (Water and Rivers Commission, 1997). Exceptions to this occur at the high-point of the site, in the north-east corner, where the groundwater is 4m below the surface, and along the two drainage lines where the groundwater expresses itself above the ground.

During May, when the groundwater table is at its lowest elevation, the separation distance between groundwater and the surface level at the site is approximately 4m (Department of Environment, 2004). Exceptions to this occur at the high point of the site where the groundwater is approximately 8m below the surface during this period and along the two drainage lines where the groundwater falls to approximately 1–2m below the surface.

The site is located on the south-eastern edge of the Gnangara Mound, and as such the groundwater flow is in a general southerly direction towards the Swan River (Davidson, 1995). More detailed groundwater contours for the site indicate groundwater flow is loosely in a southerly to south-westerly direction (Figure 6).

A groundwater monitoring program commenced following the installation of the Monitor Bore Series CGW1–CGW12 in February 2006, and continued until January 2008. The bores were sampled for water levels and physical parameters on a monthly basis, and for groundwater quality on a quarterly basis. A map showing the location of each of the monitor bores is provided as Figure 6 of this EAR.

Results of the monitoring program are presented as Figure A below, and generally indicate fluctuating groundwater levels consistent with expected seasonal variations (i.e. decreased levels during summer and increased levels during winter), with some minor, irregular peaks and troughs at a couple of the monitor bores.

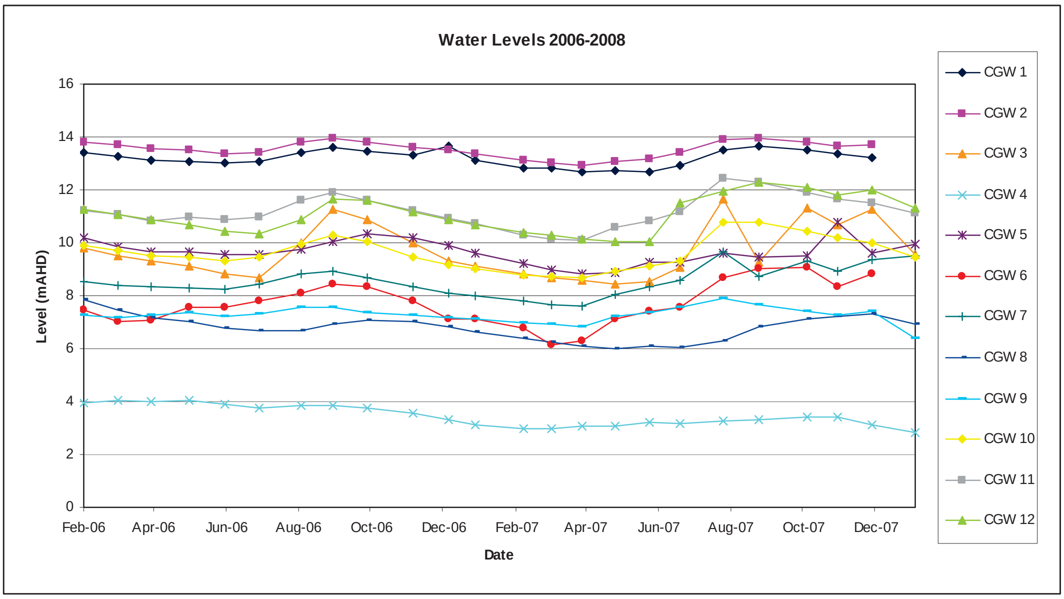


Figure A: Groundwater levels recorded during the Caversham Groundwater Monitoring Program, 2006–2008

3.3.2.2 Groundwater Quality

Monitor Bores CGW1–CGW12 were monitored for groundwater quality on a quarterly basis between March 2006 and November 2008. The full set of results is presented as Appendix 2 of this report.

The groundwater quality results from the monitoring program are comparable to two sets of monitoring criteria; the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) and the Swan Canning Cleanup Program's (SCCP) catchment water quality targets (Swan River Trust, 2004). The monitoring criteria are presented in Tables 1 and 2 below.

Table 1: Default Trigger Values for Physical and Chemical Stressors for South-western Australia, Slightly Disturbed Ecosystems: Freshwater Lakes and Reservoirs (ANZECC, 2000)

Analyte	Default Trigger Value
Total Phosphorous	0.01mg/L
Total Nitrogen	0.35mg/L
NOx-N	0.01mg/L
Ammonia-N	0.01mg/L
pH	6.5 – 8.0

No criteria exist within ANZECC (2000) for disturbed environments, so these criteria levels provide a guide only.

Table 2: Swan Canning Clean-up Program's Catchment Water Quality Targets (Swan River Trust, 2004)

Analyte	Default Trigger Value
Total Phosphorous	0.1mg/L
Total Nitrogen	1.0mg/L

The SCCP targets were developed by the Swan River Trust to provide guidance for developments and catchment management to reduce the nutrient input entering the Swan River. These targets were generally considered for use between 2001–2005, but provide a good guidance for disturbed environments.

Over the course of the two year monitoring period, nutrient concentrations at most monitor bores exceeded both sets of criteria. Total Nitrogen (TN) and Total Phosphorous (TP) recorded the highest number of exceedances over several monitor bores.

The TN levels at Monitor Bores CGW1, CGW2 and CGW12 were consistently higher than the guidance criteria, over the two year monitoring period (Figure B). These three monitor bores are located in the north eastern portion of the site.

TN levels at Monitor Bores CGW1 and CGW12 increased significantly during 2007, where the highest concentration of TN was recorded at Monitor Bore CGW1 (27mg/l), during the August 2007 sampling event.

Concentrations of TN in groundwater at Monitor Bores CGW1, CGW2 and CGW12 remained high during the final quarterly sampling event in November 2007, as did the TN concentration at Monitor Bore CGW3. The TN concentration at this monitor bore increased from 0.8mg/L to 6.9mg/L between May and August 2007, and decreased slightly to 4.7mg/L in November 2007, however still constituting a significant exceedance of both criteria. All other monitor bores recorded TN concentrations at or below SCCP and ANZECC criteria by the final sampling event.

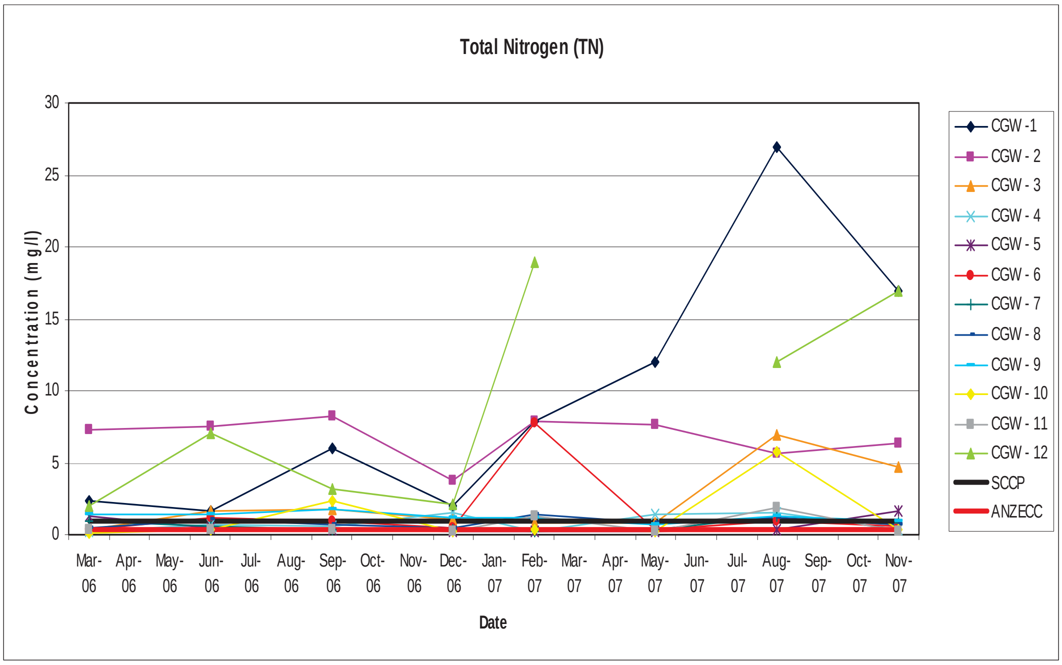


Figure B: Total Nitrogen Concentrations recorded during the Caversham Groundwater Monitoring Program, 2006–2008

Concentrations of Total Kjeldahl Nitrogen (TKN) and Nitrate (NOx-N) also increased in line with the elevations in TN at the corresponding monitor bores discussed above. This is understandable, as TKN and NOx-N make up the overall concentration of TN.

TKN and NOx-N are soluble forms of nitrogen which are normally leached into groundwater from nearby fertiliser application, and both can be absorbed by plants. Large amounts of nitrate in groundwater may cause eutrophication, which causes an excess of nutrients, resulting in oxygen deprivation and potential fish deaths in lakes or rivers connected to the system. An increase in nitrogen concentrations in groundwater may lead to algal blooms where the groundwater is discharged. Nitrification may also occur with increased nitrogen levels in groundwater, producing nitrite which can be toxic to plants at low pH values.

One significant rise in the concentration of Ammonia-N was recorded during the August 2007 sampling event, where it reached 25mg/L at Monitor Bore CGW1. This concentration decreased to 15mg/l during the final quarterly sampling event in November 2007. All other monitor bores recorded Ammonia-N concentrations of approximately 0.2mg/l over the period of the monitoring program. Although this constitutes exceedances of both SCCP and ANZECC criteria, the fairly uniform results indicate reasonably stable concentrations of Ammonia-N within groundwater at the site throughout the monitoring program.

The TP concentrations at Monitor Bores CGW1 and CGW2 remained high over the course of the two year monitoring period (Figure C). Particularly high levels of TP were recorded at these two bores during the May 2007 and August 2007 sampling events. A number of other bores also recorded significantly elevated TP levels during 2007;

CGW4, CGW5 and CGW12, with concentrations at CGW3 and CGW6 being slightly elevated during early to mid 2007. These monitor bores represent seven of the eight bores located in the eastern two thirds of the site.

Levels of TP remained high at Monitor Bores CGW1, CGW2 and CGW12 during the final sampling event (November 2007). The TP concentration at all other monitor bores returned to at or below SCCP or ANZECC criteria by the final sampling event.

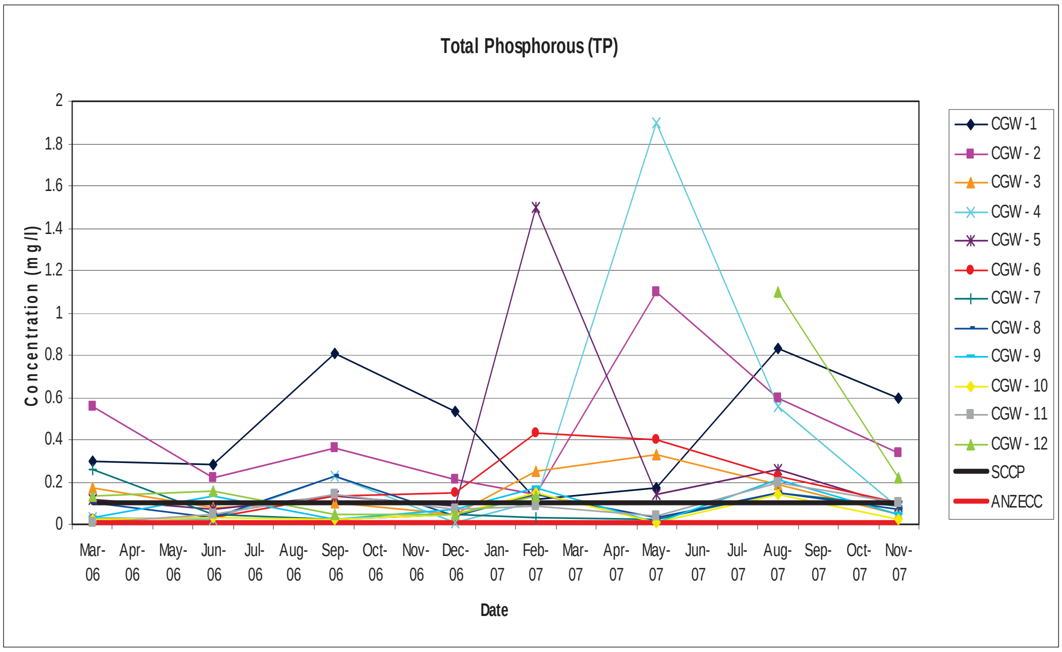


Figure C: Total Phosphorus Concentrations recorded during the Caversham Groundwater Monitoring Program, 2006–2008

3.3.3 Drainage and Watercourses

Two drains flow across the site (Figure 6); one originating to the north of the site and drains land to the north of Reid Highway, flowing through the western portion of the site in a north–south alignment before it enters Bennett Brook to the south of the site.

The other drain originates to the east of the site and briefly flows through the south-eastern portion, before exiting the site south of Benara Road and entering Bennett Brook. Both drains are ephemeral and become dry during the summer. Both drains most likely began as natural watercourses which were altered to some extent, to drain the surrounding agricultural land.

Other than the scattered *Melaleuca* spp. which occur along the western drain, these agricultural-style drains do not support significant ecological values and have minimal hydrological values.

3.4 Vegetation and Flora

Prior to European settlement of the area, the native vegetation within the site was representative of the Southern River Complex, which consists of open woodland of *Eucalyptus calophylla – Eucalyptus marginata – Banksia* spp. with fringing woodland of *Eucalyptus rudis – Melaleuca rhaphiophylla* along creek beds.

Of the original area of the Southern River Complex on the Swan coastal Plain, 17% currently remains while 10% is proposed for protection, which meets the criteria for levels of protection identified within the Bush Forever documentation (Government of Western Australia, 2000).

Examination of the earliest available aerial photography, taken in 1953, shows the site was cleared prior, with the exception of two small areas to the north of Patricia Street (Figure 7).

Of these two areas, Lots 214 and P94 Patricia Street appear to have been cleared in the mid 1980s and then left to regrow before being cleared once more in the late 1990s. Lot 214 does not currently appear to contain remnant native vegetation of any significance, while a small group of mature *Eucalyptus* spp. remain on Lot P94.

The other area of remnant native vegetation, on the northern portion of Lots P85–P87 and P214 Patricia Street, has remained uncleared.

On-site examination of the remnant native vegetation within Lots P85–P87 and P214 Patricia Street indicates a Jarrah/Marri/*Banksia*/Sheoak woodland – low forest with a degraded understorey. Overall, the vegetation in the northern portion of Lots P85–P87 and P214 Patricia Street is in degraded condition.

Some remnant native vegetation also occurs throughout the remainder of the site, represented as scattered individual trees. These trees are predominantly *Melaleuca* spp. along parts of the western drainage line and scattered Marri and *Eucalyptus* spp. throughout the remainder of the site.

3.5 Native Fauna

A search of the Department of Conservation and Land Management's Threatened Fauna Database of an area within 10km of the site suggests a number of threatened fauna species inhabit or may once have inhabited the general area.

Species identified on the database (and their designated level of conservation priority) include:

- Chuditch (Schedule 1 – Fauna that is rare or is likely to become extinct).
- Western Ringtail Possum (Schedule 1).

- Baudin's Black Cockatoo (Schedule 1).
- Carnaby's Black Cockatoo (Schedule 1).
- White-tailed Black Cockatoo (Schedule 1).
- Graceful Sunmoth (Schedule 1).
- Peregrine Falcon (Schedule 4 – Other specially protected fauna).
- Major Mitchell's Cockatoo (Schedule 4).
- Black Bittern (Priority 2 – Taxa with few, poorly known populations on conservation lands).
- Western Brush Wallaby (Priority 4 – Taxa in need of monitoring).
- Water Rat (Priority 4).
- Grey Falcon (Priority 4).
- Bush Stonecurlew (Priority 4).
- Guildford Springtail (Priority 4).
- Quenda (Priority 5 – Taxa in need of monitoring (conservation dependent)).

The degraded area of remnant native vegetation within Lots P85–P87 and P214 Patricia Street presents the only area of vegetation within the site which could provide habitat for any of the identified species listed above. However, based on the size and condition of this area of vegetation, the likelihood of any of these still inhabiting the site is relatively low.

3.6 Acid Sulfate Soils

The Western Australian Planning Commission (May 2007) Bulletin No. 64 – Acid Sulfate Soils regional mapping indicates that a small portion of the south-western corner of the site associated with the western drain contains soils that are High risk of Acid Sulfate Soils (ASS) or Potential Acid Sulfate Soils (PASS) occurring <3m from soil surface (Figure 8). These soils are most likely peaty deposits associated with the drainage channel.

An area to the north of Patricia Street, which loosely correlates with the extent of remnant native vegetation, and a small area in the south-east of the site (along the drain), is mapped by WAPC (2007) as Moderate to Low risk of ASS or PASS occurring >3m from soil surface and no risk of occurrence <3m from soil surface.

The remainder of the site is mapped as low to nil risk of ASS or PASS occurring >3m from soil surface and no risk of occurrence <3m from soil surface.

3.7 Contamination

At this stage, no Preliminary Site Investigation (PSI) has been undertaken for the site. Given the current and past land uses for the site, a PSI will be undertaken prior to soil disturbing activities.

3.8 Aboriginal Heritage

Two Aboriginal sites listed on the Department of Indigenous Affairs (DIA) database occur within the site (Figure 9).

Site 3746 is known as Moore's Camp and was used by Jack Moore during the 1930s and 1940s. Mythology suggests Jack Moore was the last known person to have seen the Wagyl. The site is as 'Stored Data' and it is not on the Permanent Register. Moore's Camp is located on Lot 86 Patricia Street, at the edge of the native vegetation.

Site 3744 is known as Marshall's Paddock and is a burial site, or contains skeletal remains. The site is listed on the Permanent Register of the DIA database and is considered a closed site, which means that public access to information about the site is restricted. Marshall's Paddock is located within the central western portion of the site.

3.9 Dampier – Bunbury Natural Gas Pipeline

The Dampier – Bunbury Natural Gas Pipeline (DBNGP) lies along the eastern boundary of the site (Figure 10). The DBNGP was constructed during the early 1980s and is sunken below ground.

3.10 Reid Highway and Proposed Perth – Darwin Highway

The site is bound to the north by Reid Highway and to the west by the proposed Lord Street extension, generating traffic noise into the periphery of some areas of the site.

3.11 Perth International Airport Flight Path

Perth International Airport is located approximately 5km south of the site. Planes approach the airport from the north along West Swan Road. The 20 Australian Noise Exposure Forecast (ANEF) contour from the Airport lies adjacent to the eastern boundary of the site (Figure 10).

3.12 Surrounding Land Uses

3.12.1 Viticulture/Horticulture

Land both within and adjacent to the south and east of the site is currently used for viticulture and other intensive horticulture, such as the growing of table grapes and melons.

Most vineyards which are currently operating within the site intend to cease operation once residential development within the site commences. However, some operators within the site, such as the Pinnelli Vineyard, intend to continue practising viticulture for the foreseeable future (Figure 10). Vineyards located to the south and east of the site along Benara Road and West Swan Road are likely to continue operation for the foreseeable future.

3.12.2 Residential Development

Immediately west of the site's western boundary lies residential development which has only recently been completed (Figure 10). This area of residential development is relatively small and is tightly bound by Reid Highway to the north, Bennett Brook to the west, Benara Road to the south and the Lord Street extension to the east.

3.12.3 Bennett Street Poultry Farm

A poultry farm exists on the western side of Bennett Street, adjacent to the south-west corner of the site (Figure 10). This farm produces chicken meat and has operated since the 1960s. It is the intention of the current operators of the farm to continue operations for the foreseeable future.

3.12.4 Victoria Street Mushroom Farm

A small mushroom farm is located north of the site, on Lot 52 Victoria Road, within the West Swan (east) Urban Cell. The farm operates under a temporary approval, which is currently being reviewed by the City of Swan. The farm is zoned 'Urban' under the Metropolitan Region Scheme and is separated from the Caversham Local Structure Plan area by Reid Highway.

3.12.5 Austral Brick and Tile Factory

A brick and tile factory operated by Austral Bricks is located approximately 700m south of the site. The factory produces bricks and roof tiles but has a relatively small capacity compared to other brick factories in the area (e.g. Midland Brick).

4.0 CAVERSHAM VITICULTURAL OPERATOR SURVEYS

To determine representative viticultural practices and operations in the vicinity of the site, a number of vineyards were selected as being representative of the surrounding land uses. Three operations either within or adjacent to the site, that were determined to be representative of the viticultural/horticultural activities conducted within the immediate vicinity, were selected.

The selected operations were:

1. Vineyard at Lots 18 Bennett Street and Lots 5 and 8 Benara Road ('Pinnelli Vineyard'), operated by Domenic Pinnelli.

2. Vineyard/table grapes and melon production at Lots 2 and 13 Arthur Street, operated by Richard Taylor.

3. Table grape production at Lots 210 and 211 West Swan Road, operated by Peter Botica.

Figure 10 illustrates the location of these sites.

4.1.1 Survey Scope

A face-to-face survey with each of the operators from the above operations was conducted during October 2005. The surveys focused on the following points:

- The details of the agricultural practises used on each site, with an emphasis on the application of chemicals:
  - Types of spray applied.
  - Method of application (eg. boom spray, airblast mister).
  - Frequency and timing of application.
- The permanency of the agricultural activities.
- The scale of the operations.
- Any other relevant information.

4.1.2 Survey Results

4.1.2.1 Pinnelli Vineyard – 40 Lots 18 Bennett Street and Lots 5 & 8 Benara Road

Details of Agricultural Practices

The Pinnelli Vineyard is located within and adjacent to the south-western corner of the site. The vineyard has been established for over twenty-three years and the complete winemaking process from growing wine grapes through to production and sales of wine occur on site. The operation is considered to be medium-scale. It is the intention of the vineyard operators to continue their viticultural practices and not partake in urban development within the structure plan area.

The types of sprays used include herbicides, fungicide, insecticides and growth regulators. Herbicides are applied during July and August, while fungicide is sprayed from September through to May. Insecticides are sprayed on an as needs basis. The most consistent spraying involves the application of fungicides during months of spring, summer and autumn. During these periods fungicides are applied every 10–14 days. The operators prefer to spray during the early morning or evening, when winds tend to be relatively calm or light, and although they try to avoid spraying in windy conditions due to time constraints they sometimes spray in conditions which are not ideal.

All sprays are applied using a blower which is mounted at the back of a tractor. The blower consists of a fan which forces the chemical through small outlets to create a mist which is forced upwards and outwards away from the blower. The operating noise of the blower is considered loud.

Noise also emanates from bird scarers, which are used during the growing season (September – April), and machine harvesters and grape crushers, which are used during the harvest/wine production season (February – April). During the wine production process, the grape crushing machinery is used twenty-four hours a day.

Dust is occasionally created when the ground is ploughed (to install new vines). Dust suppression techniques are not employed but the operators do take into consideration wind conditions when ploughing.

During the months of spring, organic fertilisers are applied and these can generate an odour.

Impact of Operations

The potential impact of this vineyard operation on land immediately adjacent site is considered to be medium-high, particularly during spring – autumn.

4.1.2.2 Vineyard/Horticultural - Lots 2 and 13 Arthur Street

Details of Agricultural Practices

Lots 2 and 13 Arthur Street lie within the site and the operations include production of wine grapes, table grapes, melons, and also sheep grazing. The operation may be considered relatively small scale. The operator expects to continue operations for the short-term, until staged urban development reaches the property.

The types of sprays used include herbicides, fungicide, insecticides and growth regulators. Fungicide is sprayed from September through to December, while insecticides are sprayed on an as needs basis. Growth regulator is sprayed during November, while herbicides are sprayed during May, September and October. During the September – December period fungicides are applied every fourteen days.

The operator prefers to spray during the early morning or evening, when winds tend to be calm or relatively light, and evaporation rates are low. The operator is mindful of wind direction when spraying.

All sprays are applied using either a boom spray or blower which is located at the back of a tractor. The operating noise of the blower is loud.

Dust is very occasionally created when the ground is ploughed (to install new vines or crops). Dust suppression techniques are not employed when ploughing is undertaken.

No applications are used within the operations which create any significant odours.

4.1.2.3 Vineyard - Lots 210 and 211 West Swan Road

Details of Agricultural Practices

Lots 210 and 211 West Swan Road lies adjacent to the east of the site and produces table grapes. The operation is relatively small scale. The operator expects to continue operations in the short-term, and his intention beyond then is unclear.

The types of sprays used include herbicides, fungicide, insecticides and growth regulators. Spraying occurs relatively infrequently, with the exception of the September – January growth period when fungicide is applied every fortnight. Pesticides are applied only once before picking commences. The operator prefers to spray during the early morning or evening, when winds tend to be relatively light, and when evaporation rates are lower.

All sprays are applied using either a blower or boom spray which is located at the back of a tractor. The operating noise of the blower is loud.

Dust is occasionally created when the ground is ploughed (to install new vines).

No applications are used within the operation which creates any significant odours.

4.1.3 Summary of Results

The results of the survey indicate that of the three operators interviewed, two are relatively small scale while one is medium scale in size (the Pinnelli Vineyard). The operation located within the site on Arthur Street is likely to continue operations in the short-term until staged development reaches the property. The Pinnelli Vineyard intends to continue operating into the foreseeable future, while the West Swan Road property can be expected to continue operating into the short-term future at least. The operator of the West Swan Road property has indicated his preference for his land to be developed for residential use in the long-term future (although this is unlikely as it is not zoned 'Urban').

The results of the survey suggest that similar practices are carried out across all three of the operations, with the main difference being that the Pinnelli Vineyard is more intensive in its stated application of chemicals and its use of machinery (given that it processes grapes and makes wine on site). Thus, spray drift and noise impacts from the Pinnelli Vineyard are likely to be greater than from other small scale operations, such as those surveyed on Arthur Street and West Swan Road. Extrapolation of the survey results, based on review of aerial photography and ground-truthing of land adjacent to the site boundary, leads to the conclusion that the Pinnelli Vineyard is the only medium-scale operation adjacent to the site and that the remainder of operations adjacent to the site are small scale.

The results suggest that spray drift and noise impacts intermittently originating from Pinnelli Vineyard are likely to be greater than those originating from the small scale operations along Benara Road and West Swan Road. Regardless, the impacts from the small scale operations are also likely to have some intermittent impact on the proposed adjacent urban development.

On this basis, these intermittent operational activities present a constraint to urban development within the site, and appropriate buffers must be determined to minimise the impacts.

The Environmental Protection Authority's (2004) Draft Separation Distances between Industrial and Sensitive Land Uses vineyard buffer of 500m is considered applicable in the absence of site specific assessment. The following assessment describes and illustrates the grounds on which this buffer may be considered for variation.

5.0 PROPOSED LOCAL STRUCTURE PLAN

The Caversham Local Structure Plan seeks to provide the necessary planning frame work for a 198ha area of land bounded by Benara Road, West Swan Road, Reid Highway and the proposed Lord Street extension, within the City of Swan.

The proposed Local Structure Plan for Caversham (LSP) (Plan No. 2965-2001g.dgn, Revision G, 3 October 2008) has been prepared by RPS Koltasz Smith and has been completed in accordance with the requirements of the 'Residential Development' zone as outlined in Part 5 of City of Swan's Local Planning Strategy No. 17.

The objectives of the Residential Development zone are to:

(a) *'provide for the coordinated development of future residential areas through the application of a comprehensive plan to guide subdivision and development to be known as a 'Structure Plan';*

(b) *provide for predominantly residential development, but including also a range of compatible services, consistent with the needs of an integrated neighbourhood, and planned so as to minimise adverse impacts on the amenity;*

(c) *avoid the development of land for any purpose or at a time when it is likely to compromise development elsewhere in the district or prejudice the future development of land in the Residential Development zone for more appropriate purposes; and*

(d) *take account of the need to protect the amenity and ongoing use of adjacent property owners as well as to provide for the needs of future residents..'*

The zone contains a comprehensive suite of provisions which guide the preparation and adoption of local structure plans and associated development cost sharing mechanisms. The scheme also outlines the matters that are required to be addressed in preparing a local structure plan including supporting documentation, the requirements/process to advertise and the assessment and adoption process to be undertaken by the City and the WAPC.

The LSP incorporates the following land uses:

- A mixture of residential densities ranging from R15 to R60.
- A lifestyle/retirement village.
- A neighbourhood centre.
- A community site.
- A primary school.
- Public open space (POS).
- Provision for drainage.
- 'Transitional lots' along the southern and eastern site boundaries.

The transitional lots are intended to provide additional protection of future residents from existing and surrounding land uses that may pose a potential impact. The detailed design of these lots and more detail about their objective(s) and purpose is presented in the Transition Lot (Buffer) Management Plan, being prepared jointly by RPS Koltasz Smith and RPS Environment and Planning.

A copy of the proposed Local Structure Plan is presented in Figure 11 of this EAR.

6.0 POTENTIAL ENVIRONMENTAL IMPACT OF DEVELOPMENT AND DISCUSSION OF MANAGEMENT COMMITMENTS

Development of any site creates the potential for negative environmental impacts if not managed appropriately.

This section details the potential impacts that could occur as a result of the proposed LSP and details how these potential impacts will be managed in order to protect, and in most cases enhance, the existing natural environment.

6.1 Groundwater

6.1.1 Maximum Groundwater Levels

The close proximity of maximum groundwater levels to the surface level in some areas of the site presents a consideration for urban development within the site.

Fill will be required to ensure that sufficient vertical separation distance between the groundwater and the built form is achieved. Sufficient vertical separation to groundwater ensures that flooding of the future development does not occur and long-term protection of the groundwater resource is secured.

However, the importation of fill to facilitate development is more a commercial constraint than an environmental constraint.

The exact level of fill required to achieve the vertical separation distances required for urban development is not yet known, but will be calculated by the project engineers at the detailed design stage, from the results of the groundwater monitoring program.

6.1.2 Groundwater Quality

The water quality data collected during the groundwater monitoring program suggest that groundwater quality is extremely variable across the site, with many sites recording large increases in nutrients at various stages throughout the monitoring program. However, in general, the groundwater under the site is particularly high in nutrients.

Given the current land uses on the site include a poultry farm, with the remainder of the site being cleared and used for agricultural activities and grazing, development of the site for urban purposes is likely to improve the quality of drainage water entering the groundwater. Agricultural activities are known to produce high nutrient levels, such as Total Niitrogen (TN) and Total Phosphorus (TP). These nutrients then enter surface water and groundwater resources.

6.2 Surface Water

6.2.1 Wetlands

According to Hill et al. (1996), a large sumpland covers the majority of the Caversham development site.

As detailed in Section 3.3.1, a successful wetland reclassification on 9 May 2006 resulted in the majority of the sumpland being reclassified by the DEC (then Department of Environment) from 'Resource Enhancement' management category wetland to 'Multiple Use' management category wetland. A small area of remnant vegetation in the north-eastern corner of the site was reclassified as 'Dryland' and removed from the wetland database. An area along the southern boundary is no longer mapped as wetland.

The DEC uses the Water and Rivers Commission (2001) Wetlands Position Statement as a guide to all issues concerning wetlands on the Swan Coastal Plain. The varying levels of protection for wetlands of different management categories as recognised within the Wetlands Position Statement are described in Table 3 below.

Table 3: DEC Wetland Management Categories – Levels of Protection

Management Category	General Description	Management Objectives
Conservation	Wetlands support a high level of ecological attributes and functions.	Highest priority wetlands. Objective is preservation of wetland attributes and functions through various mechanisms including: ▪ Reservation in national parks, crown reserves and State owned land. ▪ Protection under Environmental Protection Policies. ▪ Wetland covenanting by landowners. These are the most valuable wetlands and the commission will oppose any activity that may lead to further loss or degradation. No development.
Resource Enhancement	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is for management, restoration and protection towards improving their conservation value. These wetlands have the potential to be restored to conservation category. This can be achieved by restoring wetland structure, function and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use	Wetlands with few important ecological attributes and functions remaining.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through land care. Should be considered in strategic planning (e.g. drainage, town/land use planning).

The management objective for 'Multiple Use' wetlands includes *'use, development and management (being) considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.'*

Given that the wetland within the site has been extensively modified and supports few ecological attributes, urban development is a land use which is consistent with these management objectives, and as such the 'Multiple Use' wetland is not considered an constraint to urban development of the site.

Notwithstanding the above, the development will incorporate water sensitive urban design strategies that will ensure protection of the better quality wetlands downstream of the site (eg. Bennett Brook). Essentially, treatment of stormwater will occur within the site prior to discharge toward surrounding wetland areas.

6.2.2 Watercourses

The two drains which flow across the site perform a drainage function for both lands upstream of, and within the site, and ultimately discharge water into the Swan River via Bennett Brook.

Currently, significant nutrient export from the site is expected to occur as a result of untreated stormwater run-off and groundwater discharge. Given the widespread intensive horticultural activities which currently occur within the site, it is likely that stormwater run-off containing nutrients and other contaminants is entering the surrounding catchment, and ultimately the Swan River.

The LSP proposes rehabilitation and enhancement of the western-most drain, using a 'Living Stream' concept. POS has been strategically positioned to incorporate this drainage channel, which meanders from the northern boundary of the property, through to the centre of the development and then to the south-western corner, where a 1.41ha drainage basin exists.

Rehabilitation of this existing drain into a wider, more meandering channel, will allow for treatment of stormwater run-off prior to discharge into the greater catchment, through a stormwater treatment train approach. The treatment train approach is likely to incorporate soft and hard treatment options. Enhancement of this drain will also provide increased biodiversity and fauna habitat, following planting of native plant species typical of the Caversham/Swan area. The existing *Melaleuca* spp. will be retained along the revegetated margins of the drain.

Reconfiguration of the bed morphology of the drain will involve the removal of the concrete channels, were they occur, and replacement with a natural surface capable of allowing infiltration. Holding basins (or pools) will be incorporated into the detailed living stream design, as will widening of some areas for wading bird habitat. These areas will provide fauna habitat areas as well as providing a focal point within a POS area for visitors to the area.

The eastern drain will be piped following residential development.

In additional, a Local Water Management Strategy has been prepared by Cardno BSD (August 2007), which outlines the mechanisms for how surface water drainage and groundwater will be managed within the Caversham site post-development, through the following:

- Water Conservation Strategy.
- Stormwater Management Strategy.
- Groundwater Management Strategy.
- Matters to be addressed at subdivision stage and within the yet-to-be-completed Urban Water Management Plans.
- Monitoring and Implementation Requirements.

In summary, as part of the LWMS, the client commits to the following key management strategies:

- Maintenance of the pre-development hydrological regime.
- Localised surface water aquifer recharge, via on-site infiltration and piped drainage network.
- Directing piped drainage to roadside drainage swales or localised infiltration swales prior to discharge to major surface water drainage channels.
- Roadside drainage swales will be designed to retain a 1 in 5 year storm event.
- Overflow drainage will flow through vegetated treatment systems prior to entering major drainage channels, such as Bennett Brook.
- Localised infiltration swales will be designed to retain the 1 year ARI storm as a minimum.
- Locations within selected POS corridor areas will be designed to store the 1 in 100 year storm event.
- Retention of remnant native vegetation within POS to reduce landscaping water requirements.
- Implementation of Gross Pollutant Traps, bubble ups and other such Best Management Practices.
- Due to the presence of clayey soils in some parts of the site, subsoil drains and stormwater lot connections will be provided in all areas where finished sand levels are less than 1.5m above the clay layer.

The detailed design phase will provide further specific information on how the commitments in the LWMS will be designed and implemented within the development.

6.3 Drainage and Nutrient Export

Appropriately planned and implemented development of the site for residential purposes has the capacity to significantly reduce the export of nutrients and other contaminants into the catchment, assuming best practice water management design is incorporated within the urban design process. This is because sewered urban land uses may have significantly reduced nutrient and contaminant loading and inputs compared to agricultural and intensive horticultural activities.

Differing rates of nutrient input from agricultural, horticultural and residential land use were compared by Gerritse et al. (1992). Annual input rates per hectare for both nitrogen and phosphorus were greatest on land used for horticulture (192kg/ha/yr N and 102kg/ha/yr P), while inputs for both agricultural pasture grazing (18–65kg/ha/yr N and 20kg/ha/yr P) and residential purposes (connected to sewered mains) (35kg/ha/yr N and 20kg/ha/yr P) were dramatically less. Given the level of horticultural activities currently employed within and surrounding the site, it is likely that nutrient inputs into the site, and stormwater run-off and groundwater exportation from the site, will be significantly reduced as a result of urbanisation.

Given that the LWMS (Cardno BSD, August 2007) focuses on on-site stormwater retention and infiltration, contaminants and nutrients exported off site is expected to reduce post-development compared to pre-development levels. As such, on-site retention and infiltration of stormwater will help to limit the impact of the development upon the surrounding Bennett Brook system and greater Swan River catchment.

6.4 Vegetation and Flora

Remnant native vegetation presents no significant constraint to urban development as little native vegetation remains within the site.

The Jarrah/Marri/*Banksia*/Sheoak woodland – low forest which occurs within Lots P85–P87 and P214 Patricia Street – is in degraded condition, and consequently may be considered of low environmental value. Retention of this vegetation within the proposed Lifestyle/Retirement Village would be as much a landscape/amenity benefit as an environmental one.

The scattered *Melaleuca* spp. which occur along portions of the western drain will be retained as part of the living stream corridor, which links a series of POS areas to form a potential habitat corridor. These native trees will assist with nutrient stripping and will provide increased habitat and amenity as part of the living stream/treatment system and the surrounding POS areas.

Landscaping will incorporate waterwise plant species, with local native species being utilised where possible.

6.5 Acid Sulfate Soils

An Acid Sulfate Soils Self Assessment was conducted in accordance with Bulletin No. 64 (WAPC, 2003) and the DEC Acid Sulfate Soils Guidelines Series (2003–2004). The results of this were uncertain, due to a lack of detailed information about the construction works, which will be available at the detailed subdivision design stage.

However, the majority of the site is mapped as low to nil risk of ASS occurring >3m from the soil surface and no risk at depths <3m from the soil surface. Therefore, ASS is unlikely to pose a potential impact to development, particularly if all infrastructure and services are constructed within the imported fill or less than 3m below the current ground surface.

The upland area containing the degraded remnant vegetation (in the north-eastern corner of the site) is mapped by the WAPC as moderate to low risk >3m from the soil surface and no risk <3m from the soil surface. This majority of this area corresponds to the Lifestyle/Retirement Village. In addition, a small area in the south-west of the site is mapped as high risk of ASS occurring <3m from the soil surface. According to the LSP, a 1.41ha drainage basin is proposed this area, and it forms the last point in the treatment train/living stream prior to discharging off site. These areas will be subject to detailed sampling for Acid Sulfate Soils prior to any excavation works (i.e. a Preliminary Site Assessment), in accordance with the DEC's Acid Sulfate Soils Guideline Series. The results will inform the exact configuration of the basin and location of buildings and/or infrastructure for the Lifestyle/Retirement Village.

6.6 Contamination

Given that a large number of lots within the site have been used, are or currently being used, for horticultural and other rural activities, a Preliminary Site Investigation (PSI) for potential contamination will be undertaken prior to ground disturbing activities, according to the Department of Environmental Protection (2001) Contaminated Sites Management Series.

Horticulture/viticulture is identified by the DEC as a potentially contaminating land use. Key contaminants of concern associated with this land use include:

- Trace metals from fertilisers, corroding metals, boiler scale, etc.

- Nutrients from fertilisers, animal feed and manure.

- Organochlorine and organophosphate based pesticides commonly applied to horticultural properties to control pests and buildings to control termites prior to the mid 1980s.
- Other pesticides such as synthetic pyrethroids and hepoxides commonly applied to horticultural facilities.
- Petroleum hydrocarbons and solvents often stored at horticultural properties or for the lubrication and maintenance of machinery.
- Phenols and other cleaning products used as detergents.
- Polycyclic Aromatic Hydrocarbons (PAHs) often associated with the breakdown of oil residues, kerosene and creosote.

Asbestos containing materials may also be present in some of the houses, sheds and shelters across the site.

The purpose of a PSI is to identify areas of potential contamination, the potential contaminants and factors that would affect the nature, magnitude and extent of the contamination. The PSI includes:

- A review of relevant site characteristics.
- A review of site development and activities through historical aerial photography, land title and land ownership consultations.
- A site inspection.

If the PSI identifies the need for further assessment, a soil and/or groundwater Sampling and Analysis Program (SAP) will be prepared, potentially to the satisfaction of an auditor, and detailed site sampling according to the SAP will be carried out as part of the Detailed Site Investigation (DSI).

6.7 Aboriginal Heritage

Two Aboriginal sites are recorded within the site.

Although Moore's Camp is not on the DIA's Permanent Register, it is well known to the local Aboriginal Community as a place of significance. The site will be protected as part of the Lifestyle/Retirement Village. This site will be subject to detailed design at a later stage.

The burial site or skeletal remains at Marshall's Paddock presents an unknown constraint because of the restriction to access relevant information. This site will be retained in a 0.3ha POS area within the development.

6.8 Dampier – Bunbury Natural Gas Pipeline and Parmelia Gas Pipeline

The Dampier – Bunbury Natural Gas Pipeline and Parmelia Gas Pipeline alignments form a portion of the eastern boundary of the LSP area. The LSP proposes a 75m setback to the Dampier – Bunbury Natural Gas Pipeline alignment, which is furthest west of the two pipelines.

This setback exceeds that of a previous risk assessment undertaken in Parmelia involving a high-pressure gas pipeline and proposed residential development, which found a distance of 32m sufficient to meet the EPA risk criteria (Environmental Protection Authority, 2000).

These pipeline alignments, and the 75m buffer, are incorporated within the proposed transition (buffer) lots along the eastern site boundary. Further detail on these transition lots is provided within the Transition Lot (Buffer) Management Plan (2008), jointly prepared by RPS Koltasz Smith and RPS Environment and Planning.

6.9 Reid Highway and Proposed Perth – Darwin Highway

The existing residential development which lies to the west of the site is bound to the north by Reid Highway. The close proximity of this development to the Highway and the lack of visible buffers suggest noise originating from Reid Highway traffic is not substantial.

However, due to the site's close proximity to Reid Highway and the proposed Lord Street extension, a Noise Impact Assessment has been undertaken as a precaution. The assessment determined the requirement for noise mitigation measures within the Caversham Urban Cell, and includes strategies relating to landscaping, bunding, building design and construction.

The Noise Impact Assessment undertaken by Lloyd Acoustics (2006) recommended the following noise management techniques:

- Constructing a 2.1–2.4m high wall as the western boundary wall of residences adjacent to the future Lord Street extension.

- Constructing a 2.1–3.0m high wall as the northern boundary wall of residences adjacent to Reid Highway.

- Memorials on the titles of properties immediately adjacent to the Lord Street extension and Reid Highway advising of the possible noise impacts and requirement to use quiet house design principles.

Further details on how the LSP responds to noise management are provided within the Noise Impact Assessment report (Lloyd Acoustics, 2006).

6.10 Perth International Airport Noise Contours

The 20 Australian Noise Exposure Forecast (ANEF) contour from the Perth Airport encroaches only slightly within the eastern boundary of the site. This noise contour is widely recognised as the critical limit for noise exposure to residential areas.

Future residents will be protected as this noise contour is contained within the transitional lots along the eastern site boundary. Further information on the transition (buffer) lots is provided in the Transitional Lot (Buffer) Management Plan (2008), jointly prepared by RPS Koltasz Smith and RPS Environment and Planning. The remainder of the site lies outside the 20 ANEF, and as such, no constraint to development exists.

6.11 Buffer Management – Surrounding Land Uses

6.11.1 Viticulture

There are a number of viticulture/horticulture operations both within and adjacent to the LSP area. The vineyards currently operating within the site intend to cease operations once residential development commences. However, some operators outside the site, such as the Pinnelli Vineyard, have expressed their intention to continue practising viticulture for the foreseeable future. Some vineyards located to the south and east of the site along Benara Road and West Swan Road are also likely to continue operations for the foreseeable future.

The Environmental Protection Authority's Guidance Statement No.3 - *Separation Distances between Industrial and Sensitive Land Uses (June 2005)* identifies vineyards as requiring a standard 500m buffer, due to the potential for gaseous (chemical spray drift), noise, dust and odour impacts. This default buffer distance assumes no other acceptable management measures are implemented within the development. Figure 10 illustrates the extent to which a 500m buffer encroaches within the site, from vineyards which are likely to remain in operation after development of the site.

As such, constraint to urban development within the site exists given the potential impact these viticultural practices might have on the adjacent urban development.

However, it is noted that broad-scale viticulture (including winery) operators must comply with the *Environmental Code of Practice for the Use of Agricultural and Veterinary Chemicals in Western Australia 2002*.

However, given the Caversham Urban Cell cannot control operational practices for neighbouring viticultural activities, suitable management measures will be employed within the development which further assist in the reduction of any impacts.

Section 7 of this report examines this potential constraint in further detail, including mitigation and management options being committed to, in order to reduce the standard 500m buffer set by the EPA's Guidance Statement No.3, without impacting on future residents of the development. A key strategy will be the incorporation of transitional (buffer) lots along the eastern and southern boundaries of the site. The Transitional Lot (Buffer) Management Plan (2008), jointly prepared by RPS Koltasz Smith and RPS Environment and Planning, outlines this feature of the development in greater detail.

6.11.2 Bennett Street Poultry Farm

The poultry farm which operates on Bennett Street, adjacent to the south-west corner of the site, presents a constraint to urban development of the site, due to the fact that the current operators of the farm wish to continue operations into the foreseeable future.

The Environmental Protection Authority's Guidance Statement No.3 (June 2005) identifies poultry farms as requiring a 300–1000m buffer, depending on the size of the farm. The buffer is intended to minimise impacts associated with potential noise, dust and/or odour emissions.

However, it is noted that a buffer of only 150m exists between the residential development west of the Caversham Urban Cell and the Bennett Street Poultry Farm, which suggests that odour impacts from the poultry farm are not significant. However, a larger buffer will be employed for the current site, given the predominant winds during the afternoon originate from the west-south-west, towards the site (Figure 12).

In addition, this land use is subject to the provisions of the *Environmental Code of Practice for Poultry Farms in Western Australia 1999*, which governs operational procedures in an attempt to minimise off site impacts to surrounding areas. However, as with viticultural activities, the Caversham Urban Cell cannot control operational practices for neighbouring poultry farms. As such, suitable management measures will be employed within the development, which further assist in the reduction of any impacts from the poultry farm.
A key strategy will be the incorporation of transitional (buffer) lots along the eastern and southern boundaries of the site. The Transitional Lot (Buffer) Management Plan

(2008), jointly prepared by RPS Koltasz Smith and RPS Environment and Planning, outlines this feature of the development in greater detail.

6.11.3 Victoria Street Mushroom Farm

Given the Victoria Road Mushroom Farm is a small operation, currently operating under a temporary approval, on land zoned 'Urban' under the Metropolitan Region Scheme, this land use is not considered to be a constraint to development of the Caversham Urban Cell for the purposes of residential development.

6.11.4 Brick and Tile Factory

Austral Bricks operates a brick and tile factory located on Harper Street, which lies approximately 750m south of the site. The Environmental Protection Authority's Guidance Statement No.3 (June 2005) identifies clay brickworks as requiring a 300–1000m buffer, depending on the size of the factory. Figure 10 illustrates the extent to which the maximum1000m buffer impinges into the site.

Austral Brick's Environmental Manager Dean Wilkinson has provided information relating to the size of the factory and likely impacts from the factory's operations on the surrounding area. According to Mr Wilkinson, the factory is the smallest brick factory operating in the Perth Metropolitan Area, at the time of questioning (2006). Mr Wilkinson also noted the presence of vineyards between the factory and Benara Road, and suggested that vineyards are extremely sensitive to fluoride and other brick factory emissions. The apparent good health of these vineyards suggests the factory is not affecting the vines.

No modelling has been undertaken at the time of local structure planning. However, the implementation of the transitional (buffer) lots will result in almost a 1000m to the nearest resident. On this basis, this land use is not anticipated to impact on the LSP area.

7.0 VITICULTURAL CONSTRAINTS

7.1 Predicted Impact of Viticultural Activities on Urban Development within the Structure Plan Area

7.1.1 Previous Investigations Regarding Buffer Distances and Spray Drift

7.1.1.1 Queensland Department of Natural Resources

The Queensland Department of Natural Resources (QDNR) has conducted considerable research into formulating planning guidelines for separating agricultural and residential land uses, in *Planning Guidelines Separating Agricultural and Residential Land Uses* (1997). The QDNR reports the following with regard to aerial application of sprays via light aircraft:

- Research and field trials have shown vegetated buffers are effective in capturing up to 80% of pesticide spray drift from an application upwind of a single row of trees (Harden, 1992 in QDNR, 1997, Section 3.9); and

- It should be noted that the recommended vegetated buffer (which includes multiple rows of trees) will not capture 100% of the chemical spray drift, but may reduce spray drift to less than 1% at a sensitive receptor when managed in terms of porosity, litter build up and noxious weed control to ensure effectiveness (Section 3.12).

- The recommended buffer in these circumstances was 40m wide with a cleared 10m firebreak on each side, with a porosity of 0.5 (i.e. 50% air space). However, it is important to note that this buffer was considered applicable where sprays are applied or 'dusted' by light aircraft. Logically, spray from a ground based tractor mounted boom or blower could be considered less prone to drift.

Codes of Practice

The DEP's Draft *Environmental Code of Practice for Market Gardens* (2000) and the Department of Agriculture's Code of Practice for the *Use of Agricultural and Veterinary Chemicals in Western Australia* (2002) provide a number of best management practices that can be implemented to minimise the potential for spray drift. Whilst no market gardens operate at the site, the principles for spray drift management remain relevant.

Extrapolation of data provided within Diagram 2 of the DEP's Draft Code indicates that at wind speeds of 9 to 11km/h (above which no spraying should occur), less than 5% of spray applied with a boom placed at 40cm above the ground will drift, and this will 'land' within approximately 50m downwind of the point of application without the creation of an intercept barrier (such as vegetation). Less than 15% of spray applied with a boom at

80cm under the same conditions will drift, and similarly this will 'land' within approximately 50m downwind of the application point.

This information is relevant in considering weed spraying between vines.

Figure 13 outlines the DEC's Spray Drift Concept, including the extrapolated information.

7.2 Local Climatic Characteristics

The effects of off site impacts of viticultural activities are also significantly influenced by local climatic characteristics. With respect to the potential impacts from spray drift to the proposed urban development within the structure plan area, it is relevant and important to consider not only the direction of prevailing winds, but also the velocity of the wind.

The Department of Agriculture's *Code of Practice for the Use of Agricultural and Veterinary Chemicals in Western Australia* (2002) recommends that spray application should not occur at wind speeds greater than 15km/hour. Results of the site-specific survey suggest operators within the vicinity of the site adhere to these recommendations.

Because of the location of the vineyards in relation to the site, it is necessary to consider the frequency of easterly, south-easterly, southerly and south-westerly winds which may transport spray drift and noise from the vineyards towards the structure plan area.

Annual wind-roses have been constructed from wind speed and direction data for Perth International Airport (the nearest Bureau of Meteorology station to Caversham) collected in the morning at 9am and the afternoon at 3pm (Figure 12).

The wind-roses present wind records for all directions and strengths, and indicate that:

- In the mornings winds in the area are predominantly easterlies (approximately 25% of the time), calm (15%) or north-easterlies (approximately 18%).

- In the afternoon, winds are predominantly south-westerly (over 30% of the time) or westerly (over 20% of the time).

However, wafting (less than 10kmh) south-easterly winds occur only approximately 5% of the time in mornings, and approximately 6% of the time in afternoons, while wafting easterly winds occur only approximately 4% of the time in mornings, and approximately 3% of the time in afternoons. Wafting north-easterly winds occur only approximately 8% of the time in mornings, and approximately 2% of the time in afternoons.

Consequently, assuming the operators of the vineyards accord with relevant Codes of Practice with regard to spraying, the frequency of conditions in which it may be possible for spray drift to impact upon the residential site is relatively low.

7.3 Adherence to Occupational Health and Safety Legislation

Assuming the agricultural activities surrounding the site are in compliance with the requirements of the *Occupational Health and Safety Act 1984*, it is unlikely that the potential for spray drift impacts on the proposed residential development would be significant.

Under its obligations to employees and customers under the *Occupational Health and Safety Act 1984*, the vineyards must operate a safe and hazard free working environment. In other words, the safety requirements for the employees of these businesses will logically also protect people that will live in the vicinity of the agricultural operations.

However, it is recognised that the developers of the Caversham Urban Cell, and indeed the greater Swan Sub-regional Structure Plan Area, cannot influence or control the operational procedures of the existing viticulture activities. As such, appropriate management strategies will be implemented to further negate the potential for negative impacts on future residents of the development.

7.4 Noise

7.4.1 Noise Impact Assessment

A detailed Noise Impact Assessment was conducted by Lloyd Acoustics (2006), and the resultant reported is appended in full to the Structure Plan Report. In summary, the study identified four main noise sources from viticultural activities including:

- Spraying equipment.
- Tractor.
- Bird scarers.
- Grape crushers.

Of these sources, noise issues associated with bird scarers and grape crushers were dismissed on the basis that both of these are only used by the Pinnelli Vineyard, and that the bird scarer is only used occasionally (and its use can be reasonably managed by adherence to the EPA's Best Practice Guidelines for Bird Scaring in Orchards) and the grape crusher is housed within a shed and consequently unlikely to be a significant source.

Tractor noise is also dismissed by Lloyd Acoustics (2006) because it is exempt from the Environmental Protection (Noise) Regulations 1997.

On the basis of potential noise from fan-type vine sprayers and night-time noise criterion, Lloyd Acoustics (2006) determined that a minimum buffer distance of 85m between residential dwellings and vineyard operations would be necessary. This is based on a fan-type sprayer operating at night-time under light downward winds. The use of the fan-type sprayer is considered reasonable as night-time spraying (i.e. to minimise evaporation rates and spray loss through stronger winds), would only be undertaken using a fan-type sprayer, as a blower type sprayer would be louder and in direct violation of the Environmental Protection (Noise) Regulations 1997.

For a detailed explanation of the noise assessment process and management strategies proposed, refer to Lloyd Acoustics' Noise Impact Assessment (2006), appended to the Local Structure Plan Report.

7.5 Management and Design Strategies

7.5.1 Buffer Distance and Design

Sections 7.1–7.4 have presented information from which a conclusion may be made that the potential impacts of spray drift from the adjacent viticultural operations upon the proposed residential development are relatively low. These sections also recommend a suitable buffer distance to manage noise that would be generated from fan-type vine sprayers at night-time.

It is acknowledged that a certain level of responsibility to manage negative factors associated with viticulture rests with the agricultural activity operators) under the relevant Codes of Practice, and by law, in terms of chemical exposure and occupational health and safety). However, as previously stated, in order to further mitigate the potential for spray drift impacts, buffer distances and design strategies need to be considered for the development.

Based on its extensive research, the QDNR established minimum buffer widths, with and without buffer elements, as summarised in the table below.

The QDNR research indicates that through appropriate design, buffer distances can be significantly reduced. The most appropriate buffer design in this situation is widely recognised as a 40m planted buffer of mature, dense trees and shrubs. A vegetated buffer would not only serve to reduce spray drift impact but also provide a visual barrier between the two land uses. This is particularly important for the protection of the rural landscape when viewed from Benara Road and West Swan Road.

The specific design of the vegetated buffer, including the appropriate species composition (taking into consideration height and density), will require further investigation, and be negotiated with the City of Swan. This is proposed to be undertaken as soon as possible, given the vegetation will need time to establish prior to residents moving in to the subdivision.

Table 4: Buffer Distances as Determined by Queensland Department of Natural Resources (Queensland Department of Natural Resources, 1997)

Parameter	Duration Threshold	Minimum Default Distance (m)	Minimum Design Distance with Buffer Element (m)
Chemical spray drift	None	300	40
Intermittent noise[1]	> 10hrs/yr < 50hrs/yr	60 (d) 1000 (n)	15 (d) 250 (n)
Long-term noise[1]	> 50hrs/yr	500 (d) 1000# (n)	120 (d) 1000# (n)
Dust/smoke/ash	None	150	40

1 = Based on source noise level of 90 dB(A) (LAmax T) at 7.5m
d = Noise occurring in day-time (6am-10pm)
n = Noise occurring night-time (10pm-6am)
 # = Long-term noise occurring between 10pm-6am is likely to be considered intrusive and therefore unreasonable. Such noise sources may be ameliorated by a combination of enclosing or muffling the noise or by provision of a buffer area and attention to residential design.
Source: QDNR (1997)

The QDNR research summarised in Table 4 suggests a buffer width of 120m which includes a 40m vegetated buffer would be sufficient to minimise impacts to urban development associated from the adjacent vineyards. This 120m buffer incorporates the following distances required to minimise each respective impact:

- Chemical spray drift – 40m requirement.
- Intermittent day time noise – 15m requirement.
- Long-term day time noise – 120m required.
- Dust/smoke/ash – 40m requirement.

The potential for noise impacts is less clear, although on the basis of the QDNR (1997) research a preliminary but highly conservative buffer for likely noise impacts is suggested.

However, the Noise Impact Assessment undertaken by Lloyd Acoustics (2006) (see Section 4.6.1) indicates that on the basis that fan-type blowers would be used during the night-time, a buffer distance between residential dwellings and vineyard activities of only 85m would be required.

On this basis, an 85m buffer, incorporating a 40m buffer of vegetation, along the immediate boundary of the site is recommended as an appropriate buffer.

A Transition Lot (Buffer) Management Plan has been jointly prepared by RPS Koltasz Smith and RPS Environment and Planning. This document details the concept of the transition lots and the broad, overarching design features. Detailed investigation into the composition of the vegetated buffer to achieve landscape objectives and minimisation of impacts from spray drift and noise will be undertaken following approval of the Local Structure Plan.

The transition lots are intended to provide additional protection of future residents from existing and surrounding land uses that may pose a potential impact. Essentially, they are large lots, with a building envelope located in the northern or western portion of each lot, which maximises the distance of the residence from the vineyards. The transition lot will consist of a 55m deep non-residential component at the rear of the lot, and a 30m deep residential component from the street front boundary. The 55m component will consist of a 40m deep vegetated buffer to screen potential spray drift, with the balance of 15m as usable yard area.

Please refer to the Transition Lot (Buffer) Management Plan for more detailed explanation of this concept.

7.5.2 Advice to Purchasers and Memorials on Lot Titles

All prospective purchasers of lots within the site should be advised of the vineyards' existence and potential impacts on the contract of sale. Additionally, memorials on the title of all lots within a 1300m distance (based on the distance to achieve daytime levels of 35dB(A) using a blower-type sprayer, as identified by Lloyd Acoustics (2006)) of any vineyards should be advised of the location and potential impacts of the vineyards on amenity.

All houses within the transition lot zone will also be required to incorporate quiet house design principles. These principles are detailed in Lloyd Acoustics' Noise Impact Assessment (2006).

Please refer to the *Transition Lot (Buffer) Management Plan* (RPS Koltasz Smith and RPS Environment and Planning, 2008) and the *Noise Impact Assessment* (Lloyd Acoustics, 2006) for more detailed explanations.

8.0 KEY CONCLUSIONS

Residential development is considered suitable for the site. Review of the proposed Local Structure Plan and comparison with the existing natural environment provides the following key conclusions:

- The site's topography, soils and landforms present no significant obstacles to development. However, fill be required to facilitate the development for residential purposes.

- No significant remnant native vegetation will need to be cleared, as a majority of the site has limited native vegetation remaining. The areas of remnant native vegetation to the north of Patricia Street will be protected within the Lifestyle/Retirement Village.

- Nutrient export from the site to the Swan River is likely to be reduced as a result of sewered urban development, given best practice urban water management will be incorporated within the urban design. An Urban Water Management Plan will be prepared at subdivision stage, and be in accordance with the principles of the approved *Local Water Management Strategy* (Cardno BSD, August 2007).

- The *Local Water Management Strategy* (Cardno BSD, August 2007) and the yet-to-be-prepared Urban Water Management Plan will ensure protection of the better quality wetland areas adjacent to the site.

- The enhancement of the western most drainage channel, using a 'Living Stream' concept.

  This drain will be rehabilitated using native species, enhancing biodiversity at the site and providing additional habitat for local fauna. The living stream will be incorporated into the overall stormwater system and will incorporate a treatment train approach, for the treatment of stormwater (for nutrients), prior to discharge off site. The living stream will include various fauna habitats, including:

  - Wide, shallow sections for wading birds.
  - Native trees for bird nesting.
  - Reeds for dragon flies and macroinvertebrate protection.

  Planting with native plant species will also assist with any potential erosion issues. The area will provide a focal point for future residents, with passive recreational benefits.

- The two known Aboriginal Sites will be protected in Public Open Space an the Lifestyle/Retirement Village landscaped areas.

- The site lies outside the 20 ANEF noise contour associated with Perth International Airport.

- The transitional (buffer) lots identified as part of the Transitional Lot (Buffer) Management Plan (RPS Koltasz Smith and RPS Environment and Planning, 2008) provide protection from the negative impacts of noise and spray drift that could potentially be generated from nearby viticultural activities.

- These lots will incorporate a thick vegetated buffer of native vegetation. As such, these lots will also provide a landscaping screen to neighbouring wineries, thus improving the landscape amenity of the development.

- Noise associated with Reid Highway and the proposed Lord Street extension is addressed in the *Noise Impact Assessment* (Lloyd Acoustics, 2006).

- The Dampier – Bunbury Natural Gas Pipeline lies within the proposed transitional lots along the eastern site boundary.

Specific design strategies that will be incorporated as part of the development are anticipated to protect and enhance the existing environmental features of the site. Commitments being made by the developer, as part of the Local Structure Plan design process, include:

- Preparation and implementation of an Urban Water Management Plan to guide detailed design of the stormwater system and will ensure protection of the better quality wetland areas adjacent to the site as well as the groundwater resources in the area.

- Undertaking a Preliminary Site Investigation (PSI) to determine the likelihood for on-site contamination. The PSI will be required for all lots which are recognised as having past or present land uses which may have impacted upon soil and groundwater quality. It will be undertaken prior to soil disturbing activities.

- Undertaking a Preliminary Site Assessment PSA) to determine the presence or otherwise of Acid Sulfate Soils (ASS). This assessment will be undertaken in areas mapped by the WAPC having any risk of ASS within 3m of soil surface, and along the western most drainage channel, given substantial earthworks in this area are likely. The outcomes of the PSA will inform detailed subdivision design, and as such will be undertaken prior to detailed subdivision design.

- Determination with the City of Swan (and potentially the DEC) of the detailed characteristics and species composition for the transitional lots.

9.0 REFERENCES

ANZECC. (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Default Trigger Values for Physical and Chemical Stressors for South-western Australia, Slightly Disturbed Ecosystems: Freshwater Lakes and Reservoirs, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT.

Bowman Bishaw Gorham. (2004) Dampier to Bunbury Natural Gas Pipeline Corridor Widening – Kwinana to Bunbury Project – Strategic Environmental Review. Unpublished report prepared for the Gas Pipeline Working Group, Department of Industry and Resources, Perth.

Cardno BSD Pty Ltd. (August 2007). Caversham Local Structure Plan – Local Water Management Strategy, prepared for the Caversham Main Landowners Group, Cardno BSD Pty Ltd, Subiaco, WA.

Davidson, W.A. (1995) Hydrogeology and Groundwater Resources of the Perth Region, Western Australia. Western Australia Geological Survey, Bulletin 142.

Department of Agriculture. (2002). Code of Practice for the Use of Agricultural and Veterinary Chemicals in Western Australia. Department of Agriculture, Perth.

Department of Agriculture, Water and Rivers Commission, Department of Environmental Protection and Wine Industry Association of Western Australia. (2002). Environmental Management Guidelines for Vineyards. Department of Agriculture, Perth.

Department for Consumer and Employment Protection. (2003). Working with Pesticides. http://www.safetyline.wa.gov.au/pagebin/pg000185.htm.

Department of Environment. (2001–2003). Contaminated Sites Management Series. Department of Environmental, Perth.

Department of Environment. (2004). Perth Groundwater Atlas, Second Edition. Department of Environment, Perth.

Department of Environment. (2004). Environmental Code of Practice for Poultry Farms in Western Australia, Department of Environment in consultation with Department of Agriculture, Department of Planning and Infrastructure, Health, Western Australian Local Government Association; Shire of Gingin and Shire of Serpentine Jarrahdale, Perth Western Australia.

Department of Environmental Protection. (1997). Environmental Protection (Noise) Regulations 1997, State Government, Western Australia.

Department of Environmental Protection. (2001). Contaminated Sties Management Series – Potentially Contaminating Activities, Industries and Landuses. Department of Environmental Protection, Perth.

Department of Environmental Protection. (2000). Draft Environmental Code of Practice for Market Gardens on the Swan Coastal Plain. Department of Environmental Protection, Perth.

Department of Water. (2008). Perth Groundwater Atlas, accessed online 21 October 2008 via http://www.water.wa.gov.au/idelve/gwa/, Government of Western Australia, Perth, WA.

Environmental Protection Authority. (2000). Achieving EPA Risk Criteria for development in proximity to existing and proposed High Pressure Gas Transmission Pipelines – Guidance Statement No. 50 (Draft). Environmental Protection Authority, Perth.

Environmental Protection Authority. (2005). Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986) – Separation Distances between Industrial and Sensitive Land Uses. Guidance Statement No. 3, June 2005. Environmental Protection Authority, Perth.

Environmental Protection Authority. (2008). Environmental Guidance for Planning and Development. Guidance Statement No. 33, May 2008. Environmental Protection Authority, Perth.

Gerritse, J.A., Adeney, J.A. and Bates, L.E. (1992). Nutrient Inputs from Various Land Uses on the Darling Plateau in Western Australia – Results of a Survey. CSIRO, Division of Water Resources.

Government of Western Australia. (2000). Bush Forever: Keeping the Bush in the City: Volumes 1 and 2. Department of Environmental Protection, Perth.

Hassell. (May 2008). Sub Regional Structure Plan for the Swan Urban Growth Corridor: Draft G for Public Comment, prepared for the Department of Planning and Infrastructure by Hassell Pty. Ltd., Perth, WA.

Hill, A.L., Semeniuk, C.A., Semeniuk, V., Del Marco, A. (1996). Wetlands of the Swan Coastal Plain: Volume 2b. Water and Rivers Commission, Perth.

Lloyd Acoustics (now Lloyd George Acoustics). (2006). Noise Impact Assessment: Caversham Structure Plan. Unpublished report. Lloyd Acoustics, Perth.

Queensland Department of Natural Resources. (1997). Planning Guidelines Separating Agricultural and Residential Land Uses. DNRQ 97088.

RPS Koltasz Smith and RPS Environment and Planning Pty Ltd. (2008). Transition Lot (Buffer) Management Plan, prepared on behalf of Caversham Main Landowners Group, Perth, WA.

Swan River Trust. (2004). Swan Canning Cleanup Program Action Plan Implementation: 2004, Government of Western Australia, Perth, WA.

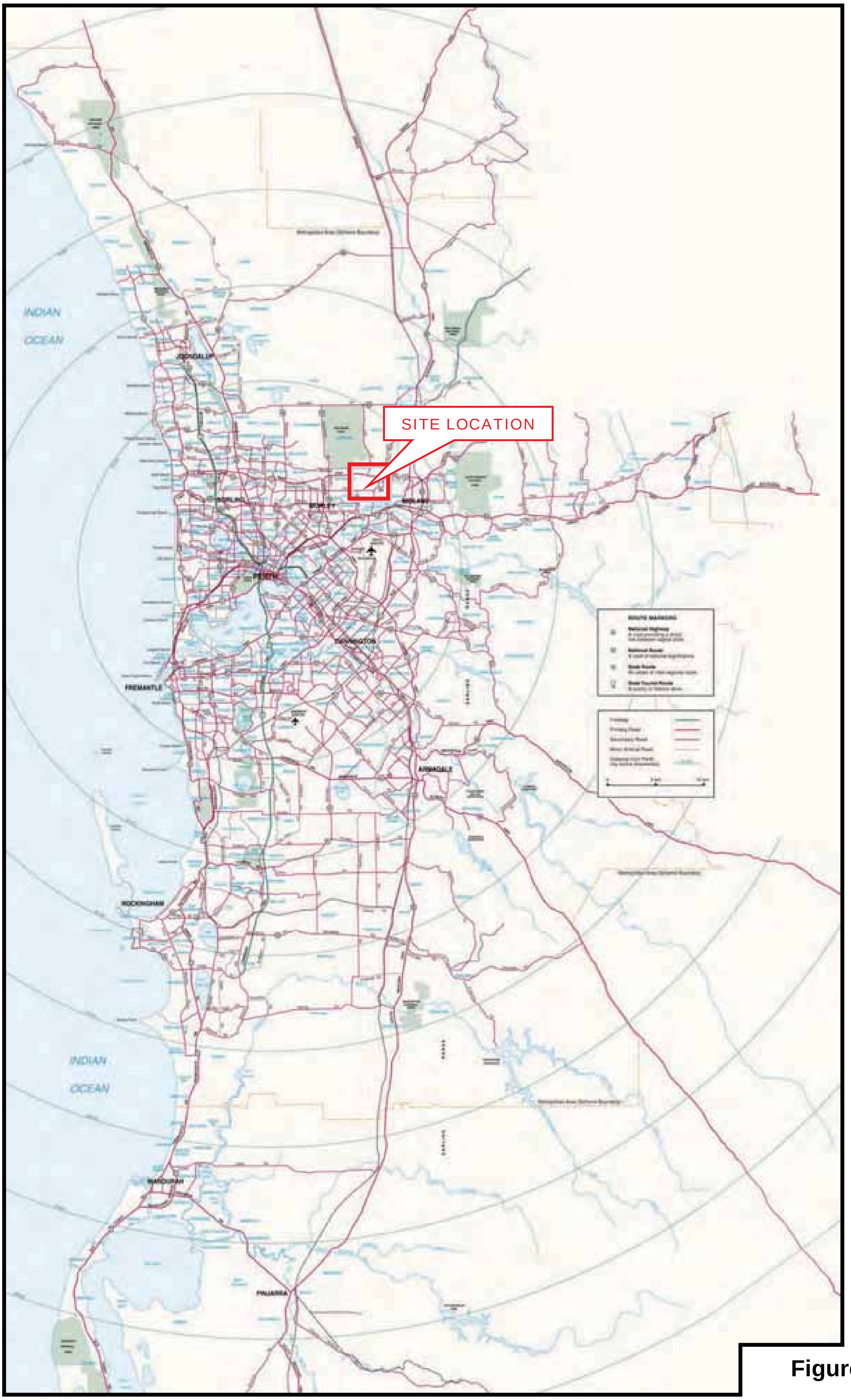
Water and Rivers Commission. (1997). Perth Groundwater Atlas. Water and Rivers Commission, Perth.

Water and Rivers Commission. (2003). Urban Stormwater Management in WA. Principles and Objectives. Water and Rivers Commission, Perth.

Western Australian Planning Commission. (2003, addendum May 2007). Planning Bulletin Number 64. Acid Sulfate Soils. Western Australian Planning Commission, Perth.

Western Australian Planning Commission. (2005). Statement of Planning Policy: Road and Rail Transport Noise (Draft). Western Australian Planning Commission, Perth.

FIGURES



0 10 30 50km

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Source: StreetSmart, 2002

Figure 1

Site Location

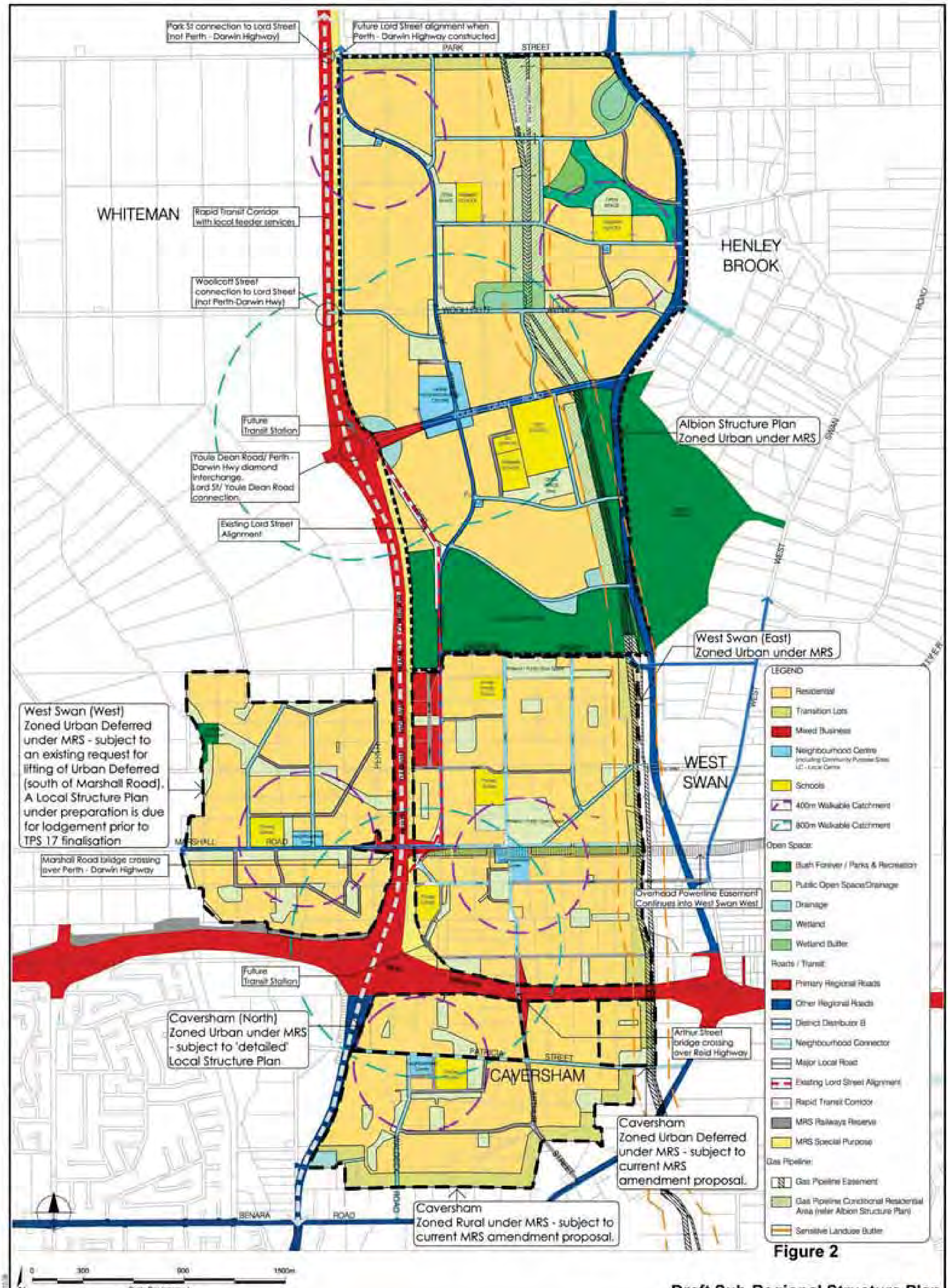

Figure 2

Draft Sub-Regional Structure Plan

Source: RPS Koltasz Smith, 12.07.07

RPS

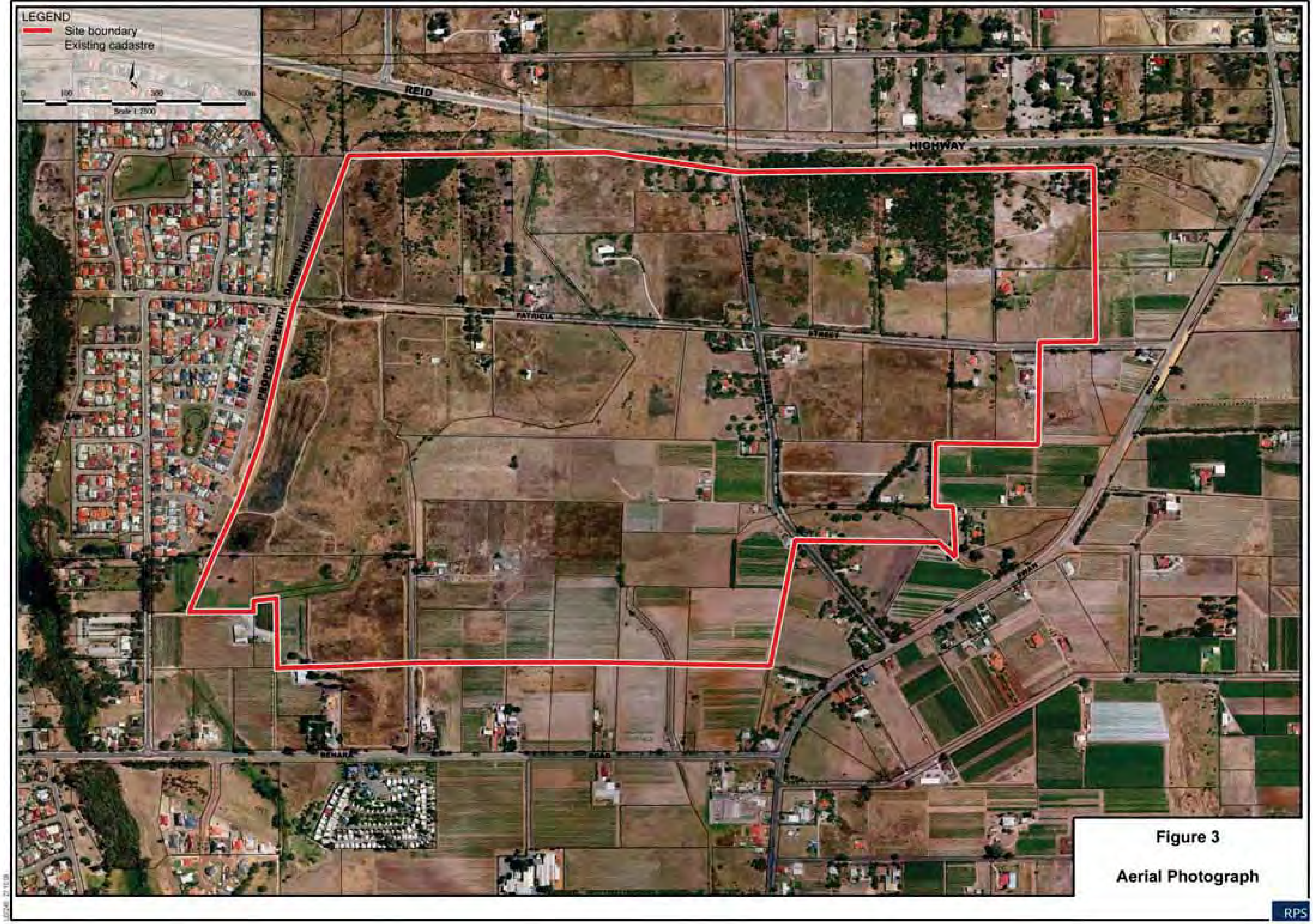

Figure 3

Aerial Photograph

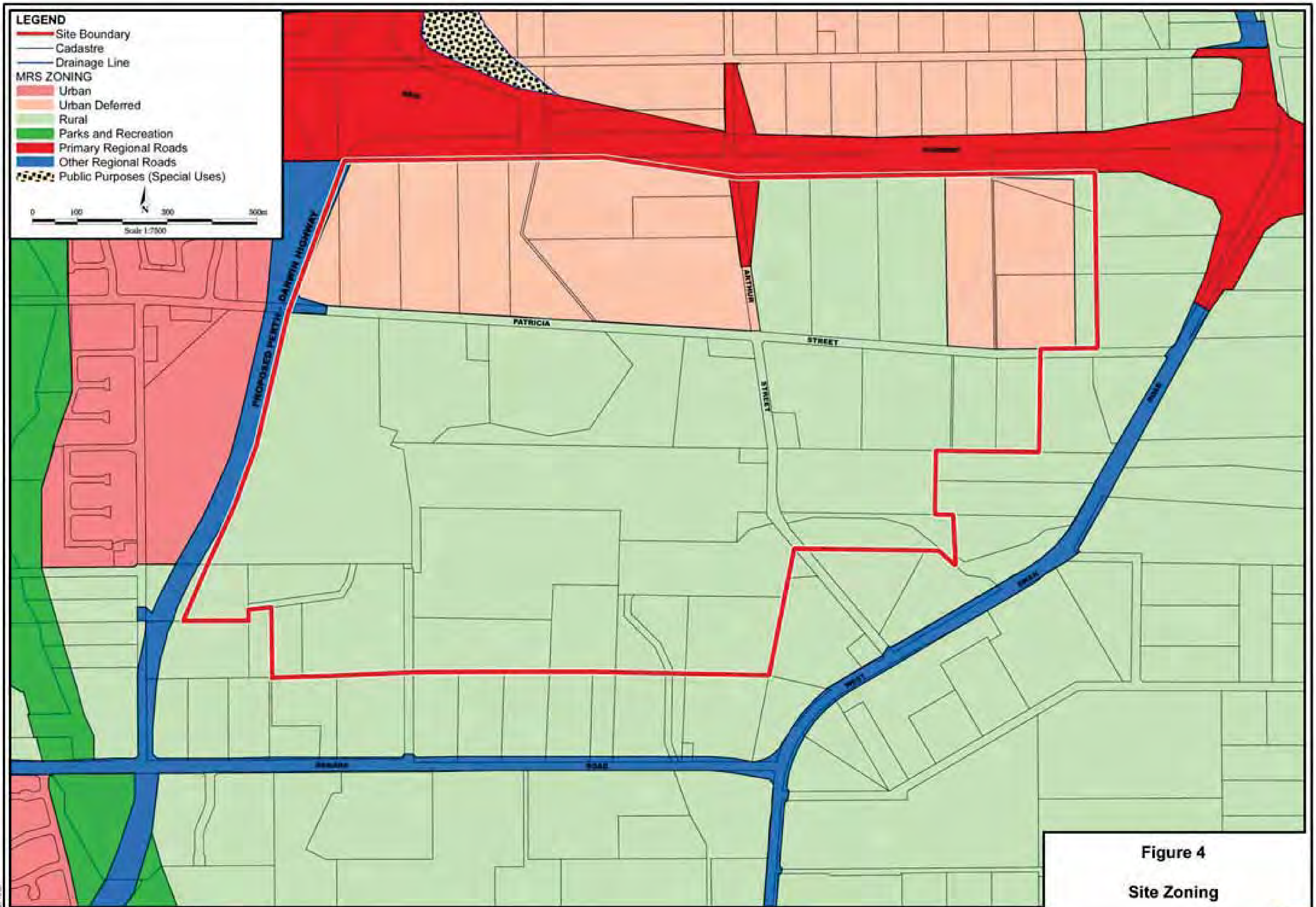

Figure 4

Site Zoning

Source: Department for Planning and Infrastructure, 2002

RPS

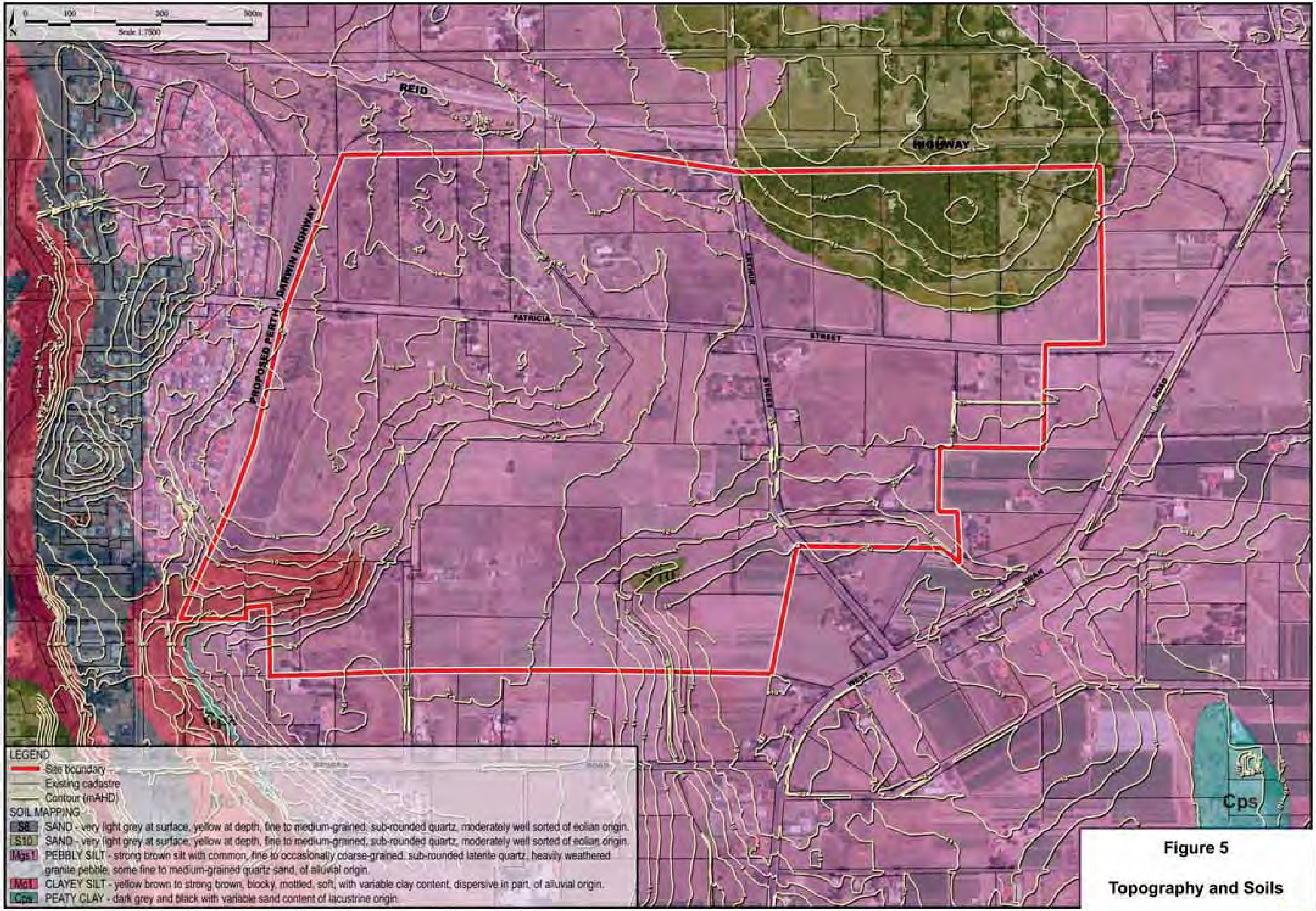

Figure 5

Topography and Soils

Source: Soil Mapping - Department of Minerals and Energy, 2007

RPS

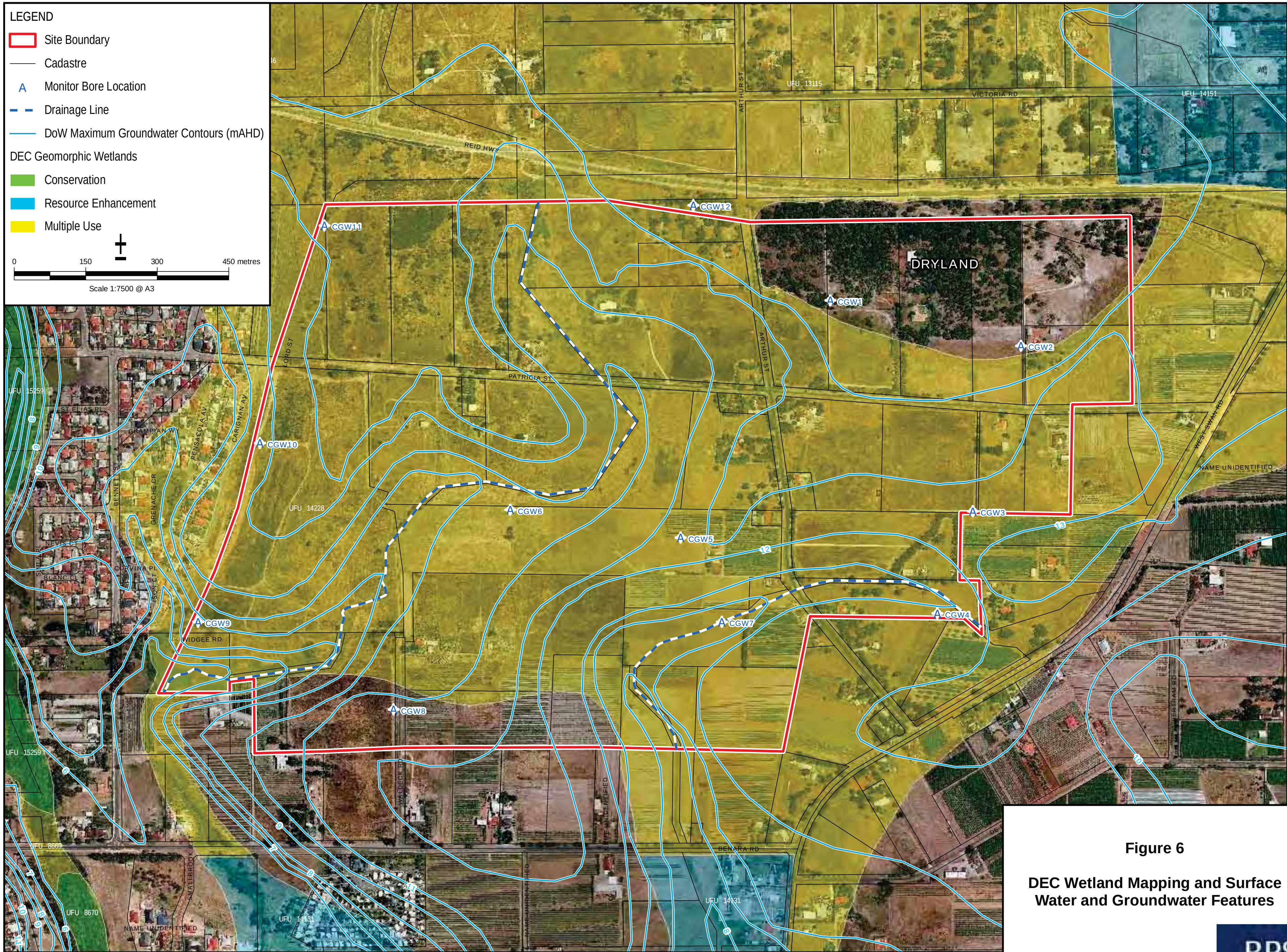

Figure 6

DEC Wetland Mapping and Surface Water and Groundwater Features

RPS

Source: Wetland Mapping - DEC, 17th July 2008 Groundwater Contours - DoW, 2005

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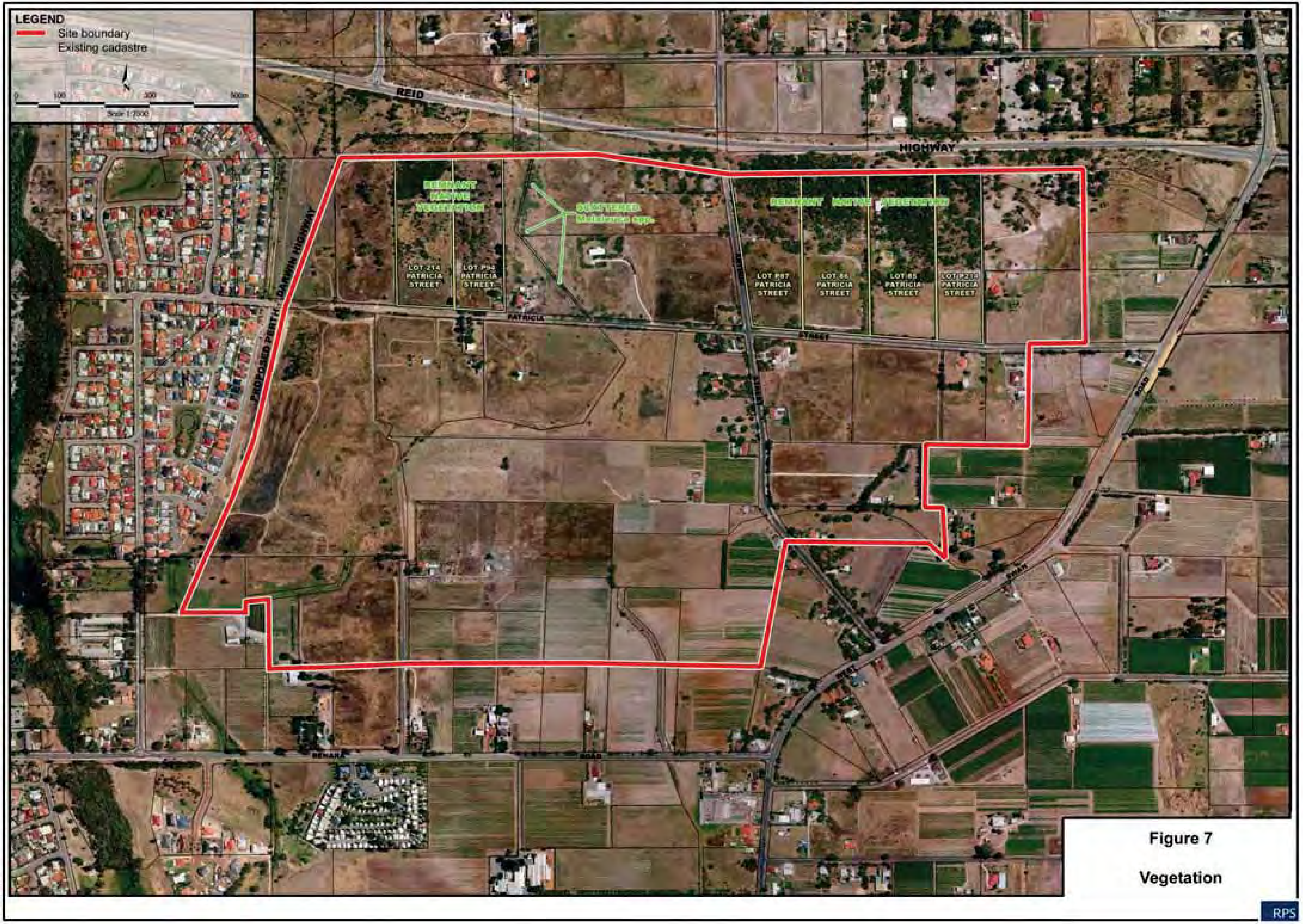


Figure 7

Vegetation

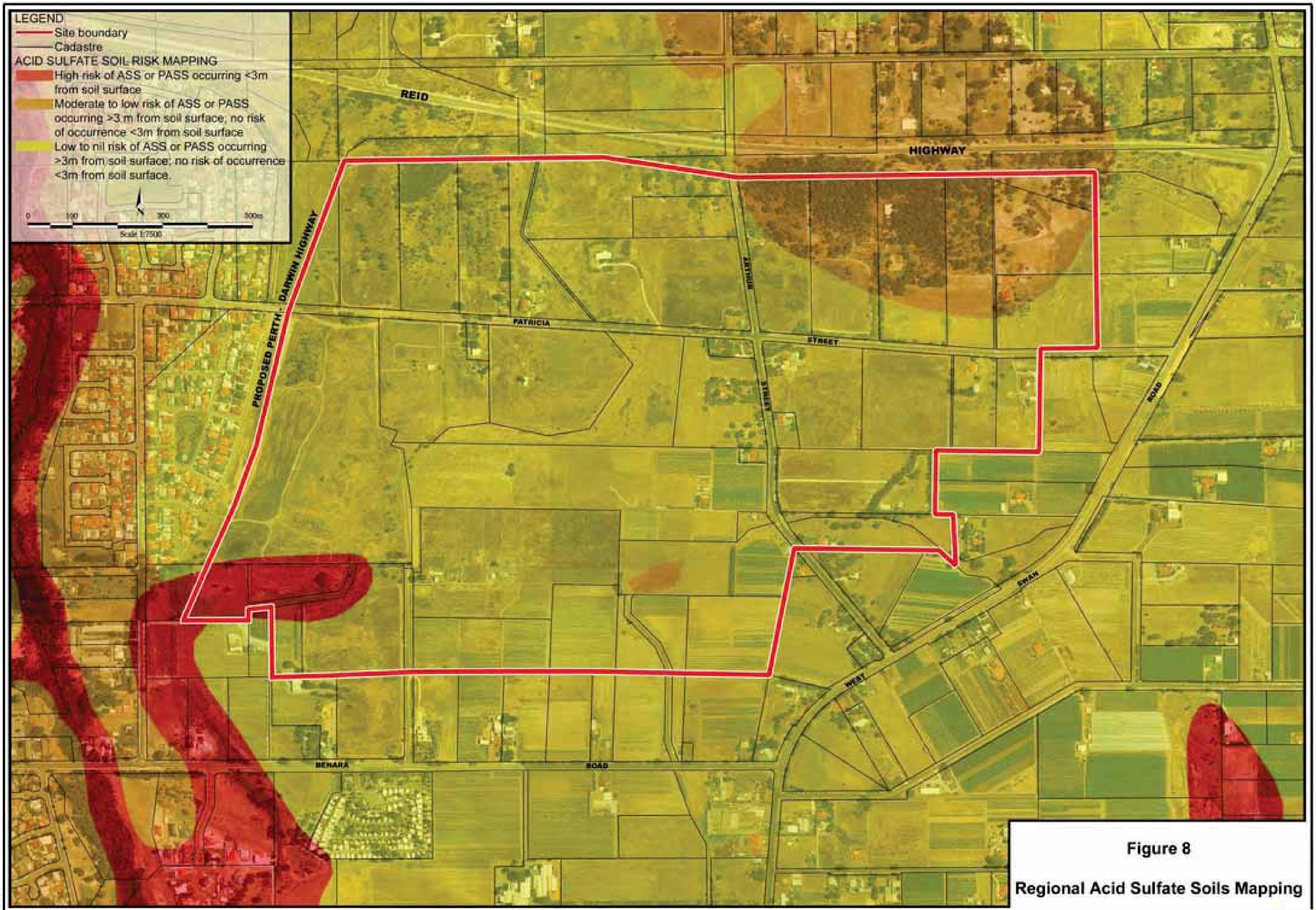


Figure 8

Regional Acid Sulfate Soils Mapping

Source: DEC, 2004

RPS

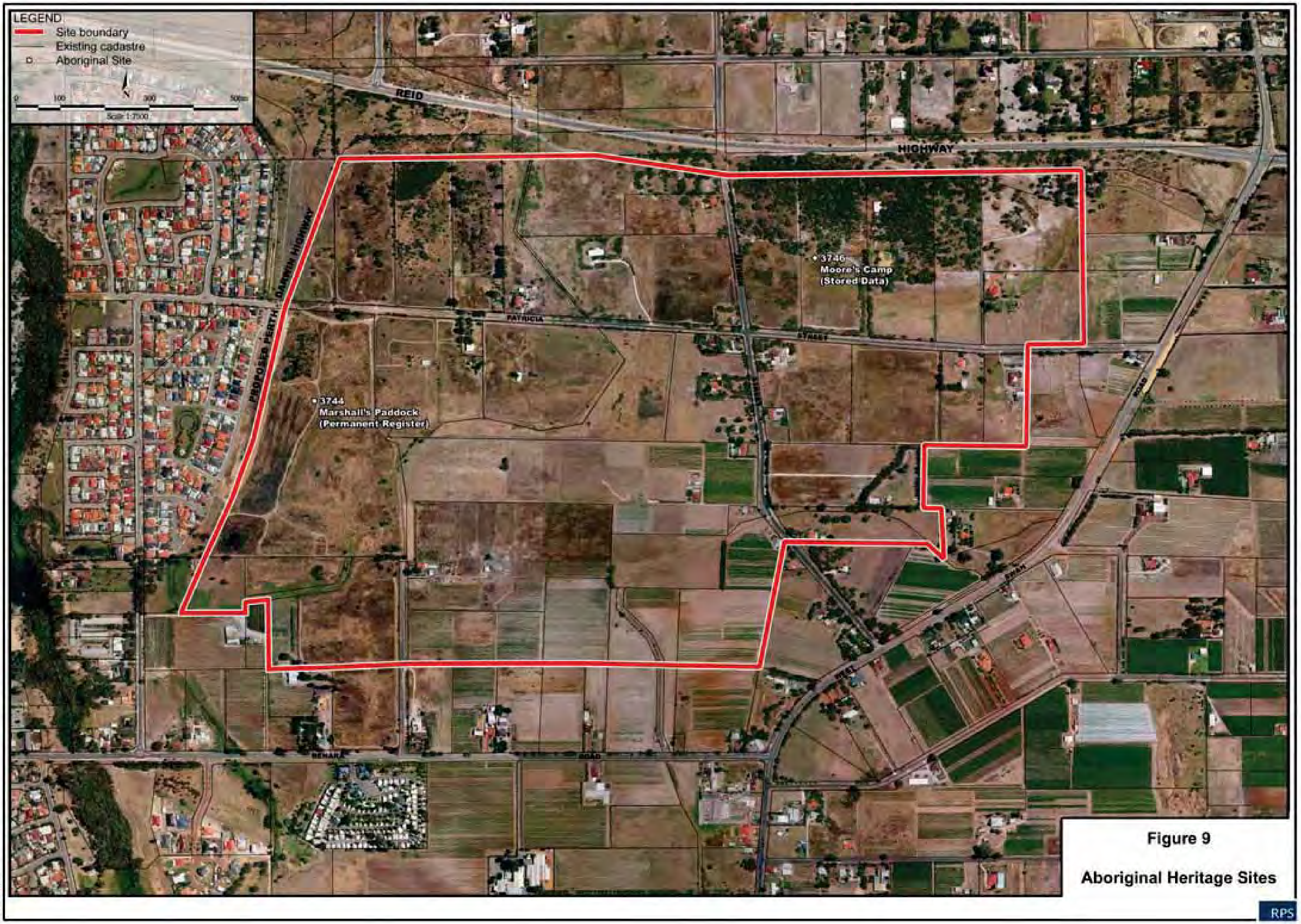


Figure 9

Aboriginal Heritage Sites

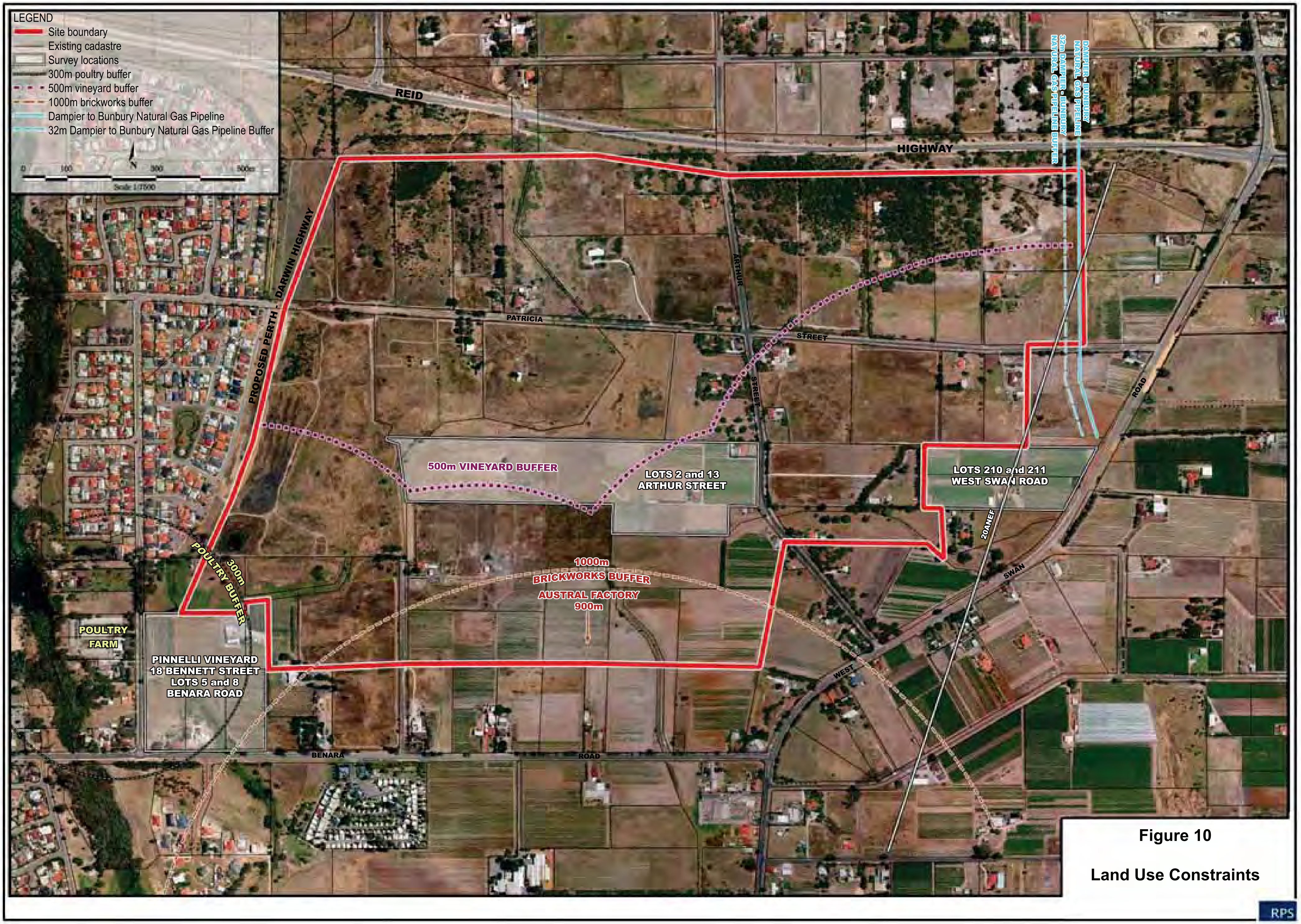
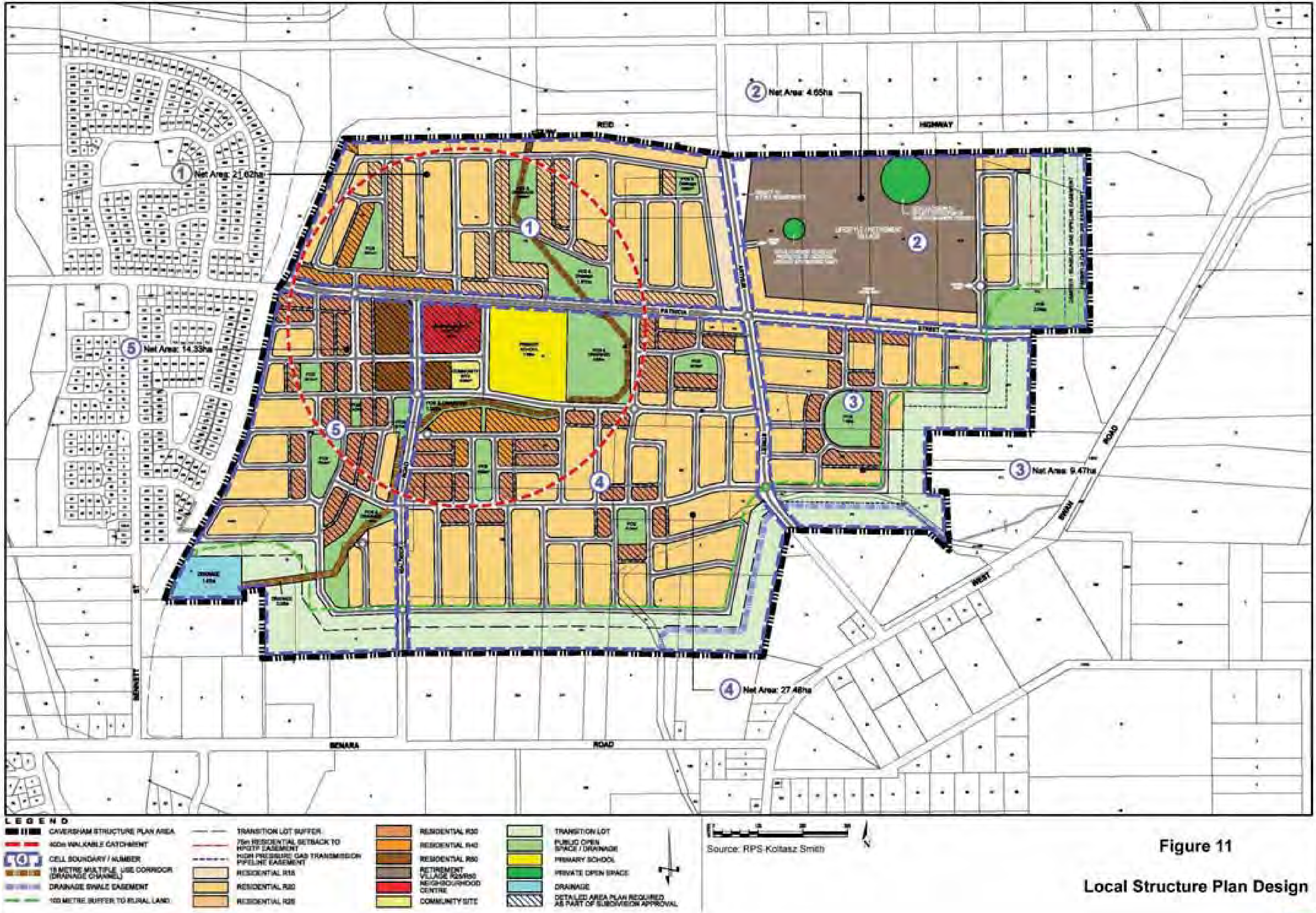


Figure 10

Land Use Constraints



Source: RPS Koltasz Smith

Figure 11

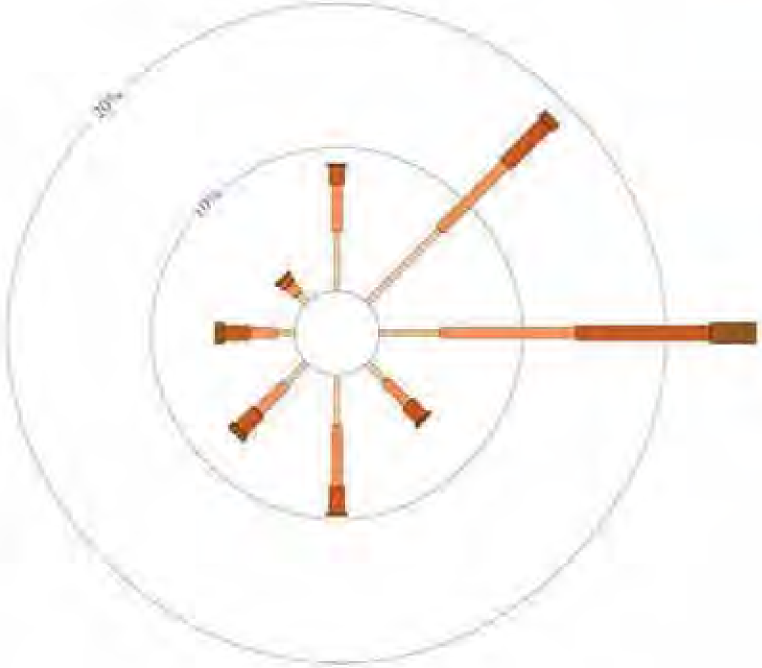
Local Structure Plan Design

RPS

WIND FREQUENCY ANALYSIS (in km/h)
PERTH AIRPORT   STATION NUMBER 009021
Latitude: -31.93 ° Longitude: 115.98 °

9 am
21932 Total Observations (1944 to 2004)

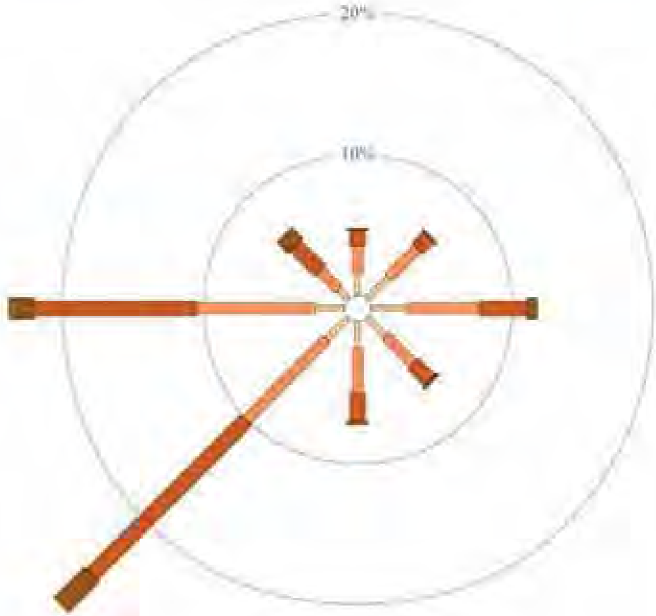
Calm 15%



WIND FREQUENCY ANALYSIS (in km/h)
PERTH AIRPORT   STATION NUMBER 009021
Latitude: -31.93 ° Longitude: 115.98 °

3 pm
21917 Total Observations (1944 to 2004)

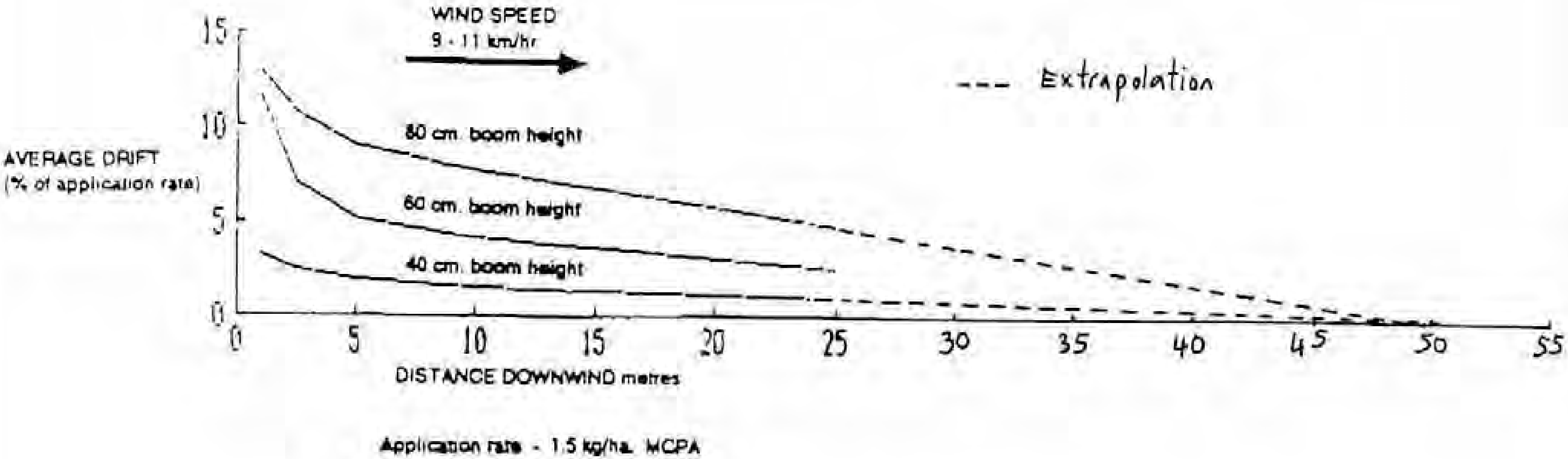
Calm 5%



Wind directions are divided into eight compass directions. Calm has no direction.
An asterisk (*) indicates that calm is less than 1%.
An observed wind speed which falls precisely on the boundary between two divisions (eg 10km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.

Figure 12

BOM Wind Roses



Source: Swedish EPA
Modified from DEP Draft Environmental Code of Practice for Market Gardens on the Swan Coastal Plain.

Figure 13

DEC Spray Drift Diagram

APPENDIX 1

EPA Environmental Impact Assessment Process

Pre-referral

Where a scheme is likely to have environmental implications, the EPA recommends that the applicant/responsible authority:

- researches environmental issues during formulation of scheme
- identifies environmental objectives and criteria to be met
- identifies potential environmental impacts and how these will be managed
- consults as appropriate with the EPA Service Unit, DEC regions and specialist branches and other government agencies.

↓

Referral by responsible authority to EPA

Scheme initiated/adopted by the responsible authority for example, local government or WAPC, and referred to the EPA with environmental information where relevant

↓

EPA Service Unit (on behalf of the EPA) processes referral:

And may:

- consult the DEC regional office and/or technical branches of DEC
- seek additional information that will assist the EPA to set level of assessment

↓

EPA makes a decision on referral

Options are:

- scheme not assessed (EPA Service Unit may provide advice with input from DEC)
- scheme assessed (formal assessment procedures will follow)
- scheme incapable of being made environmentally acceptable

STATE ENVIRONMENTAL IMPACT ASSESSMENT - SCHEME REFERRAL PROCESS ***(Figure A2 in EPA Guidance Statement No.33, May 2008)***

APPENDIX 2

Quarterly Groundwater Quality Monitoring Results

Sample ID	Date	Ammonia-N	Total Kjeldahl Nitrogen	Nox-N	Total Nitrogen	Reactive Phosphorus	Total Phosphorus
CGW -1	15/03/2006	0.2	2.4	0.01	2.4	0.29	0.3
	14/06/2006	0.2	1.6	0.08	1.7	0.25	0.28
	13/09/2006	0.2	5.9	0.06	5.96	0.71	0.81
	20/12/2006	0.2	1.8	0.2	2	0.39	0.53
	21/02/2007	0.2	3.7	4.2	7.9	0.11	0.12
	8/05/2007	0.2	3.8	8.20	12.00	0.17	0.17
	8/08/2007	25	26	0.62	27	0.63	0.83
	13/11/2007	15	17	0.05	17.00	0.6	0.6
CGW - 2	15/03/2006	0.2	1.7	5.60	7.3	0.36	0.56
	14/06/2006	0.2	1.4	6.10	7.5	0.2	0.22
	13/09/2006	0.2	3.4	4.80	8.2	0.23	0.36
	20/12/2006	0.2	2	1.80	3.8	0.21	0.21
	21/02/2007	0.2	0.2	7.9	7.9	0.14	0.14
	8/05/2007	0.2	1.9	5.70	7.60	0.08	1.1
	8/08/2007	0.2	1.3	4.4	5.7	0.56	0.60
	13/11/2007	0.2	0.8	5.60	6.40	0.34	0.34
CGW - 3	15/03/2006	0.2	0.3	0.08	0.4	0.05	0.17
	14/06/2006	0.2	0.8	0.79	1.6	0.02	0.08
	13/09/2006	0.2	1.1	0.64	1.74	0.06	0.1
	20/12/2006	0.2	0.6	0.44	1.04	0.02	0.05
	21/02/2007	0.2	0.2	0.81	0.8	0.10	0.25
	8/05/2007	0.2	0.2	0.56	0.80	0.02	0.33
	8/08/2007	0.2	0.8	6.1	6.9	0.07	0.19
	13/11/2007	0.2	0.2	4.70	4.70	0.05	0.05
CGW - 4	15/03/2006	0.2	0.2	0.02	0.2	0.01	0.03
	14/06/2006	0.2	0.6	0.06	0.7	0.01	0.02
	13/09/2006	0.2	0.6	0.02	0.62	0.01	0.23
	20/12/2006	1.5	1.5	0.03	1.53	0.01	0.01
	21/02/2007	0.2	0.2	0.03	0.2	0.03	0.11
	8/05/2007	0.2	1.4	0.01	1.40	0.02	1.9
	8/08/2007	0.2	1.4	0.12	1.5	0.02	0.56
	13/11/2007	0.2	0.2	0.06	0.30	0.02	0.08
CGW - 5	15/03/2006	0.2	0.2	1.30	1.3	0.07	0.12
	14/06/2006	0.2	0.4	0.11	0.5	0.05	0.07
	13/09/2006	0.2	0.3	0.02	0.32	0.02	0.13
	20/12/2006	0.2	0.2	0.01	0.21	0.02	0.09
	21/02/2007	0.2	0.2	0.02	0.2	0.06	1.5
	8/05/2007	0.2	0.2	0.01	0.20	0.04	0.14
	8/08/2007	0.2	0.3	0.03	0.3	0.07	0.26
	13/11/2007	0.2	0.2	1.60	1.60	0.09	0.09
CGW - 6	15/03/2006	0.2	0.2	0.30	0.3	0.01	0.02
	14/06/2006	0.2	0.4	0.82	1.2	0.01	0.03
	13/09/2006	0.2	0.6	0.32	0.92	0.01	0.13
	20/12/2006	0.2	0.3	0.13	0.43	0.01	0.15
	21/02/2007	0.3	7.5	0.30	7.8	0.01	0.43
	8/05/2007	0.2	0.2	0.39	0.40	0.02	0.4
	8/08/2007	0.2	0.4	0.54	0.9	0.01	0.23
	13/11/2007	0.2	0.5	0.10	0.60	0.03	0.1
CGW - 7	15/03/2006	0.6	0.9	0.01	0.9	0.01	0.26
	14/06/2006	0.2	0.6	0.03	0.6	0.02	0.05
	13/09/2006	0.2	0.3	0.01	0.31	0.01	0.02
	20/12/2006	0.2	0.3	0.02	0.32	0.01	0.05
	21/02/2007	0.2	0.2	0.02	0.2	0.01	0.03
	8/05/2007	0.2	0.3	0.02	0.30	0.01	0.02

	8/08/2007	0.2	0.8	0.49	1.3	0.01	0.15
	13/11/2007	0.2	0.2	0.82	0.80	0.02	0.09
CGW - 8	15/03/2006	0.2	0.2	0.50	0.5	0.03	0.1
	14/06/2006	0.2	0.3	0.75	1.1	0.02	0.03
	13/09/2006	0.2	0.4	0.32	0.72	0.03	0.23
	20/12/2006	0.2	0.2	0.30	0.5	0.02	0.04
	21/02/2007	0.2	0.6	0.77	1.4	0.03	0.14
	8/05/2007	0.2	0.2	0.83	0.80	0.03	0.03
	8/08/2007	0.2	0.2	1.0	1.2	0.04	0.15
	13/11/2007	0.2	0.4	0.29	0.70	0.06	0.07
CGW - 9	15/03/2006	1.8	1.4	0.01	1.4	0.02	0.03
	14/06/2006	0.7	1.3	0.06	1.4	0.01	0.13
	13/09/2006	0.6	1.8	0.01	1.81	0.01	0.02
	20/12/2006	0.6	1.2	0.01	1.21	0.01	0.07
	21/02/2007	0.3	1.2	0.04	1.2	0.01	0.17
	8/05/2007	0.2	0.7	0.01	0.70	0.01	0.01
	8/08/2007	0.2	1.3	0.01	1.3	0.02	0.21
	13/11/2007	0.5	0.8	0.06	0.90	0.04	0.05
CGW - 10	15/03/2006	0.2	0.2	0.10	0.1	0.01	0.02
	14/06/2006	0.2	0.3	0.09	0.4	0.01	0.03
	13/09/2006	0.3	0.8	2.60	2.4	0.02	0.02
	20/12/2006	0.2	0.2	0.01	0.21	0.01	0.05
	21/02/2007	0.2	0.3	0.05	0.4	0.01	0.15
	8/05/2007	0.2	0.2	0.01	0.20	0.01	0.01
	8/08/2007	0.2	1.4	4.4	5.8	0.01	0.14
	13/11/2007	0.2	0.2	0.08	0.30	0.02	0.02
CGW - 11	15/03/2006	0.2	0.2	0.30	0.3	0.01	0.01
	14/06/2006	0.2	0.4	0.04	0.4	0.02	0.05
	13/09/2006	0.2	0.3	0.01	0.31	0.04	0.14
	20/12/2006	0.2	0.2	0.01	0.21	0.02	0.07
	21/02/2007	0.2	1.2	0.13	1.3	0.02	0.09
	8/05/2007	0.2	0.2	0.01	0.20	0.04	0.04
	8/08/2007	0.2	1.8	0.06	1.9	0.16	0.20
	13/11/2007	0.2	0.2	0.08	0.20	0.02	0.1
CGW - 12	15/03/2006	0.2	0.3	1.70	2	0.06	0.13
	14/06/2006	0.2	4.8	2.30	7.1	0.05	0.16
	13/09/2006	0.2	1.8	1.40	3.2	0.03	0.05
	20/12/2006	0.2	1.3	0.76	2.06	0.01	0.05
	21/02/2007	0.2	1.7	17	19	0.01	0.13
	8/05/2007	NO SAMPLE DUE TO INSUFFICIENT WATER					
	8/08/2007	0.2	8.1	3.4	12	0.29	1.1
	13/11/2007	0.2	4.5	12.00	17.00	0.09	0.22
CGW - Z	15/03/2006	0.2	3	0.01	3.00	0.29	0.3
	14/06/2006	0.2	1.9	0.08	2.00	0.25	0.25
	13/09/2006	0.2	0.4	0.25	0.65	0.02	0.13
	20/12/2006	0.2	0.3	0.01	0.31	0.01	0.07
	21/02/2007	0.2	2.1	0.12	2.2	0.03	0.77
	8/05/2007	0.2	0.8	0.01	0.80	0.02	0.02
	8/08/2007	0.2	0.2	1.1	1.3	0.17	0.17
	13/11/2007	0.2	0.4	0.27	0.70	0.06	0.11
CGW - B	15/03/2006	0.2	0.2	0.01	0.20	0.01	0.03
	14/06/2006	0.2	0.2	0.01	0.20	0.01	0.01
	13/09/2006	0.2	0.2	0.01	0.20	0.01	0.01
	20/12/2006	0.2	0.2	0.01	0.20	0.01	0.01
	21/02/2007	0.2	0.2	0.01	0.2	0.01	0.01
	8/05/2007	0.2	0.2	0.01	0.2	0.01	0.01
	8/08/2007	0.2	0.2	0.01	0.2	0.01	0.01

	13/11/2007	0.2	0.2	0.01	0.20	0.01	0.01
CGW - R	15/03/2006	0.2	0.2	0.01	0.20	0.01	0.01
	14/06/2006	0.2	0.2	0.01	0.20	0.01	0.01
	13/09/2006	0.2	0.2	0.01	0.20	0.01	0.01
	20/12/2006	0.2	0.2	0.01	0.20	0.01	0.01
	21/02/2007	0.2	0.2	0.01	0.2	0.01	0.01
	8/05/2007	0.2	0.2	0.01	0.2	0.01	0.01
	8/08/2007	0.2	0.2	0.01	0.2	0.01	0.01
	13/11/2007	0.2	0.2	0.01	0.20	0.01	0.01

Sample ID	Date	Water Level (mAHD)	Temperature (ºC)	pH	EC (µS/cm)
CGW 1	15/02/2006	13.43	23.0	6.39	1738
	15/03/2006	13.28	29.1	6.38	2279
	12/04/2006	13.145	22.4	6.41	2215
	15/05/2006	13.082	22.5	6.51	1877
	14/06/2006	13.02	20.9	6.33	1988
	13/07/2006	13.085	19.6	6.23	2250
	17/08/2006	13.391	19.0	6.36	2880
	13/09/2006	13.62	18.7	6.08	2570
	12/10/2006	13.463	19.1	6.67	2700
	20/11/2006	13.301	2.6	6.44	2500
	20/12/2006	13.64	28.5	6.25	2070
	11/01/2007	13.142	23.9	6.04	2210
	21/02/2007	12.825	24.1	6.29	2380
	16/03/2007	12.853	25.0	6.02	2291
	11/04/2007	12.681	24.0	6.33	2396
	9/05/2007	12.747	24.0	6.31	2182
	7/06/2007	12.67	21.4	6.7	2.23
	3/07/2007	12.926	19.7	5.74	2910
	8/08/2007	13.517	19.2	6.55	3280
	7/09/2007	13.642	17.7	6.06	4420
	18/10/2007	13.498	19.8	6.16	4150
	13/11/2007	13.357	20.4	6.36	3510
	12/12/2007	13.241	20.3	6.22	3216
	17/01/2008				
CGW 2	15/02/2006	13.798	22.8	6.54	293
	15/03/2006	13.694	23.8	6.44	331
	12/04/2006	13.563	21.7	6.6	334
	15/05/2006	13.5	23.0	6.95	335
	14/06/2006	13.373	19.1	6.52	378
	13/07/2006	13.42	19.4	6.58	404
	17/08/2006	13.789	18.0	6.61	428
	13/09/2006	13.954	16.9	6.19	402
	12/10/2006	13.829	18.8	6.34	420
	20/11/2006	13.633	21.5	6.9	350
	20/12/2006	13.498	22.1	6.68	360
	11/01/2007	13.344	23.8	6.66	356
	21/02/2007	13.114	23.7	6.45	332
	16/03/2007	13.009	25.6	5.83	315
	11/04/2007	12.935	24.2	6.48	276
	9/05/2007	13.067	22.3	6.39	255
	7/06/2007	13.184	21.4	6.93	280
	3/07/2007	13.413	18.5	5.91	356
	8/08/2007	13.913	18.6	6.73	285
	7/09/2007	13.962	17.0	7.12	318
	18/10/2007	13.819	19.4	6.5	326
	13/11/2007	13.672	20.5	6.74	263
	12/12/2007	13.729	19.8	6.39	420
	17/01/2008	13.401	25.3	6.8	239
	15/02/2006	9.813	20.2	6.28	463
	15/03/2006	9.527	29.1	6.07	593
	12/04/2006	9.337	21.9	6.36	586
	15/05/2006	9.139	21.5	6.59	539

CGW 3	14/06/2006	8.844	21.1	6.73	526
	13/07/2006	8.702	19.8	6.23	566
	17/08/2006	10.024	19.5	6.38	587
	13/09/2006	11.266	20.2	5.78	380
	12/10/2006	10.878	18.7	6.81	550
	20/11/2006	9.987	20.1	6.72	520
	20/12/2006	9.338	26.5	6.2	450
	11/01/2007	9.127	21.2	6.49	540
	21/02/2007	8.838	20.9	6.05	573
	16/03/2007	8.684	22.3	5.91	597
	11/04/2007	8.566	21.3	6.44	583
	9/05/2007	8.463	21.6	6.03	599
	7/06/2007	8.516	21.4	6.45	600
	3/07/2007	9.091	21.1	5.59	640
	8/08/2007	11.647	19.5	6.36	539
	7/09/2007	9.266	18.1	6.32	780
	18/10/2007	11.322	19.3	6.37	596
	13/11/2007	10.704	20.7	6.34	570
	12/12/2007	11.291	19.7	7.01	649
	17/01/2008	9.548	20.0	6.37	475
CGW 4	15/02/2006	3.933	20.8	5.96	3610
	15/03/2006	4.028	23.3	5.75	4540
	12/04/2006	3.983	22.0	5.72	5030
	15/05/2006	4.061	22.1	5.67	4470
	14/06/2006	3.898	22.0	5.65	4000
	13/07/2006	3.776	19.7	5.61	4930
	17/08/2006	3.847	20.1	5.63	4970
	13/09/2006	3.831	21.1	5.56	4820
	12/10/2006	3.776	20.7	5.76	4740
	20/11/2006	3.541	22.4	5.77	4830
	20/12/2006	3.312	21.9	5.61	5120
	11/01/2007	3.116	21.7	5.59	5300
	21/02/2007	3	21.5	5.58	4760
	16/03/2007	2.999	23.9	5.39	4780
	11/04/2007	3.056	21.8	5.71	5862
	9/05/2007	3.085	21.2	5.65	4800
	7/06/2007	3.205	21.5	5.55	4770
	3/07/2007	3.155	20.9	5.16	5970
	8/08/2007	3.256	21.1	5.33	5750
	7/09/2007	3.308	17.8	5.21	4320
	18/10/2007	3.408	19.7	6.32	2620
	13/11/2007	3.434	21.5	5.37	5670
	12/12/2007	3.099	20.6	6.45	1290
	17/01/2008	2.838	23.2	5.35	4200
CGW 5	15/02/2006	10.216	19.5	6.93	651
	15/03/2006	9.871	23.0	6.73	796
	12/04/2006	9.636	20.8	6.85	775
	15/05/2006	9.646	21.0	6.97	675
	14/06/2006	9.577	20.7	6.71	691
	13/07/2006	9.569	19.6	6.82	716
	17/08/2006	9.745	19.2	6.86	757
	13/09/2006	10.053	18.2	6.47	721
	12/10/2006	10.332	19.1	7.02	680
	20/11/2006	10.202	19.4	6.77	660
	20/12/2006	9.924	22.6	6.64	660
	11/01/2007	9.611	20.5	6.84	678

CGW 5	21/02/2007	9.239	20.6	6.5	672
	16/03/2007	8.972	22.3	6.28	671
	11/04/2007	8.834	21.7	6.8	676
	9/05/2007	8.859	21.9	6.59	658
	7/06/2007	9.264	21.3	6.3	640
	3/07/2007	9.253	20.1	6.48	710
	8/08/2007	9.613	19.6	6.62	685
	7/09/2007	9.448	17.4	5.34	623
	18/10/2007	9.493	18.9	6.49	649
	13/11/2007	10.763	21.0	7.01	846
	12/12/2007	9.617	21.3	6.49	721
	17/01/2008	9.971	20.4	7.06	643
CGW 6	15/02/2006	7.483	19.5	7.07	1386
	15/03/2006	7.047	24.3	7.07	1744
	12/04/2006	7.061	21.4	6.99	1817
	15/05/2006	7.573	21.3	7.06	1453
	14/06/2006	7.538	19.2	7.1	1472
	13/07/2006	7.795	18.1	7.05	1479
	17/08/2006	8.12	19.0	7.22	1546
	13/09/2006	8.418	17.2	7.04	1482
	12/10/2006	8.335	18.1	7.25	1440
	20/11/2006	7.822	19.9	7.16	1510
	20/12/2006	7.123	20.4	7.14	1580
	11/01/2007	7.108	21.7	6.89	1727
	21/02/2007	6.786	21.7	7.01	1739
	16/03/2007	6.14	24.1	6.7	1678
	11/04/2007	6.317	23.0	6.93	1904
	9/05/2007	7.098	22.2	6.97	1669
	7/06/2007	7.426	22.2	7.18	1490
	3/07/2007	7.58	20.7	6.42	1630
	8/08/2007	8.698	19.3	7.28	1517
	7/09/2007	9.048	18.6	7.34	1430
	18/10/2007	9.076	20.4	7.03	1983
	13/11/2007	8.338	21.0	7.6	1454
	12/12/2007	8.851	21.2	6.13	1870
	17/01/2008				
CGW 7	15/02/2006	8.56	20.1	5.76	2610
	15/03/2006	8.402	20.5	5.24	2730
	12/04/2006	8.324	21.7	5.24	2740
	15/05/2006	8.272	21.4	5.23	2360
	14/06/2006	8.22	20.4	4.95	2168
	13/07/2006	8.428	18.6	5.01	2270
	17/08/2006	8.813	17.7	5.19	2298
	13/09/2006	8.923	18.6	4.88	2135
	12/10/2006	8.694	18.2	5.25	2060
	20/11/2006	8.323	20.0	5.21	2170
	20/12/2006	8.109	23.2	5.13	2260
	11/01/2007	7.986	21.6	4.93	2349
	21/02/2007	7.812	21.1	5.08	2289
	16/03/2007	7.664	24.0	4.99	2391
	11/04/2007	7.61	22.4	5.3	2603
	9/05/2007	8.061	22.0	5.14	2188
	7/06/2007	8.321	21.4	5.16	2070
	3/07/2007	8.581	19.9	4.88	2392
	8/08/2007	9.656	18.6	5.47	2028
	7/09/2007	8.746	18.3	7.22	1890

	18/10/2007	9.335	19.3	5.22	2216
	13/11/2007	8.909	21.4	4.66	2660
	12/12/2007	9.366	21.4	7.22	3019
	17/01/2008	9.508	21.2	6.42	633
CGW 8	15/02/2006	7.867	20.6	6.41	618
	15/03/2006	7.458	21.8	6.6	764
	12/04/2006	7.159	20.9	6.35	759
	15/05/2006	7.005	20.9	6.28	671
	14/06/2006	6.783	20.9	6.25	694
	13/07/2006	6.668	18.9	6.13	716
	17/08/2006	6.671	16.6	6.47	779
	13/09/2006	6.907	19.3	6.12	738
	12/10/2006	7.077	19.7	6.66	710
	20/11/2006	7.008	20.6	6.44	700
	20/12/2006	6.841	22.0	6.3	700
	11/01/2007	6.64	21.0	6.45	702
	21/02/2007	6.378	20.6	6.2	704
	16/03/2007	6.23	23.9	6.08	686
	11/04/2007	6.109	20.8	6.5	710
	9/05/2007	6.02	21.1	6.3	665
	7/06/2007	6.092	21.4	6.19	680
	3/07/2007	6.044	21.0	5.28	721
	8/08/2007	6.281	20.8	6.35	707
	7/09/2007	6.818	20.1	6.23	746
	18/10/2007	7.132	16.5	5.84	318
	13/11/2007	7.212	20.5	6.46	657
	12/12/2007	7.328	21.1	6.2	918
	17/01/2008	6.938	20.8	6.11	571
CGW 9	15/02/2006	7.268	22.9	6.85	930
	15/03/2006	7.187	25.7	7.23	1237
	12/04/2006	7.265	21.6	7	1277
	15/05/2006	7.361	19.1	6.87	1110
	14/06/2006	7.243	15.9	7.02	1033
	13/07/2006	7.331	16.0	6.78	1016
	17/08/2006	7.551	15.1	6.73	1870
	13/09/2006	7.549	17.4	6.56	1829
	12/10/2006	7.375	17.8	7.13	970
	20/11/2006	7.258	21.0	6.84	980
	20/12/2006	7.192	24.1	6.8	1140
	11/01/2007	7.145	23.6	6.84	1190
	21/02/2007	6.976	24.9	6.85	1306
	16/03/2007	6.911	25.7	6.6	1321
	11/04/2007	6.84	23.5	7.08	1244
	9/05/2007	7.216	21.1	6.93	1021
	7/06/2007	7.367	17.3	6.67	1010
	3/07/2007	7.565	15.3	5.91	2458
	8/08/2007	7.898	16.2	6.82	1283
	7/09/2007	7.672	16.4	6.56	1675
	18/10/2007	7.412	19.2	6.84	1272
	13/11/2007	7.289	18.7	7.13	946
	12/12/2007	7.429	20.3	6.59	1445
	17/01/2008	6.393	23.7	6.66	910
	15/02/2006	9.884	20.3	7.03	415
	15/03/2006	9.707	22.3	6.99	442
	12/04/2006	9.509	21.2	6.85	442
	15/05/2006	9.457	21.0	6.56	422

CGW 10	14/06/2006	9.296	20.4	6.44	456
	13/07/2006	9.457	18.2	6.12	508
	17/08/2006	9.935	17.7	6.64	659
	13/09/2006	10.313	18.9	6.3	823
	12/10/2006	10.041	18.7	7.09	620
	20/11/2006	9.451	19.3	6.37	470
	20/12/2006	9.161	20.6	6.27	500
	11/01/2007	9.001	20.5	6.57	466
	21/02/2007	8.783	20.5	6.25	465
	16/03/2007	8.71	22.9	6.17	444
	11/04/2007	8.678	21.7	6.6	433
	9/05/2007	8.905	21.8	6.32	478
	7/06/2007	9.146	20.7	6.52	500
	3/07/2007	9.311	19.3	5.74	565
	8/08/2007	10.778	17.9	6.78	1116
	7/09/2007	10.768	18.3	6.72	987
	18/10/2007	10.444	18.5	6.98	736
	13/11/2007	10.172	20.7	6.8	582
	12/12/2007	10.002	20.2	6.86	511
	17/01/2008	9.449	20.8	6.54	338
CGW 11	15/02/2006	11.234	20.1	7.27	508
	15/03/2006	11.049	26.6	7.11	719
	12/04/2006	10.84	20.9	7.22	795
	15/05/2006	10.966	20.5	7.17	597
	14/06/2006	10.902	20.4	6.66	451
	13/07/2006	10.973	20.2	6.62	417
	17/08/2006	11.6	18.3	6.91	439
	13/09/2006	11.886	20.3	6.34	430
	12/10/2006	11.616	19.5	6.95	420
	20/11/2006	11.21	19.7	6.51	410
	20/12/2006	10.927	23.0	6.84	490
	11/01/2007	10.746	22.0	6.92	509
	21/02/2007	10.316	21.8	6.71	558
	16/03/2007	10.169	22.3	6.54	602
	11/04/2007	10.105	22.0	7.05	635
	9/05/2007	10.562	21.6	6.74	574
	7/06/2007	10.818	21.1	6.94	490
	3/07/2007	11.157	18.9	6.26	373
	8/08/2007	12.435	16.9	6.47	314
	7/09/2007	12.296	18.4	6.7	434
	18/10/2007	11.912	20.0	6.76	435
	13/11/2007	11.664	20.6	6.71	406
	12/12/2007	11.508	20.0	6.73	486
	17/01/2008	11.106	21.7	7.1	457
CGW 12	15/02/2006	11.255	19.9	7.92	1420
	15/03/2006	11.093	26.6	7.33	1757
	12/04/2006	10.89	20.3	7.37	1648
	15/05/2006	10.707	20.3	7.4	1444
	14/06/2006	10.447	22.3	7.26	1410
	13/07/2006	10.341	19.2	7.14	1506
	17/08/2006	10.867	18.9	7.43	1674
	13/09/2006	11.678	19.7	7.19	1584
	12/10/2006	11.63	18.4	7.47	1560
	20/11/2006	11.182	19.6	7.39	1540
	20/12/2006	10.88	20.9	7.47	1540
	11/01/2007	10.686	20.2	7.52	1525

CGW 12	21/02/2007	10.409	24.0	7.36	1420
	16/03/2007	10.282	23.4	7.09	1429
	11/04/2007	10.169	-	-	-
	9/05/2007	10.06	21.5	7.37	1406
	7/06/2007	10.054	20.9	7.25	1360
	3/07/2007	11.523	17.4	7.53	443
	8/08/2007	11.958	18.2	7.64	1172
	7/09/2007	12.302	17.4	7.3	1560
	18/10/2007	12.107	19.3	7.33	1768
	13/11/2007	11.788	20.7	7.6	1762
	12/12/2007	12.008	19.6	7.4	1889
	17/01/2008	11.327	22.3	7.3	1297

BROOKLEIGH ESTATE

PATRICIA STREET - CAVERSHAM

Urban Water Management Plan

QUBE Caversham Development Pty Ltd

November 2009 / Revision E

BROOKLEIGH ESTATE

PATRICIA ST - CAVERSHAM

Urban Water Management Plan

November 2009 / Revision E

Author: C. Le ....

Reviewer: M. Evangelisti, O. Chan ....

Approved: M. Evangelisti ....

(signed & dated) ....

Distribution: QUBE Caversham Development Pty Ltd (1), Department of Water (1)

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KEY DESIGN OBJECTIVES

EARTHWORKS AND SUBSOIL DRAINS

- Subsoil drainage pipes are to have a minimum grade of 1:500.
- Subsoil drainage pipes are to have a free outfall into the bioretention swales shown in Figure 5.1, at 500 mm above the invert of the Caversham West central drain.
- Subsoil drains are to be placed in the road reserves and lot side boundaries with a maximum spacing of 40 - 50 m, consistent with the locations and invert levels shown in Figure 5.1.
- Maximum lengths of subsoil drainage pipes are to be consistent with Table 5.1.
- Where the subsoil drain invert is *below* pre-development AAMGL, lot levels are to be at least 1.8 m above subsoil drain invert levels. Where the subsoil drain invert is *above* the pre-development AAMGL, Lot levels must be at least 1.2 m above AAMGL.
- Lot levels are to be at least 300 mm above the 100 year ARI flood levels shown in Figure 6.2.

STORMWATER DRAINAGE

- All lots to install soakwells for the on-site retention and disposal of stormwater.
- 1 year 1 hour ARI flows will be retained and infiltrated in the bioretention areas which will be located adjacent to the Caversham West drain. Figure 6.1 shows flow paths and the 1 year 1 hour ARI retention volumes.
- The 5 year ARI flows are to be conveyed predominantly by a conventional pipe network along the road reserves. 5 year ARI flows will generally follow the same flow paths as the 100 year ARI events. These flow paths are shown in Figure 6.1 and Figure 6.2.
- The peak 5 year ARI flow rate through the 750 x 450 mm box culvert crossing Patricia Street will be restricted to 0.4 m^3/s, in accordance with the revised Figure 10-11.16b of the Swan Urban Growth Corridor DWMP, provided by GHD on 11 June 2009.
- The peak 100 year ARI flow rate through the 750 x 450 mm box culvert crossing Patricia Street will be restricted to 0.7 m^3/s, in accordance with the revised Figure 10-11.16b of the Swan Urban Growth Corridor DWMP, provided by GHD on 11 June 2009.
- Flood levels within the Caversham West will return to minimum levels within 24-48 hrs after the peak 5 year or 100 year ARI storm event.

- Figure 6.2 shows the extent of flooding within the Caversham West drainage corridor for the peak 100 year ARI event.
- 5 year and 100 year ARI flows are to be conveyed via a combination of overland flow paths and pipes within the road reserves and directed to the Central Drain, as shown in Figure 6.2.

ROAD LEVELS

- The road levels are to be a minimum of 1 m above subsoil drain levels.
- The road levels are to be set such that the delineation of catchment areas is consistent with Figure 6.2.

BEST MANAGEMENT PRACTICES (BMPS)

- The bioretention swales are required at the approximate locations shown in Figure 5.1. A typical cross section is shown in Diagram 5.1.
- The structural BMPs to be implemented at Brookleigh Estate are presented in Table 7.2.
- The non-structural BMPs to be implemented at Brookleigh Estate are presented in Table 7.3.

WATER CONSERVATION

- Water conservation initiatives such as waterwise landscaping, xeriscaping, and garden and lawn care education, in combination with waterwise appliances and rainwater tanks, as outlined in Section 4.3 will be encouraged to reduce potable water consumption.
- Waterwise landscaping, rainwater tanks and the use of waterwise appliances can potentially reduce the consumption potable water from the current average of 137 kL/person/year to 45 kL/person/year.
- The water use for POS irrigation is to be no greater than 27,675 kL per annum.

IMPLEMENTATION

- Suitable monitoring and maintenance of the structural BMPs will be consistent with Section 10.2.
- Pre-development and post-development surface water monitoring programs will be established consistent with Section 9.1.
- Groundwater quality will be monitored consistent as outlined in Section 0, using fixed groundwater bores to ensure no decline in groundwater quality.

1 INTRODUCTION

1.1 THE SITE

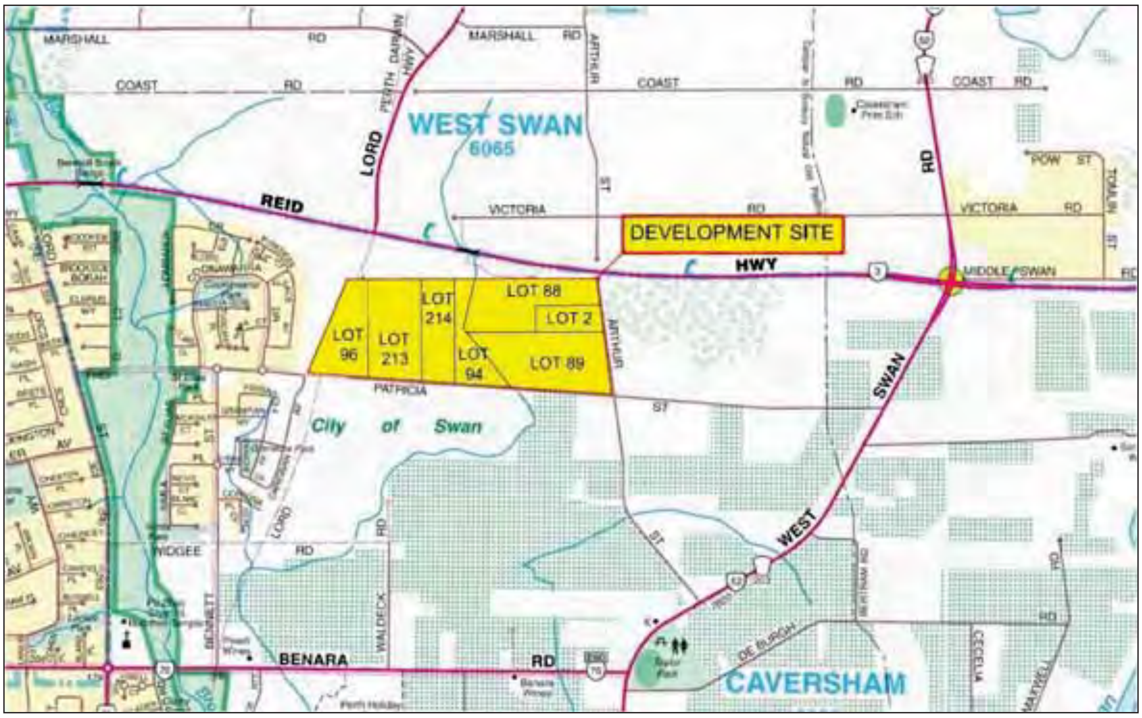
The Brookleigh Estate site is located within Caversham, within the municipal area of City of Swan. Situated approximately 1 km west of West Swan Road and Reid Hwy intersection, it is approximately 7 km north from Perth Airport. The site is bounded by Reid Hwy to the north, Patricia Street to the south, Arthur St to the east, and the proposed Lord St extension alignment to the west.

The total area of the site is approximately 32.5 ha, which has been mostly cleared on the eastern portion of the site, and the western portion is mostly uncleared bushland. As investigated by Douglas and Partners in 2005 these cleared paddocks on the eastern portion have historically been utilised for viticultural.

Under the Metropolitan Region Scheme (MRS) and City of Swan Town Planning Scheme the area of interest is zoned for 'Future Urban Development'. The locality of the site is illustrated in Diagram 1.1 below.

The subdivisional pre-calc plan prepared by McMullen Nolan (15 July 08), proposed a yield of 437 lots, and 4.34 ha set-aside for public open space (POS).

Diagram 1.1 – Brookleigh Estate locality plan



The Sub Regional Structure Plan (SRSP) for the Swan Urban Growth Corridor (Figure 1.1) was produced for the development and management of Henley Brook/Albion, West Swan, and Caversham district in the City of Swan. The Caversham DSP, shown in Figure 1.2, falls within the Swan Urban Growth Corridor SRSP. Brookleigh Estate LSP falls within the Caversham DSP is shown in Figure 1.3.

1.2 SWAN URBAN GROWTH CORRIDOR DRAINAGE AND WATER MANAGEMENT PLAN

The Swan Urban Growth Corridor Drainage and Water Management Plan (Swan DWMP) (DoW, 2009) has been produced to guide development and outline water management strategy requirements within the; Henley Brook/Albion, West Swan, Whiteman Park South, and Caversham structure plan area.

The Swan DWMP provides recommendations and references to the relevant guidelines for further study during Local Water Management Strategy (LWMS) investigation, in regards to; stormwater management, groundwater management, water quality management, water supply and conservation management, wastewater management, and protections of environmental assets.

1.3 CAVERSHAM LOCAL STRUCTURE PLAN – LOCAL WATER MANAGEMENT STRATEGY

Caversham Local Structure Plan area (CLSP) is approximately 176ha, bounded by proposed Lord St extension to the west, Reid Highway to the north, the Dampier Bunbury Natural Gas Pipeline (DBNGP) and private properties fronting West Swan Road to the east and Benara Road to the south. The LWMS (Cardno, 2007) is being developed to provide a broad level of water management strategy supporting the future development of CLSP area. The LWMS is still being finalised, and has not yet been approved by the DoW.

The CLSP LWMS provided analysis and summary of the CLSP predevelopment environmental conditions. In addition, it also provided recommendations and references to the relevant guidelines for further study during the subdivisional design, in regards to; water conservation, stormwater management strategy, groundwater management, monitoring, and sharing of stormwater management costs.

1.4 CONTENT OF THIS URBAN WATER MANAGEMENT PLAN

This urban water management plan (UWMP) is specific to Brookleigh Estate Caversham and provides management techniques to address the following, in accordance with the requirements set in the CLSP LWMS:

- Compliance with the design objectives in the CLSP LWMS. Demonstration of compliance should be achieved through appropriate assessment tools, calculations or assessments.
- Measures to achieve water conservation and efficiencies of use.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating flood management capability.
- Measures to implement onsite infiltration (i.e. at lot level)
- Specific structural and non-structural best management practices and treatment trains.
- Management of groundwater levels.
- Protection of Multiple Use Corridor (MUC), waterways (and their buffers), remnant vegetation and ecological linkages.
- Management of subdivisional works (to ensure no impact on conservation areas and management of dust).
- Monitoring program and/or contribution.

In addition, this UWMP also addresses:

- Management of disease vector and nuisance insects (mosquitoes and midges).
- Implementation including roles, responsibilities, funding and maintenance arrangements.

This UWMP seeks to obtain approval for the early land-release subdivision area (refer to Figure 1.3, Appendix A), the remaining area is conditionally subject to the endorsement of the Caversham North Local Structure Plan.

2 DESIGN OBJECTIVES

2.1 GENERAL

The CLSP LWMS (Cardno, 2007) outlined design objectives, management strategies and additional investigations required for the development of a UWMP in the Brookleigh Estate area.

Practical and sustainable water quantity criteria have been determined based on flood detention storage and waterway requirements based on Australian Rainfall & Runoff (AR&R) (Engineers Australia, 2001), the Stormwater Management Manual for Western Australia (DoW, 2007) and peak flow criteria set in the Department of Water's Swan DWMP, 2009.

The 'Decision Process for Stormwater Management in Western Australia' has been adopted from the Stormwater Management Manual for Western Australia (DoW, 2007) and is included as Figure 2.1. This flow chart summarises the design processes and criteria for stormwater management at structure planning (UWMS) and subdivision design (UWMP) stages.

Stormwater management for the structure plan requires compliance with management strategies for the following criteria:

- surface water quantity
- subsurface (groundwater) quantity
- water quality management (surface water and groundwater)
- wetland and waterway protection
- water conservation

The CLSP LWMS (Cardno, 2008) aims to achieve the following objectives (consistent with the State Planning Policy No. 2.9: Water Resources, WAPC, 2006):

- Manage the water regime so that there is:
  - No net difference in water quality and quantity, such that post-development water quality and quantity conditions are equal to or better than pre-development conditions.
  - Appropriate conditions for development which prevent flooding.
- Manage the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised.
- Achieve best practice urban water management in relation to:

- Stormwater management and retention of stormwater on site/at the source.
- Water conservation and water efficiency including re-use and recycling of water or utilisation of alternate sources where possible.

These objectives will be achieved through the actions and strategies identified in the CLSP LWMS (Cardno, 2008) and implemented in this UWMP.

2.2 WATER CONSERVATION

The water conservation design objectives are outlined in the CLSP LWMS (Cardno, 2008), and are in accordance with the targets in the Swan DWMP (DoW, 2009) and the State Water Strategy for Western Australian (Government of Western Australia, 2003). In addition, the State Water Plan (Government of Western Australia, 2007) includes a water consumption target of 100kL/person/yr. Section 4 outlines these objectives, and addresses how the potable water usage targets will be met by implementing waterwise initiatives.

2.3 SURFACE WATER QUANTITY

2.3.1 Flood conveyance

Investigation and modelling has been undertaken to meet the surface water design criteria outlined in the CLSP LWMS (Cardno, 2008), the Swan DWMP (DoW, 2009) and the Stormwater Management Manual for Western Australia (DoW, 2007).

The general criteria for surface water management include:

- For events up to 1 year 1 hour ARI, no flows will be allowed to exit the site – surface runoff will be retained and infiltrated on site.
- 5 year ARI flows will be conveyed predominantly by a conventional piped network draining the road reserve.
- 5 year ARI flows rate at the downstream end of Brookleigh Estate (i.e. Patricia Street box culvert) is not to exceed 0.4 m^3/s.
- 100 year ARI peak flow rate at the Patricia Street culvert is not to exceed 0.7 m^3/s.
- 100 year ARI flows to be conveyed by overland flow paths within the road reserve and POS areas.
- The flow path for water exceeding the design level of the flood storage area is to be directed away from development by providing an overland flow path to the Central Drain.

- A freeboard of 0.3 m will be provided between the peak 100 year ARI flood level and house/building pad levels, in accordance with stormwater management requirements of AR&R (EA, 2001).

2.3.2 Convenience/nuisance control

Stormwater infrastructure requirements as a function of road hierarchy are outlined in Figure 2.2. This demonstrates how road design for amenity should be separated from road design for flood protection. Three layers of design criteria are identified, including:

- pollution control – low level of service/amenity required
- convenience/nuisance control – medium level of service/amenity required
- flood control – high level of service/amenity required

Hydraulic modelling was undertaken for the entire CLSP area, which determined a peak 5 year ARI discharge of 0.4 m^3/s through a 750 x 450 mm box culvert crossing Patricia Street. The peak 100 year ARI discharge through the Patricia St culvert was 0.7 m^3/s.

Section 6.2 contains results of the detailed hydraulic modelling carried out to show that the discharge from Brookleigh Estate meets the specified surface water quantity criteria.

2.4 GROUNDWATER QUANTITY

Management of groundwater export will be in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007) and the groundwater management strategy for the CLSP area as set out in the Swan DWMP (DoW, 2009).

The Swan DWMP (DoW, 2009) requires that the controlled groundwater level (CGL) will be identified for the site based on the outcome of hydrogeological/geotechnical investigations. The CGL will be used to design swales and/or subsoil drainage in the subdivision to ensure local and regional environmental impacts are managed.

2.5 WATER QUALITY AND CONTAMINATION

2.5.1 General

Consideration for water quality export will be in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007).

The Stormwater Management Manual for Western Australia (DoW, 2007) requires surface water to be retained (infiltrated) for the 1 year 1 hour ARI event and requires treatment of runoff from these events. Consequently, if the appropriate treatment measures are applied to surface water, there should be a net improvement in groundwater quality due to the improved quality of surface runoff recharging the groundwater.

The guidelines specified in Stormwater Management Manual for Western Australia (DoW, 2007), Decision Process for Stormwater Management in Western Australia – Water Quality, and the interim water-related design objectives for the Swan Urban Growth Corridor area (DoW, 2009) are to be applied during subdivision design in Brookleigh Estate.

2.5.2 Surface water quality

The following design criteria are intended to apply to run-off from impervious areas and should be met in addition to the groundwater design objectives when using a water quality simulation model like MUSIC:

- Principle:
  - Reduce the average annual load of stormwater pollutants estimated to be generated by the development if it used traditional, directly connected stormwater drainage designs
- Design Objectives:
  - As compared to a development that does not actively manage water quality:
    - At least 80% reduction of total suspended solids
    - At least 60% reduction of total phosphorus
    - At least 45% reduction of total nitrogen
    - At least 70% reduction of gross pollutants

Section 7 of this report addresses the water quality design objectives outlined above.

2.5.3 Groundwater quality

When using a water quality simulation model, like MUSIC, the following design criteria should be employed depending on the location of development:

Where development is associated with a waterway or open drain that intersects the shallow water table:

- Principle:
  - Minimise the discharge of pollutants from shallow groundwater which intersects waterways or drains

- Design Objectives, as compared to a development that does not actively manage water quality:
    - At least 60% reduction of total phosphorus
    - At least 45% reduction of total nitrogen

2.5.4 Acid sulfate soils

Investigations to identify the locations of potential acid sulfate soils (PASS), actual acid sulfate soils (AASS) and contaminated areas have been completed as part of the subdivision planning for the entire Caversham Structure Plan area (Douglas Partners 2005).

Geotechnical investigations over the site identified the presence of three geological units; Guildford Formation, Alluvium, and Bassendean Sand. Based upon the acid sulfate soil mapping published by the WAPC and DoE, also in conjunction with Douglas Partners (2005) investigation and in-house laboratory testing, the risk of actual and potential acid sulfate soils at depth of up to 3.0m below the existing ground surface is considered to be low to no risk.

2.6 WETLAND AND WATERWAY PROTECTION

The Department of Environment & Conservation wetland mapping in the vicinity of Brookleigh Estate is shown in Figure 2.3. According to RPS Bowman Bishaw Gorham investigation, the entire Brookleigh Estate site condition and attributes is representative of a 'Multiple Use' Wetland, with some remanent of native vegetation, and pocket of Melaleuca spp. scattered along the central drain. Therefore, it is a design objective that good native vegetation and Melaleuca spp. will be retained.

2.7 VECTOR AND NUISANCE MANAGEMENT

Ideally all components of the program to manage stormwater at Brookleigh should be designed to ensure that, as far as practical, they do not contribute to creating an environment which increases the possibility of mosquitoes and/or midges breeding onsite.

There are two distinct stages to be considered:

- Design of the stormwater management system to ensure that as far as practical, constructed wetlands, multiple use corridors, open drains, road gullies etc do not contribute to onsite mosquito breeding.
- Ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed thereby reducing the risk of creating conditions likely to promote onsite mosquito breeding.

These design objectives/criteria are addressed in Section 7.5.

3 PRE-DEVELOPMENT ENVIRONMENT

3.1 SITE CONDITIONS

3.1.1 Surface conditions

A geotechnical investigation was carried out by Parson Brinckerhoff Pty Ltd (PB) in February 2008, it was reported that the 32.5 hectares site comprises of cleared pastures land with three residential dwellings and associated sheds and paddocks on the eastern portion, while the western portion was mostly uncleared bushland with access tracks available along the fence lines.

The site slopes centrally towards a branch drain that is graded from north to south, towards Bennet Brook. Survey data shows that ground level varies from approximately 15.2m AHD at north-east corner, 13.5m AHD at south-west corner, and 11m AHD at the southern point of the drain.

Topsoils were reported to be 0.1m to 0.2m deep from existing surface level, and consisted of silty sand for most part of the site. At the northeast corner of the site, top soils comprised of clean sand to depth of 0.4m, where as within the proximity of the open branch drain, clayey sand can be found up to 0.6m thick with high content of medium to high plasticity fines. The geotechnical bore logs from PB's site investigation are included as Appendix B.

Stormwater drainage

The existing central drain onsite is most likely a natural watercourse, which was altered to drain the surrounding agricultural land. This agricultural style drain originates to the north of the site and drains the West Swan area to the north of Reid Highway, flowing through the western portion of the Caversham LSP area in a north/south alignment before it enters Bennett Brook, south of Benara Road. Environmental Opportunities and Constraints Analysis by RPS identified that the drains do not support significant ecological values with minimal hydrological values, other than some Melaleuca spp scattered along the drain. RPS's findings regarding the open drains throughout the estate are included as Appendix C.

The geotechnical investigation indicated that low permeability soils are present at a shallow depth over the majority of the site, and onsite disposal of stormwater will be limited. A combination of subsoil drainage and imported fill will be placed to ensure that sufficient separation is achieved between finished lot levels and peak groundwater levels.

Lots within Brookleigh Estate will use soakwells to infiltrate roof runoff. Road runoff will be conveyed to the central drain, and for events up to 1 year 1 hour ARI will be retained and treated in bioretention swales adjacent to the central drain.

3.1.2 Subsurface conditions

General

The topsoil is underlain by inter-bedded layers of sand, silty sand, clayey sand, sandy clay, silty clay, and clay typical of Guildford Formation (PB 2008). A deep layer of clean sand, up to depth of 2.5m, is located at the north east corner of the site, elsewhere, clayey sand and sandy clay was intersected at relatively shallow depth typically 0.5m below surface level (PB 2008).

Therefore, the site classification in accordance with AS 2870 – 1996[1] is Class 'S' for most of the site, however, there are extensive areas where 'M' and 'H' site classification would apply. PB geotechnical report has provided a delineation of these site classification zones, which is attached as Figure 3.1 in Appendix A.

To improve the area of moderate and high reactive clay, 'M' & 'H' site classification, to achieve 'S' site classification over the entire site, PB recommended removal of the reactive material and/or filling over the reactive areas with compact, clean, stable material.

Groundwater

At the time of the geotechnical investigation, November 2007, the groundwater levels would be expected to be less than their annual maximum elevation. Groundwater was encountered in several test pits during the geotechnical investigation at depths ranging between 0.9 m and 3.8 m.

Twelve groundwater monitoring bores was installed across the Caversham Structure Plan area. Two of these bores are located at the northwest and northeast corner of Brookleigh Estate. Data was collected on a monthly monitoring program by RPS from February 2006 to January 2008. Groundwater depths recorded during the investigation for the northwest and northeast corner varies between 0.7 m - 3.1 m, and 1.1 m – 3.4 m, respectively. Appendix D contains the groundwater level data from the Caversham LWMS (Cardno, 2009).

3.2 GROUNDWATER DEPENDENT ECOSYSTEMS

There are no significant water bodies located within the Brookleigh Estate. The majority of Brookleigh Estate is low-lying, and is classified as 'multiple use' wetland, as illustrated in Figure 2.3.

The nearest conservation category wetland to the site is Bennett Brook, situated west of the site. This wetland is located over 500 m from the western boundary of Brookleigh Estate, and will not be affected by the development.

3.3 LOCAL AND REGIONAL HYDROGEOLOGY

3.3.1 General

Groundwater levels are generally shallow across the site, due the low laying Guildford Formation causing perching of surface water in the overlying sands. Seasonal groundwater level fluctuations of up to 2.3 m result in water-logging of the low-lying areas adjacent to the central drain during winter months.

The hydro-geological system for the site consists of the Superficial Aquifer (unconfined), Mirrabooka Aquifer (semi-confined), Leederville Aquifer (confined), and Yarragadee aquifer (confined).

Recharge to the superficial aquifer is by groundwater through flow and rainfall infiltration. Discharge from the superficial aquifer is by groundwater through flow, evapotranspiration and surface water drainage features such as the central drain, and downward percolation into the underlying Mirrabooka Aquifer. The Bassendean Sand formation is generally a medium to fine grained quartz sand and typically has a hydraulic conductivity of up to 10 m/day.

3.3.2 Site specific groundwater levels

Average annual maximum groundwater level (AAMGL) across the Brookleigh site has been calculated using measured groundwater levels in monitoring bores across the CLSP area, and corrected using the 31 year recorded water levels measured in nearby Water and Rivers Commission Monitoring Bores (WIN site ID 4886). The AAMGL contours and monitoring bores are presented in Figure 3.2. A detailed explanation of the methodology used to calculate these site-specific AAMGL contours is contained in Section 3.10.1 of the Caversham LWMS (Cardno, 2008).

3.4 PRE-DEVELOPMENT ENVIRONMENTAL ASSESSMENT

3.4.1 General

This section addresses the management of water quality to protect and enhance the environmental values of water bodies that receive groundwater and surface water from the Caversham area and therefore applies to Brookleigh Estate. These values include ecological values (e.g. protection of ecosystem health) and social values (e.g. the ability to safely recreate in receiving waters).

Specifically, the aims of this section are to:

» Provide a brief overview of the nature of water bodies within the study area and those potentially affected by the proposed development.

- Briefly review available information on the quality of surface water and shallow groundwater in the study area, as well as the water quality of receiving water bodies.
- Identify water quality-related objectives that can be used as 'modelling objectives' and/or 'conceptual design objectives' when developing water management strategies for the study area.

Additional information regarding the pre-development surface water and groundwater quality monitoring and analysis can be found in the Caversham LSP LWMS.

3.4.2 The study area's receiving waters

Rainfall and stormwater within the study area has the potential to enter the following receiving waters:

- Shallow groundwater. Shallow groundwater is also likely to be intercepted by subsoil drains, albeit for a short period of time each year, and directed into the development's stormwater treatment system before being re-infiltrated to the groundwater aquifer.
- Surface waters to the north of the study area, namely the West Swan catchment area, connected via the central drain. Water in the central open drain flows into Bennett Brook, then the Swan River, and ultimately the Indian Ocean.

3.4.3 Available water quality data

Two organisations have undertaken surface water or groundwater quality monitoring for the Caversham SP area:

RPS Bowman Bishop Gorham has undertaken groundwater quality monitoring from February 2007 to January 2008, at 12 locations across the Caversham SP area, of which two were located within the Brookleigh Estate.

Cardno was recently engaged to develop and implement a Surface Water Sampling and Analysis Plan to provide baseline surface water quality data within the Caversham Area. Surface water samples were taken at 5 locations along the two existing open drain within the Caversham SP, from July to September 2009. Sampling Location SWQ1 and SWQ2 are located within Brookleigh Estate SP.

3.4.4 Surface water quality data

Surface water sampling aimed to capture five rainfall events from five (5) locations that were selected to provide an indication of the surface water quality conditions both upstream and downstream of the future urban area. The samples were analysed for following parameters:

- Surface waters to the north of the study area, namely the West Swan catchment area, connected via the central drain. Water in the central open drain flows into Bennett Brook, then the Swan River, and ultimately the Indian Ocean.
- Total Nitrogen (TN);
- Total Phosphorous (TP);
- Orthphosphate (ORP);
- Oxides of Nitrogen (NOx);
- Total Kjeldahl Nitrogen (TKN);
- Ammonium (NH4);
- Temperature (Temp);
- Dissolved Oxygen (DO);
- Reduction/Oxidation Potential (Eh);
- Salinity;
- pH; and
- Electrical Conductivity (EC).

Key findings from the monitoring are summarised below:

- Sampling within the different locations of the western streamline (SWQ1, SWQ2 and SWQ3) show that the TN concentrations upstream are greater than those downstream.
- TP concentrations increased between SWQ2 and SWQ3 suggesting a potential source of phosphorous between the two locations. All other nutrient concentrations remain stable throughout each location.
- Sampling within the eastern streamline (SWQ4 and SWQ5) show the TN and TP concentrations remain consistent with 'moderate' nutrient concentration values. An increase in NOx concentrations between the two sampling locations suggests a potential source of NOx on site.
- The nutrient concentration values recorded are consistent with the dominant land-uses of the region. Vineyards are abundant in the region and use fertilisers that contain many of the nutrients sampled. The poor condition of the streamlines also means that the nutrient removal efficiencies of these areas is low. 'Duck weed' was located within the drains at all sampling locations and is consistent with the high nutrient concentrations recorded.

The results from the monitoring program and the location of the monitoring sites are shown in Appendix F.

3.4.5 Groundwater quality data

Representative data for pre-development average groundwater quality is presented in Table 3.1. This data originates from 24 monthly sampling events by RPS Bowman Bishaw Gorham from 12 bores between January 2006 and January 2008 within the Caversham Structure Plan area. Appendix D contains the groundwater level data collected during the pre-development monitoring program, as reported in the Caversham LWMS (Cardno, 2009).

Table 3.1 – Predevelopment Groundwater Quality

Location	pH	Conductivity (EC)	Redox	Dissolved Oxygen (DO)	Ammonia - N (NH_4-N)	Total Phosphorous (TP)	Total Nitrogen (TN)
CGW1	6.28	2538	24.4	2.194	0.2	0.408	3.992
CGW2	6.52	332.5	46	2.166	0.2	0.298	6.94
CGW3	6.3	567	90.9	2.834	0.2	0.13	1.116
CGW4	5.62	26136.5	22.6	1.448	0.46	0.08	0.65
CGW5	6.62	691.5	12.2	1.934	0.2	0.112	0.506
CGW6	7.00	1622	48	3.476	0.22	0.152	2.13
CGW7	5.35	2271.5	96.4	1.968	0.28	0.082	0.466
CGW8	6.24	692	97.8	3.79	0.2	0.108	0.844
CGW9	6.79	1276.5	-127.8	0.922	0.8	0.084	1.404
CGW10	6.53	552.5	-23.4	1.332	0.22	0.054	0.702
CGW11	6.78	502.5	-18	1.27	0.2	0.072	0.504
CGW12	7.38	1471	94	6.8225	0.2	0.104	3.552

The results of sample analysis by RPS, for the two bores within the Brookleigh Estate are shown below in Table 3.2. Sample analysis results for the other bores within the Caversham LSP area can be found in the Caversham LSP LWMS.

Table 3.2 – Groundwater Quality within the Brookleigh Estate area (RPS Bowman Bishaw Gorham, 2006)

Location	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	Ortho-Phosphorous (mg/L)	Ammonia - N (mg/L)	Oxides of Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)
NW corner	0.3	0.01	0.01	<0.2	0.3	<0.2
NE corner	2.0	0.13	0.06	0.2	1.7	0.3

Figure 3.3 contains average nutrient loads found at each bore location across the site during the pre-development monitoring period.

4 WATER CONSERVATION STRATEGY

4.1 WATER DEMAND

The Water Corporation carried out a study of domestic water use for Perth in 2003 with a view to collecting data on different uses within a household, identify water use and trends, and to develop forecasting model and water use efficiency programs in the future.

The study determined the total water usage, ex-house usage, in-house usage and consumption patterns. It also reported the annual water usage, average daily consumption as well as peak day demand.

The water usage as a percentage of the total demand is represented graphically in Diagram 4.1 below, from the Water Corporation's Domestic Water Study:

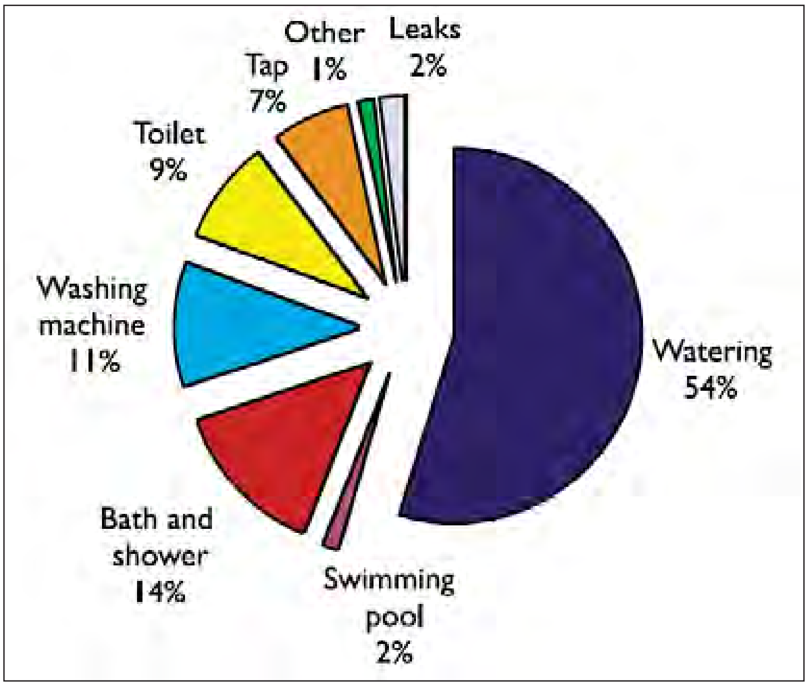


Diagram 4.1 - Single residential household water usage

Table 4.1 and Table 4.2 below summarise the annual and daily consumption for a single residential household (based on 3.35 people per household, as found in the Water Corporation study).

Table 4.1 - Average annual water consumption (single residential household)

Consumption type	Annual consumption
In-house annual average use per household	190 kL
Ex-house annual average use per household	260 kL
Leaks	10 kL
Total annual average use per household	460 kL

(Domestic Water Study – Water Corporation 2003)

Based on the statistics shown in Table 4.1 above, this equates to 137 kL/person/year (based on the 3.35 people per household, as was found in the Water Corporation study).

The State Water Strategy target for water usage is to achieve a reduction from 180 kL/person/year to 155 kL/person/year. As this target has been achieved in recent years, the recent State Water Plan (Government of Western Australia, 2007) has set a new water consumption target of 100kL/person/yr.

Table 4.2 - Average daily water consumption (single residential household)

Consumption type	L/house/day	% total use
In house use (excl toilet use)	411	33
Toilet flushing	112	9
Ex house	707	56
Leaks	29	2
Total	1259	100

(Domestic Water Study – Water Corporation 2003)

4.2 WATER CONSERVATION INITIATIVES

The Water Corporation estimates that garden watering accounts for an estimated 60% of Perth's domestic scheme water usage. This is a particularly low value use for what is effectively a high quality resource (drinking water). Consequently, a significant reduction in potable water use can be achieved by minimising water use outside of homes. Based on this, the following initiatives will be implemented to reduce water usage at Brookleigh:

- xeriscaping
- waterwise POS designs that feature areas of un-irrigated ground
- reduced areas of lawn/gardens that require significant amounts of watering
- garden and lawn care education
- encouraging residents to use rainwater tanks

4.3 WATERWISE LANDSCAPING

4.3.1 Design principles

Waterwise landscaping packages will be provided by the developer to land owners to achieve the following (from the Water Corporation's Waterwise website):

- minimise the extent of water consuming planting
- maximise the use of water conserving elements and techniques
- apply the basic principle of hydrozoning to planting design (grouping plants on the basis of having similar water requirements)

General design principles that will be adopted for Brookleigh Estate include:

- do not plant areas unless it is necessary for functional or aesthetic reasons
- maximise the use of non-planting treatments such as mulches
- Keep planted areas dense and consolidated. Sparse scattered plants are more difficult to water efficiently than ones that are in defined areas.
- Keep lawn to the minimum consistent with functional and aesthetic requirements. Avoid planting lawn on slopes or in narrow necks or paths which are difficult to water efficiently and maintain.

These design principles will be achieved through the waterwise initiatives.

4.3.2 Waterwise lawn areas

To minimise water use, lawn areas will be designed on the following basis:

- Turf areas will be reduced to cover less than 60% of outdoor areas. The remaining areas will consist of gardens and paved areas. Diagram 4.2 below shows examples of reduced turf areas.

Diagram 4.2 – Turf reduction

LOW MAINTENANCE AND WATER USE In the area between the footpath and your front lot property boundary, consider low planting such as groundcovers, sedges and tufted plants. This will avoid an area of turf to maintain and will reduce water consumption if Waterwise plants are used. This will also provide variety of colour, texture and form within your garden.

- Sprinklers that produce coarse sprays of large droplets will be used. These sprinklers are less prone to wind drift and will minimise evaporation.
- Gear drive sprinklers and impact sprinklers will only be used where large, regular areas are involved.
- Pop-up sprays will be used for smaller areas of lawn.
- Spray head layouts will closely match the outlines of the lawn to minimise overspray onto paths and gardens.
- Lawn and garden watering zones will be on separate programs.

4.3.3 Waterwise garden areas

The following measures will be implemented to promote water conservation in garden areas:

- Most garden emitters are designed to operate at low water pressures. Each garden station will be fitted with a flow reduction valve at the inlet.
- Shrubs and perennials – use drippers to individual small plants. When choosing components, work on providing 10 litres per square metre of watered soil. This corresponds to the Perth Standard Drink of 10 mm depth of precipitation.
- Larger shrubs and fruit trees – use low pressure micro-irrigation sprinklers to spread water across the entire drip zone. Their low trajectory will undershoot foliage, and avoid wind losses.

The Water Corporation website has a section devoted entirely to "Waterwise Gardens". It contains useful information to help lot owners and landscapers design waterwise gardens and select waterwise plants. The website address is: "http://www.watercorporation.com.au/W/waterwise_gardens.cfm

4.3.4 Water application rates

Irrigation controllers are to be set to deliver a 'standard drink' of 10 mm or 10 L/m^2 per application. Plants will be grouped depending on their watering needs:

- Watering/drop zone 1 – plants with a low water requirement. They will only need occasional watering over summer.
- Watering/drop zone 2 – plants with a moderate water requirement. These plants will need to be watered every 3 to 7 days.
- Watering/drop zone 3 – plants with a high water requirement. These plants will need to be watered every 1 to 2 days.

In general the plant selections shown on the Water Corporation's 'Waterwise Gardens' website are classed as belonging to either drop zone 1 or drop zone 2 for their water consumption, and lawn areas fall within drop zone 2. Table 4.3 and Table 4.4 below show the watering requirements.

Table 4.3 – Drop zone 1 watering requirements

Month	Frequency	Water use / month (L/m^2)
January	once a week*	40
February	once a week*	40
March	once a week*	40
April	once a fortnight*	20
May	no watering	0
June	no watering	0
July	no watering	0
August	no watering	0
September	once a fortnight*	20
October	once a fortnight*	20
November	once a week*	40
December	once a week*	40
	TOTAL	**260 L/m^2 per year**

Notes: 1 - watering frequency taken from the Water Corporation website
* - indicates watering only if needed.

Table 4.4 - Drop zone 2 watering requirements

Month	Frequency	Water use / month (L/m^2)
January	every second day	155
February	every second day	140
March	every third day	103
April	every fifth day	60
May	no watering	0
June	no watering	0
July	no watering	0
August	once a fortnight*	20
September	once a week*	40
October	every fourth day	78
November	every third day	100
December	every second day	155
	TOTAL	**851 L/m^2 per year**

Notes: 1 - watering frequency taken from the Water Corporation website
* - indicates watering only if needed.

4.3.5 Reductions in water use from waterwise landscaping

Using the above waterwise landscaping techniques the outdoor potable water use requirement per lot was determined based on the following assumptions:

- Average residential lot size of 485 m^2.
- Average verge area of approximately 67.5 m^2
- Average outdoor area of 50% of lot size plus the verge (242.5 m^2). Outdoor areas consist of driveways and paved areas (hardstands), lawns, gardens, and the verge.
- Average outdoor hardstand area of 50% from driveways, paved areas, alfresco etc (155 m^2).

On this basis the average outdoor area consisting of lawns and garden is approximately 145 m^2, which can be subdivided as follows:

- Turf areas will be reduced to cover less than 40% of outdoor areas (124 m^2). The remaining areas will consist of gardens and paved areas.
- Average garden area of 10% of outdoor areas (31 m^2).

This is summarised in Table 4.5 below:

Table 4.5 - Nominal lot landuse areas based on a 480 m^2 lot Size and 67.5 m^2 verge

	Percentage (%)	Area (m^2)
internal floor area	43.9	242.5
hardstands (45% of outdoor area)	28	139.5
lawns (45% of outdoor area)	22.5	139.5
gardens (10 % of outdoor area)	5.6	31
Total	**100**	**552.5**

Using the irrigation volumes shown Table 4.3 and Table 4.4, the water usage required for outdoor areas was calculated assuming that 50% of plants in the gardens will have a drop zone 1 rating. Water requirements for outdoor areas are summarised in Table 4.6 below:

Table 4.6 - Outdoor water requirements per housing/special business lot

	Area (m^2)	Watering requirement (L/ m^2 per year)	Watering requirement (kL per year)
lawn (drop zone 2)	139.5	851	118.7
garden (drop zone 2)	15.5	851	13.2
garden (drop zone 1)	15.5	260	4.1
Total	**155**		**136**

The calculations above show that waterwise landscaping packages can result in an ex-house annual average usage per household of approximately 136 kL for housing lots. Based on the statistics shown in Table 4.1, this would result in an average annual use per household of 336 kL, which equates to 100.3 kL/person/year (based on 3.35 people per household). This is a reduction of approximately 36.7 kL/person/year from the average use of 137 kL/person/year calculated from Table 4.1 (i.e. waterwise landscaping will result in less potable water use than is currently occurring through water restrictions alone).

4.4 WATERWISE APPLIANCES & RAINWATER TANKS

Simple water conservation techniques, such as installing waterwise appliances and rainwater tanks in the home can have a significant impact on reducing water consumption. Table 4.7 below summarises the savings in potable water consumption through the installation of waterwise appliances and rainwater tanks (based on 2.8 people per household). While the installation of waterwise appliances and rainwater tanks will not be enforced by the developer, they will be strongly encouraged.

The potential savings in water consumption have been taken from the Water Corporation's Waterwise Ways booklet.

The Water Corporation's Domestic Water Use Study also surveyed the percentage of households which already have the above waterwise appliances installed. These percentages, combined with the potential savings (through waterwise appliances, waterwise landscaping and rainwater tanks) have been used to calculate the total water consumption targets in Section 4.5 below.

Table 4.7 – Reduction in water consumption from water efficient appliances

Appliance type	Potential savings (kL/house/year)	Potential savings (kL/person/yr)	% of households with waterwise appliances (at time of study)
3-star rated shower head	23	7	24%
7 minutes shower (3 minutes saving)	44	13	N/A
Rainwater tanks	40	12	Unknown – assume 0%
4-star rated washing machine	35	10	8%
Dual-flush toilets	33	10	56%
4-star dishwasher	9	3	Unknown – assume 0%

4.5 WATER CONSUMPTION TARGETS

By installing waterwise appliances throughout the home, practising waterwise landscaping and installing rainwater tanks, potable water consumption can be reduced by up to 91.7 kL/person/year. Based on the water consumption values measured in the Water Corporation's Domestic Water Use Study, these savings will equate to an average potable water consumption of 45.3 kL/person/year, which is below the State Water Plan target of 100 kL/person/year.

4.6 WATERWISE POS DESIGN

Public open space (POS) at Brookleigh Estate will be irrigated using groundwater. There is a total of approximately 4.54 ha of irrigation area, comprising of 3.69 ha of POS and all trees area, which would require 27,675 kL of irrigation water based design calculations by CADsult Irrigation Design Consultant. The irrigation calculated results are presented in Table 4.8 below.

Table 4.8 – Irrigation water requirements, calculated output

CADsult – Calculated Output Section 12/11/2008		
Irrigation Season	30.3	weeks
Peak Evaporation Month	January	
Peak Mean Daily Evaporation	10.2	mm/day

CADsult – Calculated Output Section 12/11/2008		
Season Evaporation	1657	Mm
Irrigation Area (incl Solo trees)	45,000	m^2
Total Equivalent Area (incl all Trees)	45,400	m^2
Peak Day Volume	170.3	kL/day
Peak Month Volume	5281	kL/month
Season Consumption	**27675**	**kL/Annum**

To further reduce this water use, POS areas will be landscaped with the following to reduce the irrigation area:

- mulches and groundcovers
- footpaths

A request for groundwater abstraction has been submitted to the Department of Water in November 2008 for the irrigation of 4.54 ha of POS area across the entire Brookleigh development. The groundwater supply will need to be sourced from the deeper Mirrabooka aquifer at an approximate depth of 50 m below ground level.

POS landscaping design will be in accordance with the City of Swan's Local Planning Policy E9.4 – Landscape Designs. A preliminary landscape layout plan is attached as Figure 4.1, in Appendix A.

4.6.1 Maximise at-source infiltration

Water conservation is highly dependent on water sensitive urban design (WSUD) principles, which promote maximising infiltration through source control BMPs (minimising the effective impervious area of development). Consequently, adopting the structural and non-structural BMP treatment train proposed in Section 7.3 is vital to the viability of total water cycle management and its requirements to maximise water conservation and re-use. This will include:

- Maximising at-source infiltration to recharge the superficial aquifer. At source infiltration is being achieved via a series of infiltration BMPs.
  - Lot runoff will be infiltrated at source via soakwells contained within each lot. Subsoil drains within the road reserve will also promote infiltration.
  - Bioretention swales will be sized to retain and infiltrate runoff from events up to 1 year 1 hour ARI. Subsoil drains will also have a free outfall to the bioretention swales. Excess runoff in the bioretention swales will overflow to the Central drain.

4.7 WASTEWATER

Each lot within the Brookleigh Estate will be serviced by a Water Corporation sewer reticulation system gravitating towards a proposed temporary wastewater pump station prior to discharging into an existing DN300 gravity sewer main on Bennett Street. Under the Water Corporation planning, eventually a DN375 gravity main will connect this development with the Eden Hill Pump Station B (located approximately 1.3km southwest of the site), which ultimately discharges into the Beenyup Wastewater Treatment Plants.

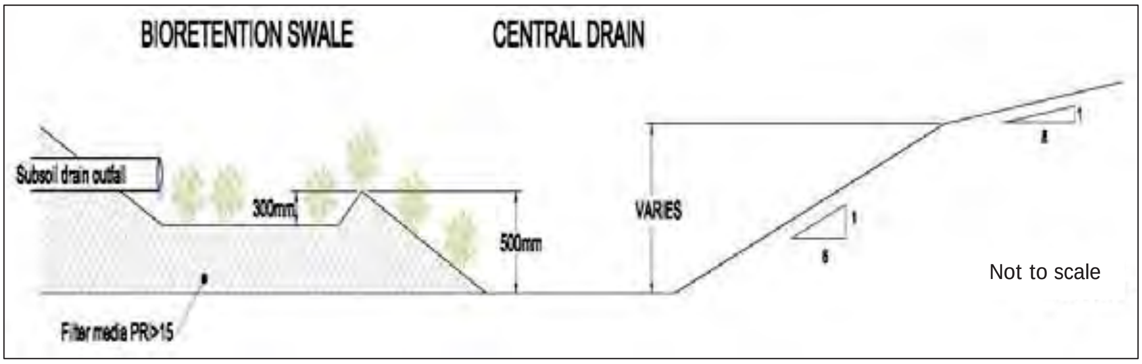
5 GROUNDWATER MANAGEMENT

5.1 SUBSOIL DRAINAGE DESIGN

5.1.1 Subsoil drain outfall

A key factor governing subsoil drainage design is the availability of a free outfall. In order to function effectively, free (non-submerged) outfalls are required for the subsoil drainage network. The subsoil drainage system within Brookleigh Estate outfalls to bioretention swales located in the POS corridor central of the subdivision. The subsoil drainage layout and outfall locations for Brookleigh Estate are shown in Figure 5.1. A sketch showing the typical subsoil drain outfall and bioretention swale arrangement is included as Diagram 5.1 below.

Diagram 5.1 - Subsoil drain outfall and bioretention swale arrangement



5.1.2 Subsoil drainage design

The subsoil drains are to be designed at a minimum grade of 1:500. The subsoil drains should have a maximum spacing of 40 m - 50 m between drains and be located in road reserves, and lot side boundaries. The proposed subsoil drainage layout and preliminary invert levels are shown on Figure 5.1.

5.1.3 Subsurface drainage theory and modelling

Subsurface drainage is accomplished by placing an artificial channel or subsoil drain below the perched groundwater table, so that the hydraulic head of the channel is less than that of the soil to be drained. The hydraulic head differential creates a hydraulic gradient in the direction of the subsoil drain, depressing the phreatic line (free water surface) in the vicinity of the subsoil drain. The constant removal of water flowing into the drain maintains the hydraulic head differential, thus maintaining the depressed phreatic line. Without further recharge, the subsoil drains will continue to operate to maintain groundwater levels at or about the level of the drains.

The hydraulic gradient and hydraulic conductivity of the soil to be drained govern the rate at which water moves toward the drain. Control of water is accomplished by controlling the hydraulic gradient. Therefore, flow is regulated by adjusting the effective depth of the drain and the spacing between drains.

It is best practice to design subsoil drains such that they do not operate above half capacity. The required subsoil drain sizes to achieve this for 40 m drain spacing at Brookleigh are tabled below.

Table 5.1 - Subsoil drain sizing

Subsoil drain pipe diameter	Maximum upstream length of subsoil pipe (sum of all upstream converging lines of any diameter)
150mm	400m
225mm	1300m
300mm	>1300m (not to exceed 2000m)

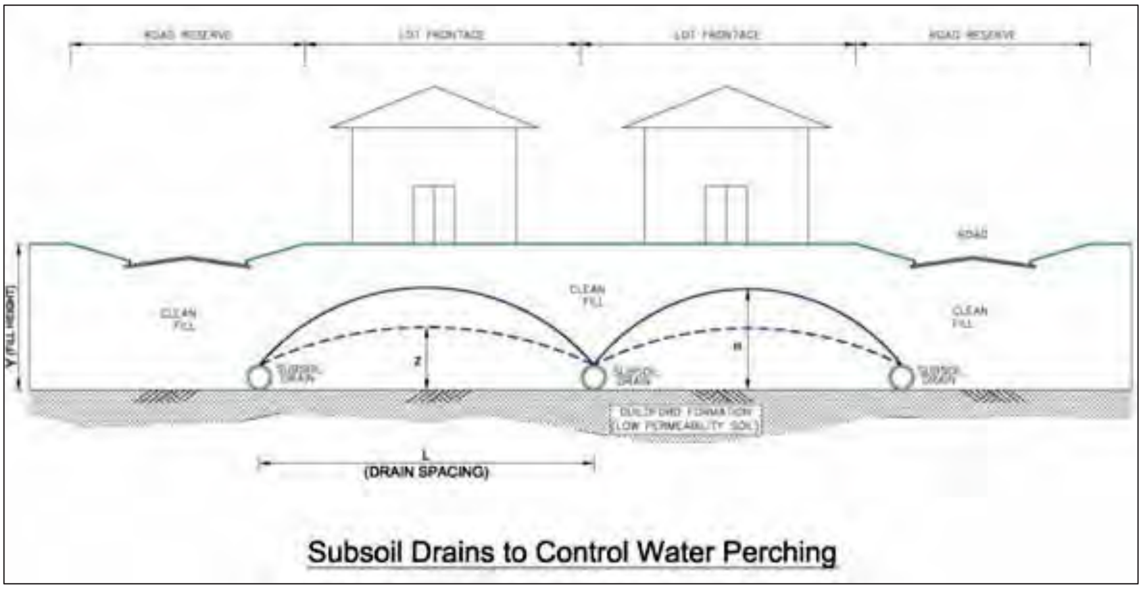
5.2 CONTROLLED GROUNDWATER LEVELS

As shown in Figure 5.2, low lying areas of the central drain are inundated during periods of high groundwater. The proposed subsoil drainage layout is shown in Figure 5.1, and for the eastern portion of the development, invert levels are generally greater than 0.2 m below pre-development AAMGL. As noted in Section 3.3 this AAMGL refers to the perched groundwater, caused by perching of infiltrated surface water over the Guildford formation, rather than 'true' groundwater. The term AAMGL has been retained in this UWMP to maintain consistency with the LWMS for the area.

The subsoil drains assist in infiltration throughout the site and are placed to ensure adequate separation to finished lot levels in periods of high groundwater. Drawdown of peak groundwater levels caused by the installation of subsoil drains and the presence of the central drain is illustrated in Figure 5.3.

Based on a minimum freeboard of 1.2 m between maximum groundwater levels and finished fill levels, Diagram 5.2 illustrates the minimum design levels relative to a subsoil drain placed above the Guildford Formation to control water perching.

Diagram 5.2 - Minimum design levels for subsoil drains on Guildford



5.3 FILL REQUIREMENTS FOR GROUNDWATER SEPARATION

A separation distance of approximately 1.2 m from the controlled groundwater level (CGL) to residential footings is required. The minimum desirable separation distance can occur naturally or can be achieved through earthworks (i.e. either cut to fill or use of imported fill). Subsoil drains will be installed through Brookleigh Estate to control local groundwater levels during periods of high groundwater, in combination with the importation of fill material. The use of subsoil drains will improve at-source infiltration in individual lots and maintain the required separation from peak groundwater levels.

The existing depth to peak groundwater levels at Brookleigh Estate is shown in Figure 5.2. Figure 5.4 illustrates minimum required lot levels to achieve a 1.2 m to 1.8 m separation distance from subsoil drain invert levels.

6 SURFACE WATER MANAGEMENT

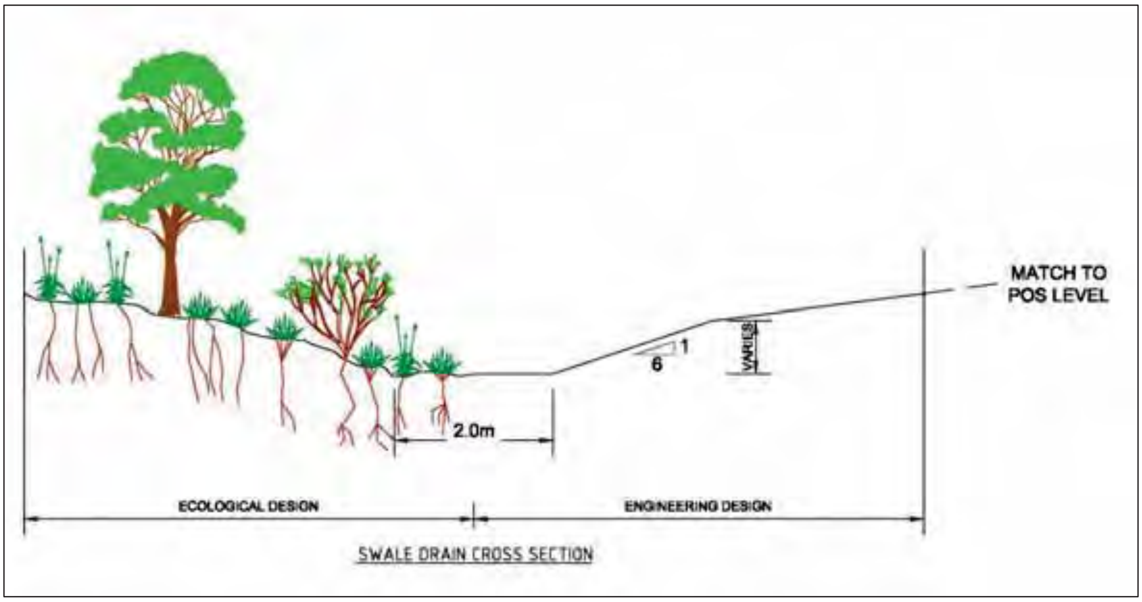
6.1 SURFACE WATER QUANTITY

Based on the surface water objectives outlined in Section 2.3, the following surface water flow and flood level criteria have been set for Brookleigh Estate in accordance with advice from the Department of Water (DoW 2008):

- Flows for events up to 1 year 1 hour ARI will be retained in the bioretention swales located adjacent to the central drain.
- 5 year flows will be conveyed predominantly by a conventional piped network draining the road reserve.
- Peak 5 year and 100 year ARI post-development flows from the Brookleigh Estate will not exceed 0.4 m^3/s and 0.7 m^3/s respectively at the culvert crossing Patricia Street, to comply with the revised modelling completed as part of the Swan Urban Growth Corridor DWMP. Maintaining these flows will ensure that developments downstream of Brookleigh Estate are not adversely affected. With consideration of the peak post-development inflow from the West Swan catchment, via the culvert crossing Reid Highway, modelling completed by Emerson Stewart for the entire Brookleigh Estate has meet the flow requirements at Patricia Street. Peak post-development flows entering Brookleigh Estate's central drain are presented below:
  - 5 year ARI peak inflow = 0.3 m^3/s
  - 100 year ARI peak inflow = 0.4 m^3/s
- 100 year flows will be conveyed to the central drain by a combination of overland flow paths and piped drains within the road reserve.
- Figure 6.1 shows the proposed 1 year ARI flow regimes and required storage areas. Figure 6.2 illustrates the hydraulic modelling results for 5 year and 100 year ARI events, including peak flow rates and flood levels. The minimum required cross section for the central drain through the drainage corridor areas central of Brookleigh Estate is also shown in Figure 6.2. The final drain cross-section will be designed by the landscape architects, and will be constructed as a natural swale with ecological function. However, the final design will need to provide an equivalent volume to the cross-sections shown in Figure 6.2 in order to maintain the flood levels determined by hydraulic and hydrologic modelling.

Diagram 6.1 below shows an indicative cross section of the final swale design.

Diagram 6.1 - Typical cross section of main drainage swale



6.1.1 Average recurrence interval (ARI) design discharge for BMPs

The Stormwater Management Manual for Western Australia (DoW, 2007) requires surface water to be retained onsite for events up to 1 year ARI, and requires treatment of runoff from this event. Consequently, if the appropriate treatment measures are applied to surface water, there should be a net improvement in groundwater quality due to the improved quality of the surface runoff recharging the groundwater.

The drainage system for Brookleigh Estate has been designed to maximise infiltration and provide water quality treatment for the 1 year 1 hour ARI event; which effectively represents 99% of the mean annual runoff from an urban catchment in Perth.

6.1.2 1 year ARI flow regime

Runoff from events up to 1 year 1 hour ARI within Brookleigh Estate are retained in the bioretention swales adjacent to the central drain south of the subdivision. Runoff from events greater than 1 year 1 hour ARI will exceed the capacity of the bioretention swales and will overflow to the central drain. Runoff for major flood events (i.e. 5 year and 100 year ARI) will be conveyed to the central drain by a combination of piped drainage and overland flow.

6.1.3 Flood storage – detention strategy

The strategy adopted for stormwater quantity management for Brookleigh Estate is to provide storage on a subcatchment level to detain flows on site for the 1 year 1 hour ARI event, and to limit the outflow at the downstream end of the Brookleigh Estate development to 0.4 m^3/s for the peak 5 year ARI event, and 0.7 m^3/s for the peak 100 year ARI event. Off-line storage will be provided in the POS areas to ensure that the peak allowable flow rates are not exceeded.

6.1.4 Flood conveyance

Major flood conveyance (i.e. runoff from 100 year ARI storm events) will generally follow the existing topography of the site. Access road reserves will be used as overland flow paths to the POS corridor.

A freeboard of 0.3 m will be provided between the peak 100 year ARI flood level and house/building pad levels, in accordance with stormwater management requirements of AR&R (EA, 2001).

Flow paths for Brookleigh Estate, and 100 year ARI peak flood levels in the central drain corridor are shown in Figure 6.2.

6.2 HYDROLOGIC AND HYDRAULIC MODELLING

Hydrologic and hydraulic modelling has been undertaken to determine peak flow rates and detention requirements of the proposed drainage system.

Modelling of the system has been undertaken using the computer software package XP-SWMM. XP-SWMM is an urban drainage design software package capable of carrying out both hydrologic and hydraulic modelling of urban catchments.

Appendix B outlines the assumptions made and the results of the hydrologic and hydraulic modelling. Water quality management (for frequent events, up to 1 year 1 hour ARI) is discussed in Section 7.

6.2.1 5 year ARI peak flow requirements

Figure 6.2 shows the peak 5 year ARI flood levels in the central drainage corridor of Brookleigh Estate, along with peak post-development flow rates at the Water Corporation easement. The modelled 5 year ARI peak flow rate at the Patricia Street culvert crossing was 0.4 m^3/s, and the peak flood level in the central drainage corridor was calculated to be 11.5 m AHD, immediately upstream of Patricia Street.

6.2.2 100 year ARI peak flow and fill requirements

Imported fill and cut-to-fill will be required in low-lying areas of the site to achieve the 0.3 m freeboard above 100 year ARI flood levels, as required by AR&R (EA, 2001). Figure 6.2 shows the peak 100 year ARI flood levels in the central drain corridor through Brookleigh Estate, and peak post-development flow rates at the Water Corporation easement.

Figure 6.2 also shows the peak 100 year flood width of the central drain through the POS corridor.

Hydraulic modelling results for Brookleigh Estate show that the peak outflow at the culvert crossing Patricia Street is 0.7 m^3/s, with a maximum flood level of 11.8 mAHD immediately upstream of Patricia Street.

7 WATER QUALITY MANAGEMENT

7.1 SURFACE WATER QUALITY

As stated in Section 2.5 the design objective associated with water quality and contamination is that structural BMPs should be sized to treat runoff from directly connected impervious areas for events up to 1 year 1 hour ARI.

In Brookleigh Estate, the following structural BMPs will be used for retention and infiltration of runoff for storm events up to 1 year 1 hour ARI (i.e. to ensure no surface water outflows from the site for this event):

- Lot runoff will be infiltrated at source via soakwells. Subsoil drains within the road reserve will promote infiltration.
- Runoff from road reserves will be directed via a pipe network into the bioretention swales adjacent to the central drain.
- Runoff from access roads that drain into stormwater gully pits for smaller rainfall events will form part of the 'leaky system' where stormwater runoff will be allowed to infiltrate through the bottom of the gully pits.
- Bioretention swales have been sized to retain discharge from the street drainage system for events up to 1 year 1 hour ARI. Subsoil drains will also have a free out fall to the bioretention swales. The location and size of these bioretention swales is shown in Figure 5.1.

7.1.1 Nutrient reductions in surface water

Modelling completed in MUSIC using a filter media depth of 0.3 m has shown that bioretention swales with surface areas as shown in Table 7.1 have sufficient capacity to contain and infiltrate all runoff from the site for events up to 1 year 1 hour ARI, and will achieve the surface water quality criteria outlined in Section 2.5. Table 7.1 below summarises the nutrient reductions achieved in Brookleigh Estate by treating runoff in these bioretention swales.

Table 7.1 - Bioretention swale surface areas and nutrient reductions

Bioretention swale	Surface area (m^2)	Nutrient reduction achieved (%)				Nutrient reduction target (%)			
		TSS	TP	TN	GP	TSS	TP	TN	GP
Bioretention 1	400 m^2	95%	79%	61%	100%	80%	60%	45%	70%
Bioretention 2	180 m^2	98%	82%	57%	100%				
Bioretention 3	175 m^2	98%	82%	57%	100%				

Bioretention swale	Surface area (m^2)	Nutrient reduction achieved (%)				Nutrient reduction target (%)			
		TSS	TP	TN	GP	TSS	TP	TN	GP
Bioretention 4	140 m^2	98%	82%	57%	100%				
Bioretention 5	530 m^2	98%	78%	60%	100%	80%	60%	45%	70%
Bioretention 6	250 m^2	98%	82%	57%	100%				
Bioretention 7	225 m^2	98%	82%	57%	100%				
Bioretention 8	500 m^2	95%	79%	61%	100%				
Bioretention 9	300 m^2	98%	82%	57%	100%				
Bioretention 10	1000 m^2	98%	82%	57%	100%				
Bioretention 11	500 m^2	98%	81%	56%	100%				

The parameters used in MUSIC modelling were in accordance with MUSIC Guidelines for Perth, Interim Final Report (Water Corporation, 2007).

7.2 GROUNDWATER QUALITY

7.2.1 Groundwater export via subsoil drains

The subsoil drains throughout Brookleigh Estate will intercept the groundwater in some areas of the site during periods of high groundwater. The subsequent drawdown of peak groundwater levels across the site is minimal, and will not impact on any groundwater dependant waterbodies.

Figure 5.3 shows the expected groundwater drawdown due to the central drain and the installation of subsoil drains in Brookleigh Estate.

Groundwater exported from the site via the subsoil drainage system will be treated in the bioretention swales at the locations shown in Figure 5.1.

7.2.2 Implementation of groundwater quality design objectives

The following strategy has been used to satisfy the recommended groundwater quality related conceptual design objectives:

- Bioretention swales will be used to treat runoff from the road reserves and discharge from subsoil drains.

- Landscaping packages provided by the developer to lot owners will encourage the use of smaller lawn areas. Landscaping packages provided by the developer to land owners will include loamy topsoil. This topsoil will increase the efficiency of fertilisers and retain a large proportion of the phosphorous that would have otherwise percolated through the Bassendean Sands into the groundwater.

7.3 STRUCTURAL AND NON-STRUCTURAL TREATMENT TRAINS

7.3.1 Structural BMPs

Water sensitive urban design

Within Brookleigh Estate a number of WSUD elements will be implemented to satisfy the structural BMP criteria listed in Section 2.5 of this report. These are summarised in Table 7.2 below, including the scale and ownership at which they apply.

Table 7.2 - WSUD elements identified for Brookleigh Estate, including scale and ownership

Scale	Ownership and maintenance	BMP
Residential/group housing	Lot Owner	» infiltration » soakwells (where appropriate) » amended topsoils
Street	Local Authority	» access roads » infiltration » sediment traps
Estate	Local Authority	» retention / detention areas integrated within POS (including gross pollutant traps) » vegetated swales » groundwater re-use

Residential lot-level BMPs

Infiltration and soil amendment

Infiltration of stormwater is common practice in Western Australian land development projects and is considered an appropriate source control measure that can significantly reduce the magnitude and volume of stormwater runoff generated from the site. In the case of the Brookleigh Estate, the Bassendean sands found across the site have low phosphorus retention capacity and nutrients generated from the proposed development will contribute to the nutrient load conveyed by the groundwater. It is recommended that stormwater be infiltrated through a top layer of sandy loam soil (soil amendment) within garden/landscaped areas, for treatment and retention of nutrients, before reaching the groundwater. Soil amendment will be included in landscaping packages offered to residents.

Rainwater generated from roof areas can be infiltrated into the groundwater without the need for pre-treatment, on the basis that roof areas generate significantly lower nutrient loads. The infiltration of roof runoff can be through the use of soakwells installed at the building stage.

Street-level BMPs

Road hierarchy

Stormwater infrastructure requirements as a function of road hierarchy are shown in Figure 2.2. This demonstrates how road design for amenity should be separated from road design for flood protection. Three layers of design criteria are identified, including:

- pollution control – low level of service/amenity required
- convenience/nuisance control – medium level of service/amenity required
- flood control – high level of service/amenity required

The following section outlines the street drainage strategy and BMPs based on the level of service required for the road.

Access roads

Access roads will drain to a conventional piped network with side entry/gully pits located to suit appropriate spread rates and pit spacing for the 5 year ARI event. Side entry pits will be a ‘leaky system’, designed so that runoff from minor rainfall events will be infiltrated. Stormwater from events exceeding the infiltration capacity of the ‘leaky system’ will be conveyed through the pipe system to bubble up pits within the bioretention swales.

The design criteria for the side entry pit system will be as follows:

- Runoff from access roads for events up to 1 year 1 hour ARI will both infiltrate and be conveyed through the drainage system.
- Runoff from access roads for events exceeding 1 year 1 hour ARI will be conveyed through a pipe system. The pipe system from the side entry pits will be designed to convey stormwater for events up to the 5 year ARI.
- Runoff from access roads exceeding the 5 year ARI will be conveyed partially through the pipe system and as overland flow.

Estate-level BMPs

The following estate level BMPs have been identified for Brookleigh Estate:

Vegetated swales

To reduce sediment loads vegetated swales can perform both a detention storage function as well as a treatment function in terms of removal of sediment during the conveyance of stormwater. Vegetated swales, consisting of a vegetated open swale should be adopted within POS areas as an alternative to the traditional kerb and gutter system for conveying stormwater runoff to the arterial drainage system in the multiple use corridor.

Bioretention swales

Bioretention swales combine the stormwater treatment functions of a vegetated swale and stormwater filtration system. Stormwater is filtered through a prescribed media (e.g. sandy loam) before being allowed to infiltrate into the groundwater system.

It is proposed to construct bioretention swales adjacent to the arterial drainage route in the drainage corridor through Brookleigh Estate. The bioretention areas have been designed to treat runoff from the roads and lots (south of the POS corridor), and have been sized to contain all runoff for events up to 1 year 1 hour ARI.

The bioretention filter media will improve the phosphorus retention index (PRI) of the soil for the purposes of enhancing onsite nutrient and metal retention. Soils with a PRI >30 will be used in the bioretention swales, as shown in Diagram 5.1. The typical depth of filter media proposed is 300 mm.

The contaminants that are trapped in the soil are mainly nutrients and metals. Hydrocarbons can be readily trapped and assimilated by the soil structure as well (as long as it is not an oil spill or similar significant event).

The bioretention swales within Brookleigh Estate drainage corridor are designed to:

- Retain and infiltrate runoff from 1 year 1 hour ARI storm events to promote sediment settlement and nutrient reduction.
- Detain runoff from 5 year ARI storm events to restrict the flow from the site to 0.4 m^3/s at the Patricia Street culvert crossing.
- Allow the surplus runoff from 100 year ARI events to bypass the detention areas by overtopping, using both the pipe network and overland flow paths to flow directly to the central drain.

7.3.2 Non-structural BMPs

Non-structural measures for the study area

Table 7.3 describes those non-structural BMPs that are being implemented for use in the Brookleigh Estate, in combination with structural measures. The table also provides a description of the BMPs, their benefits, the scale at which they should be applied and the suggested responsibilities for implementation. These non-structural BMPs were derived from Chapter 7 of the Stormwater Management Manual for Western Australia (DoW, 2007).

These recommendations:

- Seek to minimise nutrient export from the study area in stormwater and shallow groundwater.
- Seek to minimise the use of mains water.
- Are focussed on medium residential land use with some public open space.

Technical guidelines on non-structural the BMPs can be found in Ecological Engineering (2004), US EPA (2001) and Victorian Stormwater Committee (1999). In particular, Ecological Engineering (2004) contains 22 recently developed non-structural technical guidelines for use in Western Australia. Many of these are highly relevant to the study area.

Table 7.3 - Non-structural BMPs to be implemented in the study area

Proposed BMP	Description	Primary Benefits	Scale of Application	Responsibility for Implementation
Increased use of local native plants	Target should be 30% local native plants (or unfertilised area) in residential garden beds and maximum use of native plants in public open space areas.	Reduced nutrient export from the site and reduction in the use of water.	Allotment and estate scale.	Developer to apply via landscape design, promotion of landscape packages at point of sale and market testing of covenants. Council to investigate regulation of single dwelling developments after market testing of covenants. An objective of Council's policy ENG 14 'Landscaping' states that 'Landscaping of public open space is to utilise local native plants or sandplain plants to the maximum practicable extent, but no less than 30% of the landscaped area within a development (as an average across the development)'.
Reduced areas of lawns / gardens requiring significant watering & fertilising	Minimise the area within the study area that is used for activities involving the application of nutrients and the need for irrigation (i.e. residential gardens and lawns, high-maintenance public open space).	As above.	Allotment and estate scale.	See above.
Garden and lawn care education	Use of intensive, participatory and targeted garden / lawn care educational programs such as the successful 'Master Gardener' programs run in the US (see Taylor and Wong, 2002b), and the more recent 'Great Gardens' workshops. Such programs educate residents about a wide range of lawn and garden care activities (e.g. choice of plants, irrigation, fertilisation, composting, mulching, etc.). They involve recruitment of volunteers, intensive training, demonstration gardens and evaluation activities.	As above.	Allotment scale.	Developer to run while assets (e.g. roads, stormwater treatment facilities in the streetscape) are still being maintained by the developer. Developer to include information about best management practice in resident welcome packs.

Proposed BMP	Description	Primary Benefits	Scale of Application	Responsibility for Implementation
Nutrient and water management plans for POS	Develop and use simple nutrient and water management plans for all areas of public open space to minimise the need for application of large quantities of nutrients and water. DoW now require local governments to prepare & implement POS management plans.	As above.	Estate scale.	Council to apply via development conditions. Developer to prepare and use plans. Council staff to use plans once these assets are managed by Council.
Maintenance of drainage and sewerage infrastructure	Ensure all structural stormwater BMPs are maintained in accordance with approved maintenance plans. Ensure there are no illicit connections of sewerage to stormwater or groundwater.	Reduced pollutant export to receiving waters.	Estate scale.	For local stormwater drainage: Developer to prepare and implement maintenance plan for first two years that is then continued by Council. For major drainage and sewerage: Water Corporation to apply via its own inspection and maintenance activities.
Erosion and sediment control during development	Use best practice erosion and sediment control (ESC) during development especially with respect to the management of topsoil. This would involve developing an erosion and sediment control program/plan as part of the development assessment and approval process, as well as inspection and enforcement activities by trained environmental staff from the construction / building firm as well as Council.	Reduced sediment and nutrient export to receiving waters.	Allotment and estate scale	Developer to prepare and implement ESC plan for the major earthworks phase. Council and Developer to work together to investigate ways to require or encourage builders to develop and implement simple ESC plans during the building phase. Council to consider and evaluate enforcement options.

Notes: 1 - For more information regarding these measures, see Ecological Engineering (2004), Taylor and Wong (2002b) and US EPA (2001).

2 - This table assumes that the development will be sewered using best practice infrastructure and technology (an important *structural* measure to minimise groundwater contamination with nutrients)

7.4 WETLAND AND WATERWAY PROTECTION

Section 3.2 summarises the location of groundwater dependant wetlands near the Brookleigh Estate.

There are no direct flows from Brookleigh Estate into significant waterways or water bodies.

7.5 VECTOR AND NUISANCE MANAGEMENT

7.5.1 Stormwater system design

Each aspect of the stormwater management system has the potential to create a favourable environment for mosquitoes to breed. Areas requiring design consideration are:

- swale drains in POS areas
- bioretention swales in POS areas
- roadside gullies

Swale drains in the drainage corridor areas (central drain)

Drains should be maintained to prevent erosion and the establishment of emergent vegetation. Unlined drains will require maintenance regarding weed control and the removal of any silt build-up.

It is important that access is available along the drainage system to allow the drains to be maintained as required.

All junctions and discharge sections should be constructed to minimize erosion and have access to allow the removal of any build-up of silt.

With respect to mosquito management, the aim is to ensure that there is a good rate of flow along the system and that weed growth and silt build-up is kept under control. Mosquito breeding may be an issue when water flow is impeded as a result of excessive weed growth or silt build-up. It may also be of concern if there is any infiltration from the seasonal water table at times when the drains would otherwise be dry.

Bioretention swales in central drainage corridor & western POS area

Similarly to the infiltration storage areas as discussed above, it is important to ensure that bioretention swales are well-maintained, to ensure that stormwater runoff and discharge from the subsoil drainage system is infiltrated effectively and ponding of water in the bioretention swales is minimised.

Road gullies

Ideally all gullies should have the outflow pipe at the base of the gully to ensure that no residual water remains in the gully. Any gully which holds water for a period greater than five days is likely to create conditions favourable for mosquitoes to breed.

Ongoing maintenance

The most neglected part of any drainage system tends to be maintenance scheduling. Systems when first installed work efficiently as designed but over time there will be a gradual deterioration in the effectiveness of the system unless a comprehensive maintenance program is in place. In the case of stormwater management any reduction in operational efficiency of the system will increase the likelihood of mosquitoes breeding onsite.

In effect anything which restricts the flow of water through the system or allows pooling for extended periods may create conditions favourable for mosquitoes to breed.

The period of inundation of the infiltration storage areas is not expected to last longer than 5 days which is the time it takes to create favourable conditions for mosquitoes to breed. The period of inundation of the bioretention swales in the POS area are further discussed in Section 6.2.

Regular maintenance to control weed growth, silt build-up etc must be carried out. The vegetation within the bioretention swales also needs to be monitored periodically. It is important that the system is designed with this in mind and that ready access is available to any areas of the system which are likely to require maintenance.

8 MANAGEMENT OF SUBDIVISIONAL WORKS

The issues that will require management in order to ensure that construction activities will not detrimentally impact on the environment are:

- management of dust
- dewatering
- acid sulfate soils

8.1 DUST MANAGEMENT

8.1.1 Legislative requirements

The Environmental Protection Authority's (EPA) current guideline regarding the management of dust is 'Prevention of air quality impacts from land development sites' (EPA, 2000). This document provides broad guidelines for dust management whilst more detailed assessment and prevention tools are documented in the EPA's earlier document 'A guideline for the prevention of dust and smoke pollution from land development sites in Western Australia' (EPA, 1996).

8.1.2 Dust management strategy

The guidelines shall be followed when carrying out the subdivisional works.

Prior to each stage of construction an air quality management program (as documented in the 1996 publication referred to above) shall be completed and submitted to the City of Swan for approval.

8.1.3 Site specific implications

The EPA's guidelines recommend the completion of dust generating activities during winter to minimise the risk of dust generation. However the completion of earthworks at Brookleigh Estate during the winter months is not necessarily feasible, due to the high groundwater table. The cost of dewatering outweighs the additional effort required to mitigate the dust resulting from construction activities during summer. As a result it is recommended that there be no restrictions to earthworks being undertaken during summer months.

8.2 DEWATERING

Dewatering is likely to be required in some areas to enable subdivisional works (predominantly sewer installation) to proceed. Given the current over allocation of this groundwater sub-area it will be necessary for dewatering licences to be obtained from the Department of Water prior to dewatering works proceeding.

8.3 ACID SULFATE SOILS

Brookleigh Estate is located in a low to no risk ASS area as identified by Douglas Partners (2005) Geotechnical and Environmental Investigation. Therefore, an acid sulfate soil management plan (ASSMP) will not be necessary for the proposed subdivisional works.

9 MONITORING PROGRAM

Three types of water quality-related monitoring are recommended for the study area given the proposed development and site conditions. These types are briefly described in the following sections.

Given the need for the monitoring effort to be commensurate with the size of the development, it is recommended that development of the study area be treated as 'one event' when undertaking monitoring (even though staging of works will occur).

9.1 STORMWATER POLLUTANT LOAD MONITORING

Ensuring there is no increase in nutrient loads leaving the study area and entering sensitive waterways such as the Bennett Brook and the Swan River are important objectives that need to be monitored.

Surface water monitoring will consist of grab-sampling at key locations within the subdivision, which will be undertaken as part of the routine groundwater monitoring or in response to rainfall events as necessary. The locations proposed include:

- upstream of the subdivision (adjacent to Reid Hwy culverts),
- downstream of the subdivision (adjacent to Patricia St culvert),
- and, at the discharge from a key representative bio-retention basin.

These locations have been selected to provide representation of the pollutant loading across the entire development, therefore eliminating the need to sample each bio-retention basin discharge location. The proposed monitoring locations are shown in Figure 9.1.

Results from the grab sampling will to be used to indicate how successful best management practices for stormwater and shallow groundwater quality management have been in minimising pollutant loadings in surface waters that leave the site and enter downstream receiving waters.

The developers will be responsible for post-development monitoring activities in accordance with Council policies (currently for a five year period) for submission to regulatory authorities. If water quality and quantity objectives are not met during this period, the developer is to undertake a review of the system to determine why the objectives are not being met. On completion of the review, the City and developer are to agree on the recommended course of action(s) to be undertaken by the developer to ensure the objectives are met to the satisfaction of the local government. A period less than five years may be negotiated by the developers and City after three years subject to developers being able to technically demonstrate that the system is performing as intended and will continue to do so.

Monitoring should commence upon completion of landscaping of the central drainage channel (MUC). However, this is not to occur during periods when major development (i.e. earthworks) is occurring adjacent to the MUC.

To minimise costs, monitoring parameters would include:

- Dissolved Oxygen (%), pH, TN, TP and TSS for at least 20 runoff events over the proposed monitoring period.
- nutrient species (e.g. FRP, TP, NO3-N, NH4+, TN) for at least five (5) run-off events per monitoring period (as defined above)

Surface Water Trigger Values

The preliminary surface water quality trigger values have been derived from the measured surface water quality at the Patricia Street intersection with the surface channel. Consideration has also been given to the National Water Quality Management Strategy (ANZECC, 2000) default trigger values for slightly disturbed ecosystems. These are presented in Table 9.1.

Table 9.1 - Post-development Surface Water Trigger Values

Nutrient	Post Development Trigger Values	Default Trigger Values for Slightly Disturbed Ecosystems (ANZECC 2000)
TN (mg/L)	1.6	1.2
TP (mg/L)	0.2	0.065
Ortho-P (mg/L)	0.2	0.04
NH_4	0.1	0.08
NOx	0.35	0.15
DO	80% sat	
pH	6.5 - 8	6.5 - 8

The above interim trigger values are intended to be dynamic values, and they should be reviewed following each monitoring occasion to ensure that the triggers are appropriate. This is considered an appropriate approach to assess trigger values, given the entire site will be extensively modified during development via the import of fill and landscaping of lots and POS areas.

Should the trigger values be breached, the contingency action plan in Section 9.4 would be implemented.

9.2 GROUNDWATER RECHARGE MONITORING

Groundwater quality is a significant issue for the study area given its hydrogeology. The current groundwater has been predominately low in nutrient and urbanisation has the potential to contaminate groundwater, particularly where infiltration is being widely used as a means of disposing or storing stormwater.

To determine whether shallow groundwater quality is slowly improving with time or at least not degrading as a result of development, the following monitoring strategy is recommended.

9.2.1 Shallow groundwater quality monitoring

This involves the use of two bores to be installed at Brookleigh Estate to sample groundwater quality within the superficial aquifer. These bores will monitor water quality bi-monthly (i.e. every 2 months) for pH, FRP, NO3-N, TP, TN and NH4+. The aim of the monitoring would be to demonstrate that the quality of the shallowest and most recently recharged groundwater is generally improving or being maintained across the site. The upstream/downstream comparison will also facilitate assessing the effectiveness of management of the POS areas. The monitoring would be undertaken at a key representative location both upstream and downstream of the POS area to be developed in one of the first stages, which is shown in Figure 9.1. The representative location is the same for both surface and groundwater quality. This is considered to be a reasonable approach as the landscaping and subsequent management of POS areas and the MUC will be consistent across the development.

The developers will be responsible for post-development monitoring activities in accordance with Council policies (currently for a five year period) for submission to regulatory authorities. If groundwater quality is not met during this period, the developer is to undertake a review of the system to determine why the objectives are not being met. On completion of the review, the City and developer are to agree on the recommended course of action(s) to be undertaken by the developer to ensure the objectives are met to the satisfaction of the local government. A period less than five years may be negotiated by the developers and City after three years subject to developers being able to technically demonstrate that the system is performing as intended and will continue to do so.

Monitoring should commence upon completion of landscaping of the central drainage channel (MUC). However, this is not to occur during periods when major development (i.e. earthworks) is occurring adjacent to the MUC.

The groundwater quality results will be compared against the baseline groundwater quality results discussed in the following section.

Groundwater Trigger Values

The trigger values for groundwater have been derived from the average results from bores CGW11 and CGW 12. These bores indicate moderate to low nutrient levels. The trigger values provided in Table 9.2 (below) have also been derived in consideration of those provided for lowland rivers in the National Water Quality Management Strategy (ANZECC, 2000).

Table 9.2 - Post-development groundwater Trigger Values

Nutrient	Post Development Trigger Values
TN (mg/L)	2.0
TP (mg/L)	0.1
Ortho-P (mg/L)	0.1
NH_4	0.2
NOx	0.35
pH	6.5 – 8

As with surface water trigger values, the above interim trigger values are intended to be dynamic values, and they should be reviewed following each monitoring occasion to ensure that the triggers are appropriate. This is considered an appropriate approach to assess trigger values, given the entire site will be extensively modified during development via the import of fill and landscaping of lots and POS areas, and that the NWQMS default trigger values are really intended for surface water, not groundwater.

Should the trigger values be breached, the contingency action plan in Section 9.4 would be implemented.

9.3 BMP MONITORING

Various best management practices (BMPs) are proposed within Brookleigh Estate to minimise stormwater pollutant loads, groundwater pollution and variations in hydrology. Some of these are structural (e.g. bioretention systems, vegetated swales, groundwater reuse, etc.) while others non-structural (e.g. education on fertiliser use, nutrient management plans for public open space, soil amendment, xeriscaping, etc.). Chapter 10 of the Stormwater Management Manual for Western Australia provides advice on the performance monitoring of such BMPs (DoW, 2007).

Monitoring in the form of inspections by the developer's representative (i.e. civil engineering consultant) and council (i.e. City of Swan) will ensure that the BMP designs are fully implemented as approved (e.g. in accordance with the approved drawings). Such inspections would occur during and immediately upon completion of each development stage.

9.4 CONTINGENCY PROCEDURES

One concern that often arises (particularly with local government) with 'new' developments proposing water sensitive urban design elements relates to what happens if post-development monitoring finds water quality-related objectives are not being met. This section addresses this concern.

If post-development monitoring finds that water quality-related objectives have not been met, the following procedures would be undertaken by the developer and council (in the order provided):

Ensure that the development has fully complied with development conditions relating to water quality management (e.g. installation and operation of BMPs). If such BMPs have not been designed and installed as approved, then the developer would do so or council would be entitled to take regulatory action for a breach of development conditions.

Inform City of Swan via informal reporting. This will be done to ensure that any further contingency actions proposed are consistent with the standards and approach that would be undertaken by the City of Swan.

Investigate opportunities to apply additional non-structural BMPs to the study area (e.g. educational programs, street sweeping, nutrient management plans, alteration of structural BMP maintenance regimes, soil amendment, local rainwater tank rebate scheme, etc.). Funding for such additional measures would typically be covered by the local government authority.

Revision of POS management practises will be undertaken to determine if the nutrient application is appropriate. This may result in more detailed soil and leaf tissue analysis to determine nutrient requirements for the POS. This would be undertaken following receipt of the results above trigger values, and on an annual basis thereafter prior to application of nutrients by the landscape contractor.

10 IMPLEMENTATION PLAN

10.1 ROLES, RESPONSIBILITIES AND FUNDING

There are four key stakeholders to which responsibilities can be assigned to implement the UWMP:

- Developer
- City of Swan
- Water Corporation
- Land owner.

The roles, responsibilities and funding of each of these stakeholders are summarised in Table 10.1 below.

Table 10.1 - Roles, responsibilities and funding for implementation of the UWMP

Organisation	Role	Funding
Developer	» Satisfy relevant WAPC conditions including preparation of UWMP. » Design and construct the potable water supply and sewer supply to Water Corporation standards. » Design, construct and maintain (maintenance period to be negotiated between the developer and the City of Swan) public open space. » Undertake post-development monitoring activities for submission to regulatory authorities. » Ensure construction and management are consistent with UWMP.	Developer
City of Swan	» Assume responsibility for constructed roads and stormwater drainage infrastructure including the ongoing operations and maintenance. » Maintain the public open space (including irrigation) at the completion of the developer's maintenance period. » Assume responsibility for the approval of the built form.	Rates
Water Corporation	» Assume responsibility for the constructed potable water supply and sewerage infrastructure including ongoing operation and maintenance.	Rates

Organisation	Role	Funding
Land Owner	» Assume responsibility for meeting all requirements of the relevant local authority and building codes during the built form phase (including construction and maintenance of soakwells for onsite stormwater disposal). » Comply with Water Corporation's waterwise program.	Land Owner

10.2 MAINTENANCE

The responsibilities for maintenance of infrastructure are set out in Table 10.1 above.

The Water Corporation has set practices for the maintenance of water and sewer infrastructure. This section deals solely with the maintenance requirements of the stormwater structural BMPs proposed at Brookleigh Estate, as described in Section 7.3 of this report.

The developers will be responsible for maintaining public open spaces in accordance with Council policies (currently for a five year period) and rectify any design faults during this time. A period less than that specified in Council policy (but to a minimum of two years) may be negotiated by the City and developers subject to developers being able to demonstrate to the City that the public open space is adequately established and can be maintained to the City's standards.

During this maintenance period the developer is to keep a record of all maintenance activities that are carried out. These records are to be handed over to the City of Swan when the developer's maintenance period expires.

The main structural BMPs proposed at Brookleigh Estate are:

- bioretention swales
- vegetated swales within POS areas

The maintenance requirements for each of those BMPs are outlined below.

10.2.1 Bioretention swales

One of the primary maintenance requirements for bioretention systems is to inspect and repair or replace the treatment system's components. Generally this involves periodic maintenance of the landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected. The appropriate selection of plants will aide in the reduction of fertilizer and pesticide usage, which, can increase the level of nutrients entering the receiving water bodies. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Another critical maintenance consideration is the monitoring of sediment accumulation at the inlet points. Depending on the catchment activities, the deposition of sediment can smother plants and reduce the available ponding volume. (Wong et al, 2004). Should excessive sediment build up occur, it may impact on the plant health leading to a reduction in their capacity to maintain the infiltration rate of the filter media. Regular sediment removal may therefore be necessary.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and the subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated using preventive and low-toxicity pesticides to the extent possible. The highly organic and often heavily vegetated areas in standing shallow water can create a breeding ground for mosquitoes. Routine inspection for areas of standing water and corrective measures to restore proper infiltration rates are necessary to eliminate these breeding environments. In addition, bioretention systems can be susceptible to invasion by aggressive weeds and thereby increases the potential for ponding if not routinely maintained.

In order to maintain the system's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every 2 to 3 years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.Recommended timing for inspection and maintenance of bioretention swales is outlined in Table 10.2 below.

Table 10.2 - Inspection & maintenance program - bioretention swales

Inspection activities	Suggested frequency
Inspect soil and repair eroded areas.	monthly
Inspect for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before autumn, to ensure the strips are ready for winter. However, additional inspection after periods of heavy runoff is desirable. Inspect to ensure grass is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket. Check for debris and litter, and areas of sediment accumulation. Inspect health of trees and shrubs.	semi-annual inspection
Maintenance activities	**Suggested frequency**
Water plants daily for 2 weeks	at project completion
Remove litter and debris	monthly

Remove sediment Remulch void areas Treat diseased trees and shrubs Mow turf areas Repair outflow structures and erosion at inflow points Unclog underdrain Regulate soil pH regulation.	as needed
Remove and replace dead and diseased vegetation.	semi-annual
Add mulch and replace tree stakes and wires.	annual
Mulch should be replaced every 2 to 3 years or when bare spots appear. Remulch prior to the wet season.	every 2-3 years, or as needed

10.2.2 Vegetated swales in POS areas

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. A well designed and regularly maintained vegetated swale can have a long operating life.

The maintenance objectives for a vegetated swale system include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy vegetation cover. Maintenance should include:

- Frequently inspect during the first few months to ensure grass cover is establishing well. If required, reseed or plant an alternative species. Once established, continue to inspect bi-annually for signs of erosion.
- Periodically mow (typically bi-annually) with grass never cut shorter than the design flow depth, and implement weed control. Cuttings should be removed from the channel and disposed in a local composting facility.
- Carry out clearing of debris and blockages prior to winter and after major storm events. Accumulated sediments should be removed to avoid the transportation of re-suspended sediments during periods of low flow and to prevent a damming effect from sand bars.
- Repair damaged areas within the channel as required. For example, if the channel develops ruts or holes, it should be repaired by using a suitable soil that is properly tamped and seeded. The vegetation cover should be thick, else reseed as necessary.
- Regularly inspect swales for ponding. Swales can become a nuisance due to mosquito breeding in standing water if obstruction develops (e.g. accumulated debris, invasive vegetation) and/or swale slopes are too flat and inadequately maintained.

Recommended timing for inspection and maintenance of bioretention swales is outlined in Table 10.3 below.

Table 10.3 - Inspection & maintenance program – vegetated swales

Inspection activities	Suggested frequency
Inspect after seeding and after first major storms for any damages.	post-construction
Inspect for signs of erosion; damage to vegetation; channelisation of flow; debris and litter; and areas of sediment accumulation. Perform inspections at the beginning and end of the wet season. Additional inspections after periods of heavy runoff are desirable.	semi-annual
Inspect level spreader for clogging; grass along side slopes for erosion and formation of rills or gullies; and sand/soil bed for erosion problems.	annual
Maintenance activities	**Suggested frequency**
Mow grass to maintain a height of 7-10 cm, for safety, aesthetic, or other purposes. Litter should always be removed prior to mowing. Clippings should be composted. Irrigate swale during dry season (October to April) or when necessary to maintain the vegetation. Provide weed control, if necessary to control invasive species.	as needed (frequent, seasonally)
Remove litter, branches, rocks, blockages, and other debris and dispose of properly. Maintain inlet flow spreader (if applicable). Repair any damaged areas within a channel identified during inspections. Erosion rills or gullies should be corrected as needed. Bare areas should be replanted as necessary.	semi-annual
Unclog the pea gravel diaphragm, if necessary. Correct erosion problems in the sand/soil bed of dry swales. Plant an alternative grass species if the original grass cover has not been successfully established. Reseed and apply mulch to damaged areas.	annual (as needed)
Remove all accumulated sediment that may obstruct flow through the swale. Sediment accumulating near culverts and in channels should be removed when it builds up to 7cm at any spot, covers vegetation, or once it has accumulated to 10% of the original design volume. Replace the grass areas damaged in the process. Rototill or cultivate the surface of the sand/soil bed of dry swales if the swale does not draw down within 48 hours	as needed (infrequent)

10.3 ASSESSMENT AND REVIEW

The assessment of the performance of the UWMP against the design objectives / criteria can be carried in the form of post-development water quantity and water quality monitoring.

The monitoring program required for Brookleigh Estate is addressed in Section 0 of this report.

The assessment and review of the performance of the various UWMP design objectives and criteria is to be undertaken by the authorities shown in Table 10.4.

It is proposed that the outcomes of the review process be used as an education tool in order to enable:

- Authorities to review the design criteria to confirm their applicability and/or
- Subsequent developers to adjust the BMP treatment trains selected in future developments within the CLSP area.

Table 10.4 - Assessment and review responsibilities

Authority	Design Objective / Criteria
City of Swan	Water quantity (Local Authority Drainage Network). Management of disease vector and nuisance insects. Water Quality, Water Quantity.
Water Corporation	Water conservation (compliance with water wise program & usage of potable water)
Department of Water	Water quality, Water quantity, Groundwater levels,

11 SUMMARY OF UWMS OBJECTIVES AND STRATEGIES

Table 11.1 - Design objective summary

UWMS objective		Brookleigh Estate strategy		
Water conservation	**Section 2.2**	**Objectives satisfied**	**Section 4**	✓
State Water Strategy (Government of Western Australia 2007) water consumption target of less than 100 kL/person/year.		Various in-house and ex-house water saving measures are proposed. This includes the use of stormwater for non-potable use which will potentially reduce potable water consumption to approx 45.3 kL/person/year.		
Groundwater levels	**Section 2.3**	Objectives satisfied	**Section 5**	✓
Local and regional environmental impacts are managed appropriately.		BMP treatment train proposed to improve water quality exported from the site.		
Minimal threat to groundwater dependant wetlands and other ecosystems.		There are no significant waterbodies or groundwater dependant wetlands that will be impacted by the development at Brookleigh Estate.		
Water quality and contamination	**Section 2.5**	**Objectives satisfied**	**Section 7.3**	✓
Implement source controls to prevent pollution or treat stormwater as high in the catchment as possible.		» increased use of local native plants and reduced areas of lawns / gardens that require fertilisation and significant amounts of watering » garden and lawn care education » nutrient and water management plans for public open space » fertiliser control » maintenance of drainage and sewerage infrastructure » erosion and sediment control during development		

UWMS objective		Brookleigh Estate strategy		
Structural BMPs should be sized to treat runoff from directly connected impervious areas for events up to 1 year 1 hour ARI.		Bioretention swales have been designed to treat the runoff for 1 year 1 hour ARI events. Runoff from lots will be infiltrated via soakwells.		
Surface water quantity	**Section 2.3**	**Objectives satisfied**	**Section 6**	✓
Design for flood protection using outcomes/requirements from flood modelling in the Swan Urban Growth Corridor DWMP and requirements set in Australian Rainfall and Runoff (IEA, 2001).		Sufficient detention storage provided in POS areas to maintain peak 5 year and 100 year ARI flow rates as per the Swan DWMP modelling.		
The effective impervious area of the development shall be minimised.		Soakwells will be installed in individual lots to reduce the effective impervious area of the development.		
Design convenience/nuisance control structural BMPs on roads for the relevant ARI design event depending on the level of service of the road (refer to Figure 2.2).		» Runoff generated by frequent events will be retained and infiltrated on site. » 5 year ARI flows in neighbourhood connector and access roads to be conveyed by a conventional piped network draining the road reserve. » Events greater than 5 year ARI flows to be conveyed by a combination of overland flow paths and pipes within the road reserve connecting to the central drain.		
Install in transit measures to treat stormwater throughout the conveyance systems.		Vegetated swale design within POS areas to detain runoff and allow infiltration.		
Implement end-of-pipe measures to mitigate any contaminants remaining in the stormwater prior to discharging to receiving environments.		Bioretention swales within the central drainage corridor within Brookleigh Estate will detain stormwater and allow it to infiltrate prior to discharging into the vegetated central drain which will further act to improve water quality.		
Wetland and waterway protection	**Section 2.6**	**Objectives satisfied**	**Section 7.4**	✓
Use wetlands as part of the flood management system.		No CCWs located in Brookleigh Estate.		
Existing drains through wetlands to be allowed to remain.		Swales and POS within existing multiple use corridor being used to convey runoff. These are the only existing drains / flow paths that are required to maintain the existing hydrologic regime.		

UWMS objective		Brookleigh Estate strategy		
Drainage inverts below the controlled groundwater level (CGL) be permitted only where wetland groundwater levels will not be adversely affected.		No groundwater dependant wetlands are present in the immediate vicinity of Brookleigh Estate.		
Guidelines specified in Decision Process for Stormwater Management in Western Australia - Protect Waterways and Wetlands.		The retention of wetland and waterways is covered above There are no conservation category wetlands, other conservation wetlands, or waterway foreshore areas within the Brookleigh development.		
Where stormwater infiltrates into groundwater which either immediately discharges into a marine/coastal environment or is contained within a groundwater aquifer that does not interact with the surface water system on the Swan Coastal Plain.		The stormwater infiltrated into the groundwater at Brookleigh Estate will discharge into the surficial aquifer and will not immediately discharge into a marine/coastal environment. As the surficial aquifer interacts with the surface water system by way of infiltration and baseflow in swales, this condition is not applicable in the case of the Brookleigh development.		
Maintain the post-development 1 year ARI flows to pre-development conditions (irrespective of soil type).		The bioretention swales within Brookleigh Estate have been designed to retain runoff from storm events up to 1 year 1 hour ARI. As a result there will be no stormwater discharged from the site for the 1 year 1 hour ARI event. This is consistent with the pre-development regime of the Caversham site.		
Vector and nuisance management	**Section 2.7**	**Objectives satisfied**	**Section 7.5**	✓
Design of the stormwater management system to ensure that as far as practical, constructed wetlands, multiple use corridors, open drains, road gullies etc do not contribute to onsite mosquito breeding.		Design guidelines for detention basins, open drains and roadside gullies have been compiled with to ensure they do not contribute to mosquito breeding.		
Ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed thereby reducing the risk of creating conditions likely to promote onsite mosquito breeding.		The requirement for maintenance is discussed and suggested maintenance programs are included in Section 7.5.		

12 REFERENCES

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australian and New Zealand (ARMCANZ & ANZECC) (2000), *National Water Quality Management Strategy Australian Guidelines for Urban Stormwater Management*, National Water Quality Management Strategy, Canberra

Cardno WA Pty Ltd (2008), Caversham Local Structure Plan, Local Water Management Strategy, The Main Landowner Group, Perth, Western Australia

Douglas Partner (2005), Report on Geotechnical & Environmental Assessments – Patricia Street and Arthur Street Caversham, The Main Landowner Group, Perth, Western Australia

Department of Water (2007), *Stormwater Management Manual for Western Australia*, Department of Water, Perth, Western Australia

Department of Environment and Swan River Trust (2005) *Decision Process for Stormwater Management in WA*, Department of Environment, Perth, Western Australia

Ecological Engineering (2004), *Non-structural Controls, Stormwater Management Manual for Western Australia (version 2)*, a series of guidelines prepared for the Department of Environment, Perth, Western Australia

Essential Environmental Services (2006), Interim Approach for Integrating Urban Water Management with Land Use Planning within the Southern River Area: Guidance for developers, Southern River Steering Committee

Gerritse, R., Barber, C., and Adeney, J. (1990), *The Impact of Residential Urban Areas on Groundwater Quality: Swan Coastal Plain, Western Australia*, CSIRO Water Resources Series #3. CSIRO, Perth, Western Australia

Government of Western Australia (2003), *A State Water Strategy for Western Australia*, Government of Western Australia, Perth

Helen Brookes and Associates, GHD (2009), Swan Urban Growth Corridor Drainage and Water Management Plan, Department of Water, Perth, Western Australia

Institution of Engineers Australia (2001), *Australian Rainfall and Runoff, A Guide to Flood Estimation*, Institution of Engineers Australia

Parsons Brinckerhoff Australia (2008), Report on the Geotechnical Investigation for Proposed Residential Subdivision Caversham North, Cardno BSD, Perth, Western Australia

RPS Bowman Bishaw Gorham (2006), Caversham Structure Plan Environmental Opportunities and Constraints Analysis, The Main Landowner Group, Perth, Western Australia

Taylor, A., and Wong, T. (2002a), *Non-structural Stormwater Quality Best Management Practices – An Overview of Their Use, Value, Cost and Evaluation*, Technical Report 02/11, December 2002, CRC for Catchment Hydrology, Melbourne, Victoria

Taylor, A., and Wong, T. (2002b), *Non-structural Stormwater Quality Best Management Practices – A Literature Review on Their Value and Life Cycle Costs*, Technical Report 02/13, December 2002, CRC for Catchment Hydrology, Melbourne, Victoria

United States Environmental Protection Agency (US EPA) (1999), *Preliminary Data Summary of Urban Stormwater Best Management Practices*, US EPA report No. EPA-821-R-99-012, www.epa.gov/waterscience/stormwater

United States Environmental Protection Authority (US EPA) (2001), *National Menu of Best Management Practices for Storm Water Phase II*, online guideline from the US EPA, http://www.epa.gov/npdes/stormwater/menuofbmps

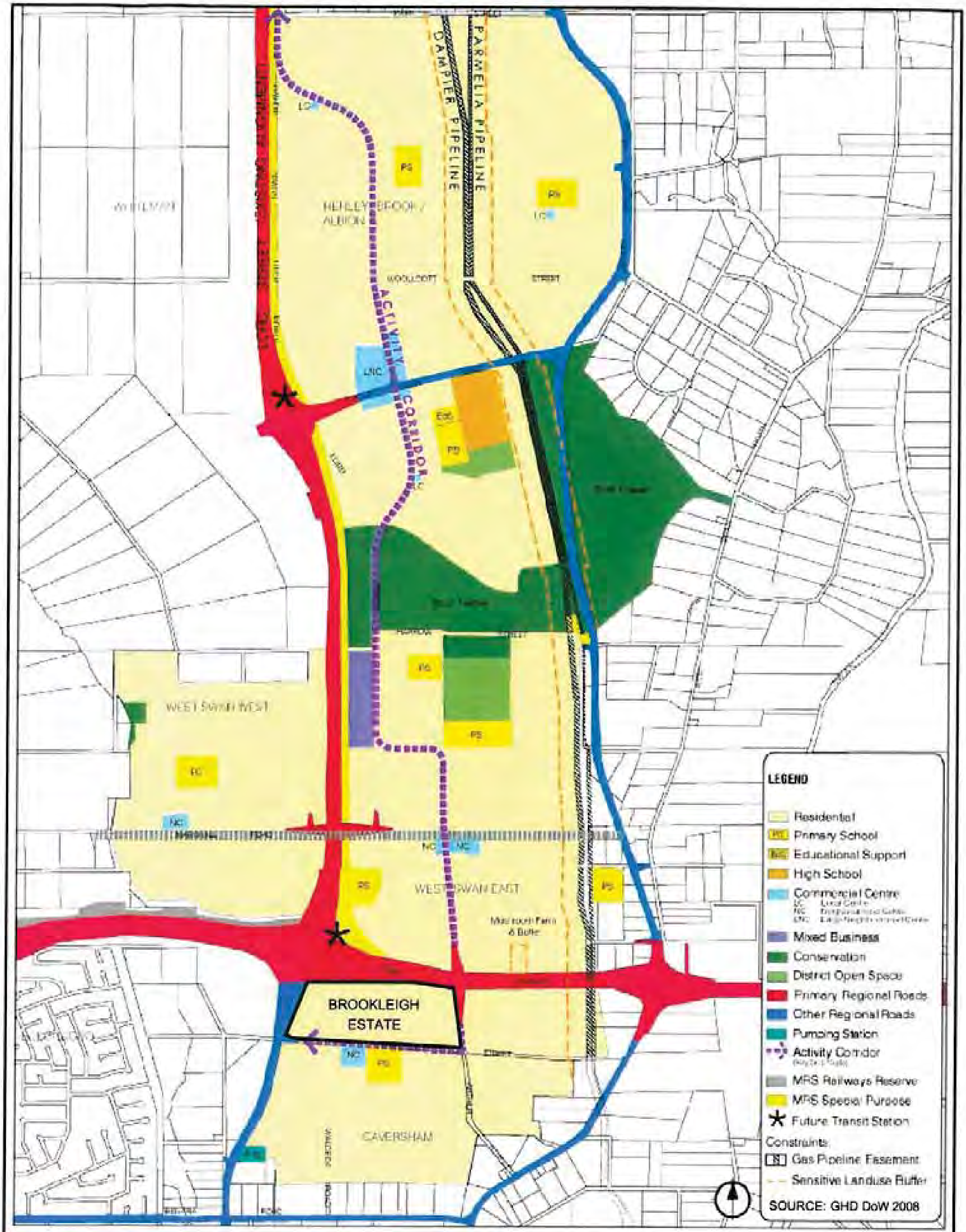
Victorian Stormwater Committee (1999), *Urban Stormwater Best Practice Environmental Guidelines*, CSIRO Publishing, Melbourne, Victoria

Water Corporation (2003), Domestic Water Use Study in Perth, Western Australia 1998 – 2007, Water Corporation, Perth

Water Corporation (2007), *MUSIC Guidelines for Perth (Interim Final Report)*, Water Corporation, Perth

APPENDIX A

FIGURES



SUB REGIONAL PLAN
FOR THE SWAN URBAN GROWTH CORRIDOR

FIGURE: 1.1
REVISION: A

1069 BROOKLEIGH ESTATE UWMP	SCALE:	NTS
	CO-ORDS:	NA
QUBE CAVERSHAM DEVELOPMENT PTY LTD	DRWN:	TS
	CHKD:	CL

EMERSON STEWART

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Plotted By: troy.stedman Plot Date: 30/11/09 - 18:07

SOURCE: RPS KOLTASZ SMITH 2008

DISTRICT STRUCTURE PLAN (DSP) CAVERSHAM

FIGURE: 1.2
REVISION: A

1069
BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE:	NTS
CO-ORDS:	NA
DRWN:	RWB
CHKD:	CL

EMERSON STEWART

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Plotted By: trov.stedman Plot Date: 30/11/09 - 18:08

LOCAL STRUCTURE PLAN (LSP) CAVERSHAM

FIGURE: 1.3
REVISION: C

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: RWR
CHKD: CL

EMERSON STEWART

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Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

1. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.
2. Prior to design, developers shall consult with the Department of Environment (DoE), local government authorities and other relevant stakeholders. Maintenance requirements should be considered at this stage.
3. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.
4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to) conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitat and vegetation identified in *Bush Forever* (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or high acid sulfate soil risk area?
2. Does the soil or groundwater contain *highly elevated* nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxyhydroxide content) and local wetting and drying cycles.

Yes (to either question)

Avoid mobilisation or disturbance of the in-situ contaminants

If yes to question 1 – seek further advice from the DoE.

If yes to question 2 – consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

No (most situations)

1. Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment.
2. Hydraulic requirements shall be determined by ecosystem requirements and the hydrologic form of the local and downstream environment. Physical survey measurements and a biological survey should be undertaken.
3. Hydrologic and hydraulic analyses, modelling and design shall incorporate the recommendations and methodology of *Australian Rainfall and Runoff, A Guide to Flood Estimation* (IEA, 2001).
4. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

Less than and up to 1 year ARI events

Generally, rainfall from 1 year average recurrence interval (ARI) events should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible), unless it can be clearly demonstrated that achievement of this objective is impractical due to site conditions.

Generally, for detention systems, preserve the pre-development 1 year ARI peak discharge rate. Use best management practices (structural and non-structural) to treat water quality.

Greater than 1 year and up to 100 year ARI events

Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

Design for greater than 1 year and less than 10 year ARI events

Minor system conveyance (i.e. swales and pipes).

Design for 10 year to 100 year ARI events

Major system conveyance (i.e. via overland flow).

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of nutrients towards receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.
2. The components of the water quality treatment train must be designed so that their combined effect meets the water quality management objectives as specified in the relevant regional water quality management targets (e.g. local government stormwater management plans, the Regional Natural Resource Management Strategy, *Swan-Canning Cleanup Program Action Plan* (SRT, 1999) and the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (EPA, 1992)). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of DoE.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach should be consistent with the *River Restoration Manual* (WRC, 1999-2003), *Draft Waterways WA – A Policy for Statewide Management of Waterways in Western Australia* (WRC, 2000), *Foreshore Policy 1 – Identifying the Foreshore Area* (WRC, 2002) and, in the Swan and Canning Catchments, the *Environmental Protection (Swan and Canning Rivers) Policy 1998* (EPA, 1998). For wetlands, the approach should be consistent with the *Environmental Protection of Wetlands Position Statement No. 4* (EPA, 2004) and the *Wetlands Conservation Policy for WA* (Government of WA, 1997). On the Swan Coastal Plain, the approach to managing wetlands should also be consistent with the *Environmental Protection (Swan Coastal Plain Lakes) Policy, 1992* (EPA, 1992) and the *Position Statement: Wetlands* (WRC, 2001).
2. There shall be no new constructed stormwater infrastructure within Conservation category wetlands and their buffers, or other conservation value wetlands and their buffers, or within a waterway foreshore area (e.g. no pipes or constructed channels within these wetlands and their buffers, or within waterway foreshore areas), unless authorised by the DoE or the Environmental Protection Authority. For Resource Enhancement and Multiple Use category wetlands, stormwater management shall be consistent with the objectives outlined in the *Position Statement: Wetlands* (WRC, 2001).
3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined lakes that require groundwater to maintain water levels in summer) or the modification of a wetland type (e.g. converting a dampland into a lake). Where water conservation (e.g. summer water supply) and environmental and health concerns (e.g. hydrology, water quality, mosquitoes, midges, algal blooms, acid sulfate soils and iron monosulfide minerals) can be adequately demonstrated to be addressed through design and maintenance, consideration may be given to the creation of artificial lakes/ponds. Seasonal wet infiltration areas or approved constructed waterways (i.e. ephemeral 'Living Streams') are preferred options.

Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through a Controlled Groundwater Level (CGL) approach shall demonstrate through adequate field investigations, to the satisfaction of the Department of Environment, that local and regional environmental impacts are adequately managed.
2. The CGL may be defined as the controlled (i.e. modified) groundwater level (measured in metres Australian Height Datum) at which the DoE will permit drainage inverts to be set. The CGL must be based on local and regional environmental water requirements, determined in accordance with the *Environmental Water Provisions Policy for Western Australia* (WRC, 2000) and the *Urban Development and Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems* (DoE, in preparation).
3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater level should not expose ASS to the air, as this may cause groundwater contamination. Refer to the ASS Guideline Series, including *Identification and Investigation of Acid Sulfate Soils* (DoE, 2004). If field investigations identify ASS, seek further advice from DoE.

SOURCE: WESTERN AUSTRALIAN PLANNING COMMISSION

DoW DECISION MAKING PROCESS

FIGURE: 2.1
REVISION: A

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NA
CO-ORDS: NA
DRWN: JWS
CHKD: CI

EMERSON STEWART

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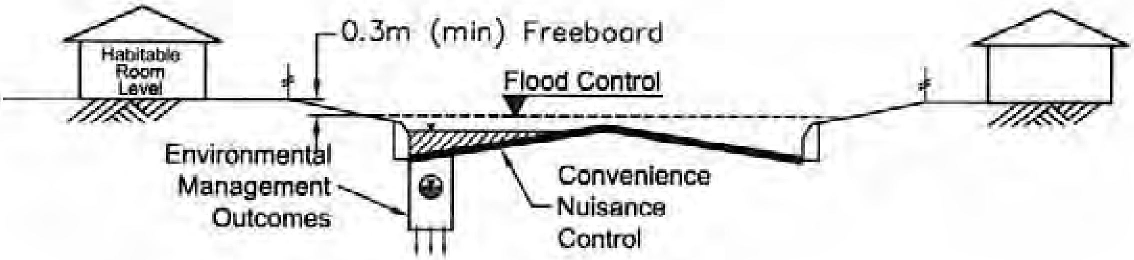
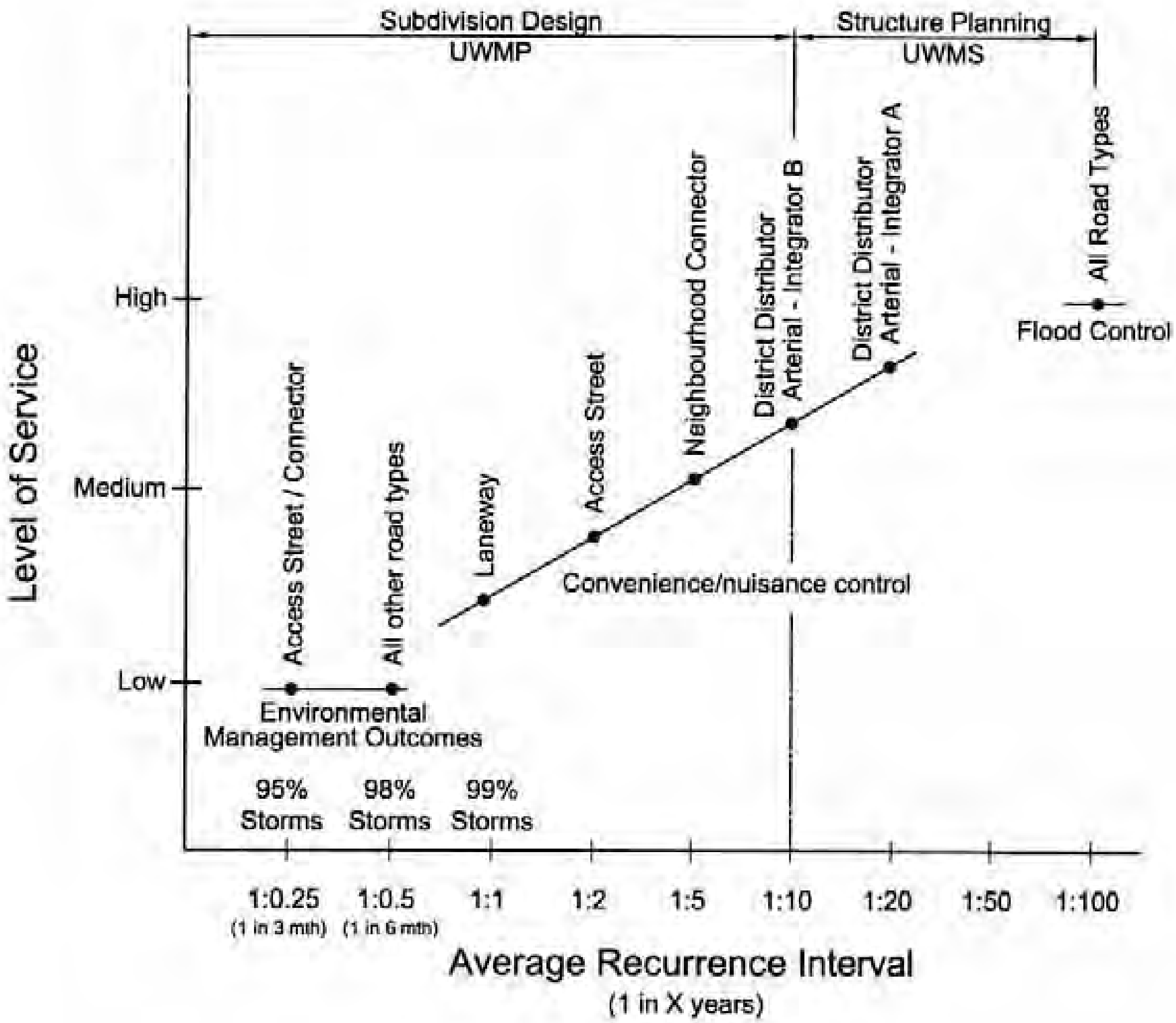
Stormwater Infrastructure Requirements as a Function of Road Hierarchy





STORMWATER INFRASTRUCTURE REQUIREMENTS

FIGURE: 2.2
REVISION: A

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NA
CO-ORDS: NA
DRWN: RWR
CHKD: Ω

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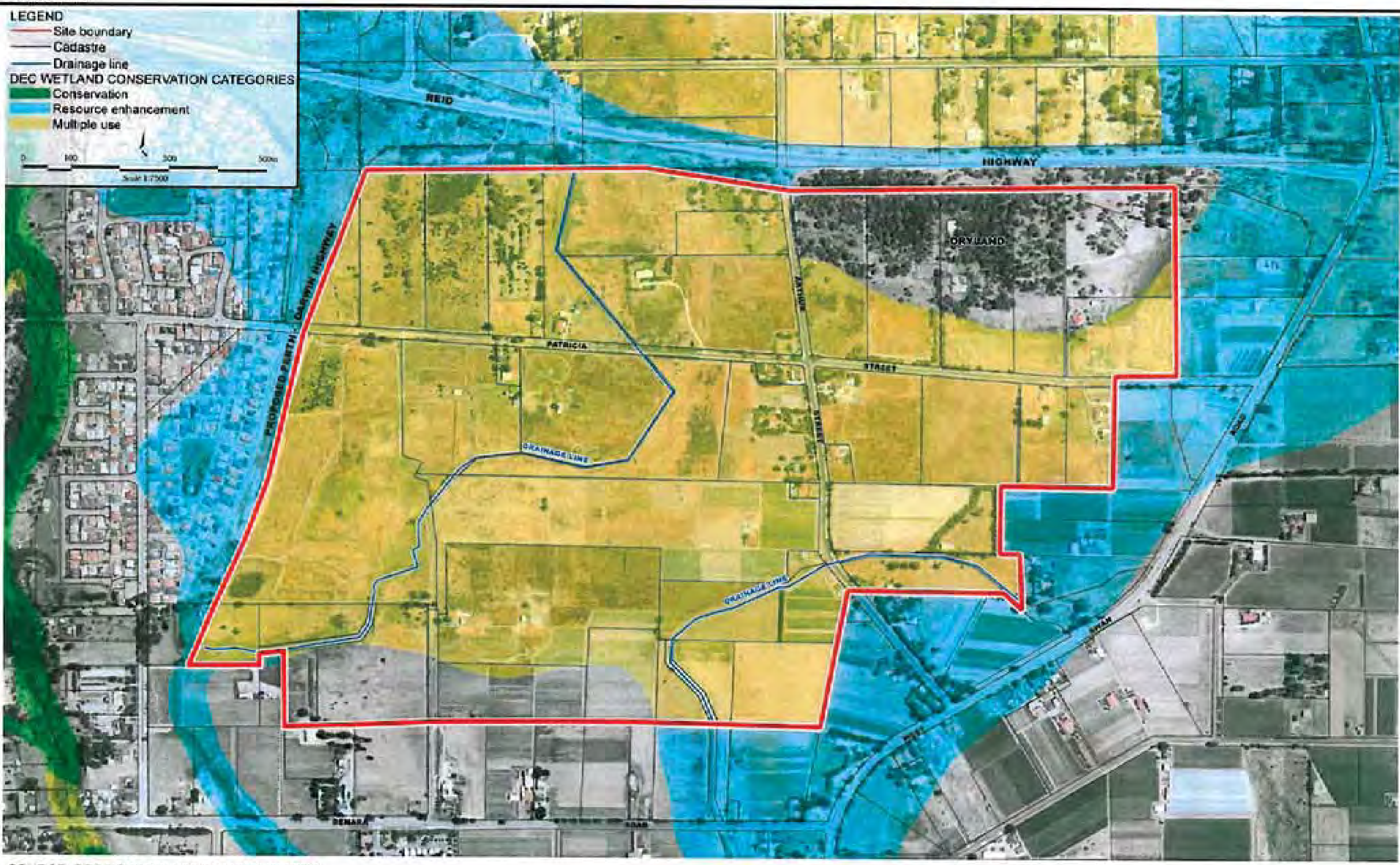
1069-F002-0003.DWG



SOURCE: RPS BOWMAN BISHAW GORHAM 2006

DEC WETLANDS AND DRAINAGE

FIGURE: 2.3
REVISION: A

1069
BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: RWB
CHKD: CL

EMERSON STEWART

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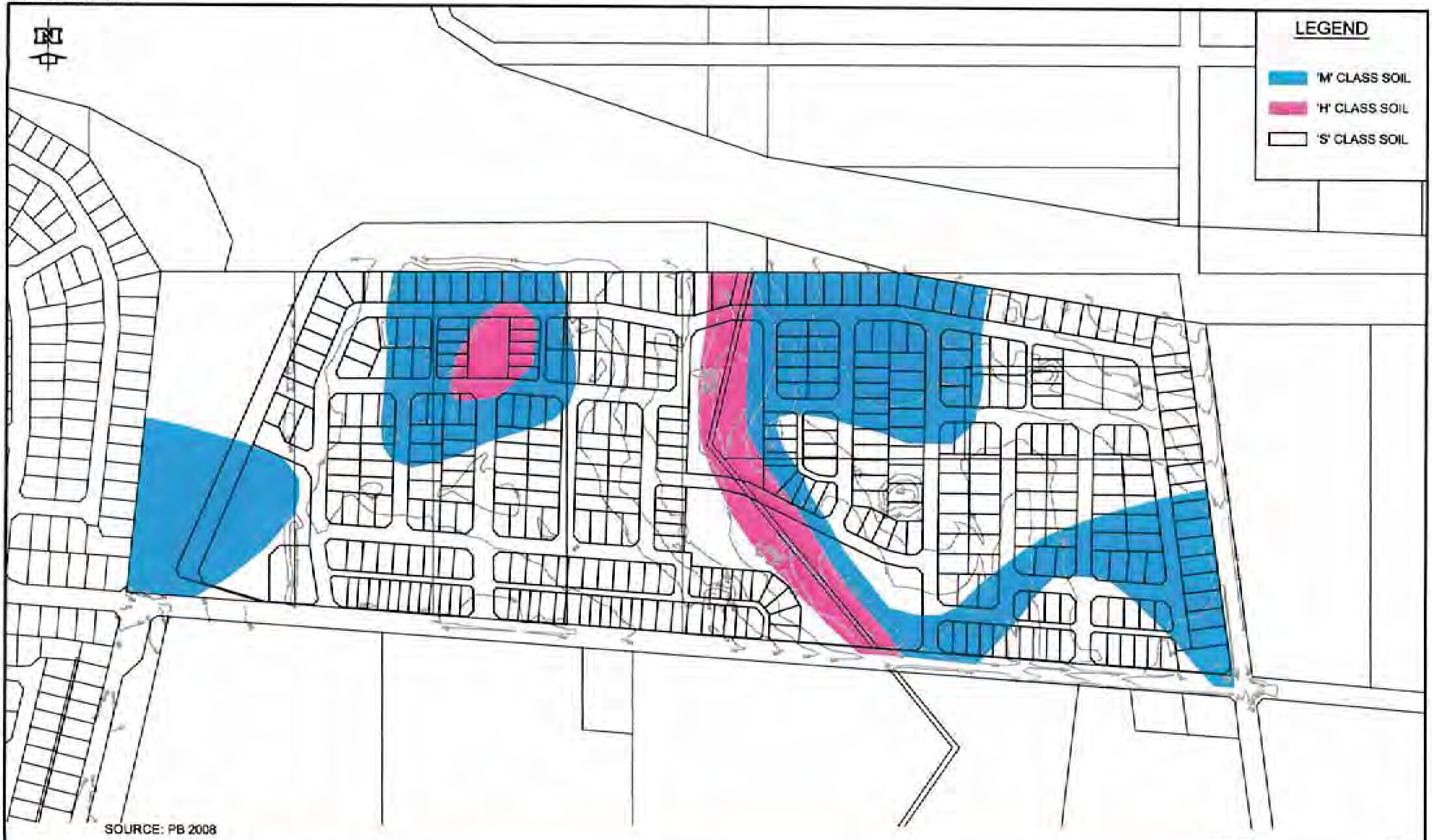

INTERPOLATED SITE CLASSIFICATION PLAN

FIGURE: 3.1
REVISION: B

1069
BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE:	NTS
CO-ORDS:	NA
DRWN:	RWB
CHKD:	CL

EMERSON STEWART

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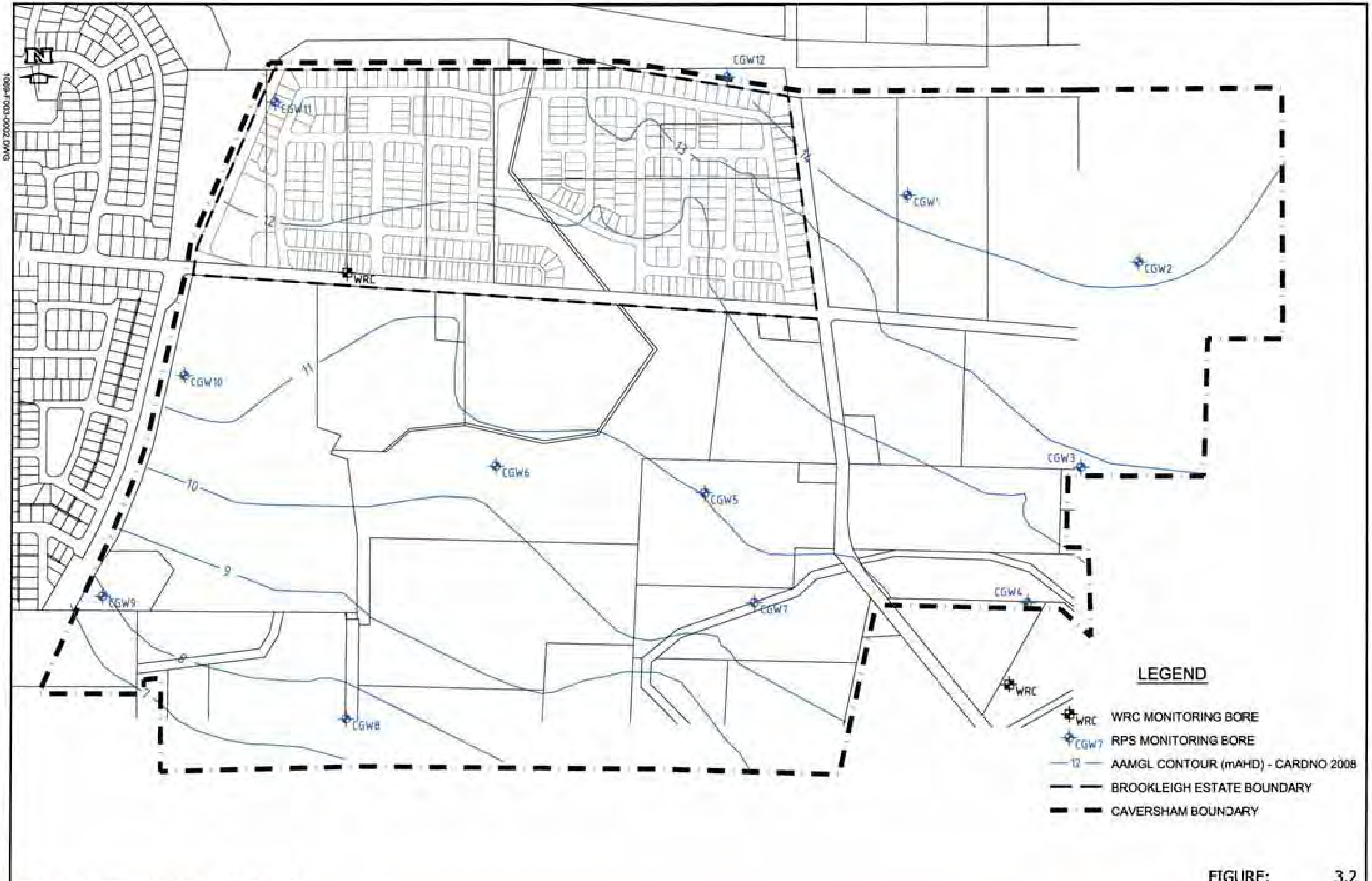

PRE-DEVELOPMENT AAMGL CONTOURS

FIGURE: 3.2
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRAWN: RWB
CHKD: CL

EMERSON STEWART

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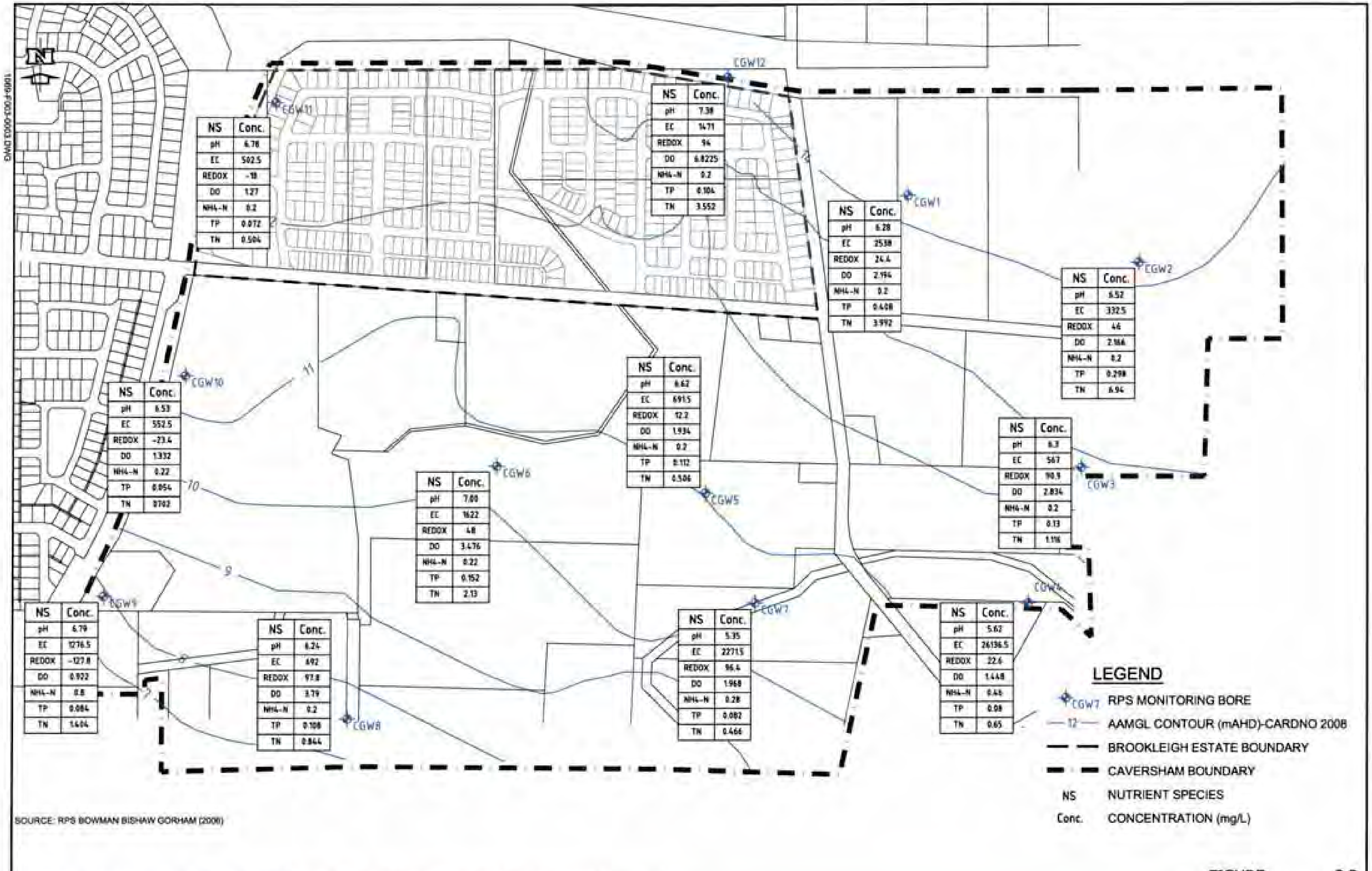

NS	Conc.
pH	6.78
EC	502.5
REDOX	-18
DO	1.27
NH4-N	0.2
TP	0.072
TN	0.504

NS	Conc.
pH	7.38
EC	1471
REDOX	94
DO	6.8225
NH4-N	0.2
TP	0.104
TN	3.552

NS	Conc.
pH	6.28
EC	2538
REDOX	24.4
DO	2.194
NH4-N	0.2
TP	0.408
TN	3.992

NS	Conc.
pH	6.52
EC	332.5
REDOX	46
DO	2.166
NH4-N	0.2
TP	0.298
TN	6.94

NS	Conc.
pH	6.53
EC	552.5
REDOX	-23.4
DO	1.332
NH4-N	0.22
TP	0.054
TN	0702

NS	Conc.
pH	6.62
EC	691.5
REDOX	12.2
DO	1.934
NH4-N	0.2
TP	0.112
TN	0.506

NS	Conc.
pH	6.3
EC	567
REDOX	90.9
DO	2.834
NH4-N	0.2
TP	0.13
TN	1.116

NS	Conc.
pH	7.00
EC	1622
REDOX	48
DO	3.476
NH4-N	0.22
TP	0.152
TN	2.13

NS	Conc.
pH	6.79
EC	1276.5
REDOX	-127.8
DO	0.922
NH4-N	0.8
TP	0.084
TN	1.404

NS	Conc.
pH	6.24
EC	692
REDOX	97.8
DO	3.79
NH4-N	0.2
TP	0.108
TN	0.844

NS	Conc.
pH	5.35
EC	2271.5
REDOX	96.4
DO	1.968
NH4-N	0.28
TP	0.082
TN	0.466

NS	Conc.
pH	5.62
EC	26136.5
REDOX	22.6
DO	1.448
NH4-N	0.46
TP	0.08
TN	0.65

FIGURE: 3.3
REVISION: B

PREDEVELOPMENT MONITORING LOCATIONS AND AVERAGE GROUNDWATER QUALITY

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
COHRES: NA
DRAWN: RWW
CHKD: TV

EMERSON STEWART

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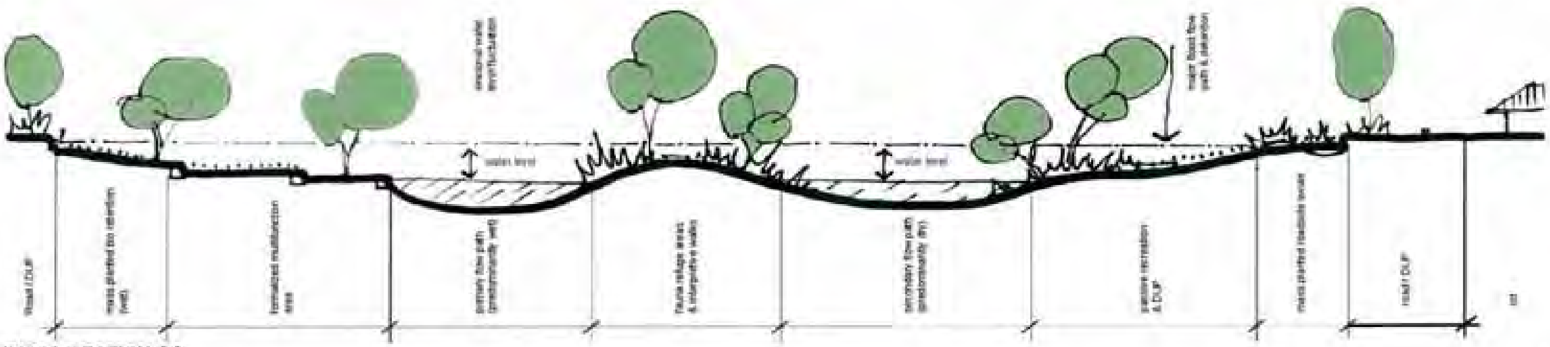
legend

- trees
- creek
- footpath
- picnic area
- activity node

typical plant list

Genus	Species	Common Name	Mature Height (m)
Trees			
Agonis	flexuosa	WA Peppermint	7
Allocasuarina	fraseriana	Common Sheoak	12
Banksia	grandis	Bull Banksia	8
Banksia	ilicifolia	Holly-leaved Banksia	7
Banksia	littoralis	Swamp Banksia	10
Brachychiton	acerifolia	Illawarra Flame Tree	15
Corymbia	calophylla	Marri	25
Eucalyptus	rudis	Flooded Gum	15
Eucalyptus	todtiana	Prickly Bark	10
Fraxinus	oxycarpa 'Raywood'	Claret Ash	22
Melaleuca	preissiana	"Moonah"	10
Melaleuca	rhaphiophylla	Swamp Paperbark	8
Nuytsia	floribunda	"Western" Christmas Tree	8
Xanthorrhoea	preissii	Grass Tree	3
Shrubs			
Allocasuarina	humilis	Dwarf Sheoak	1.5
Beaufortia	elegans	Elegant Beaufortia	1
Beaufortia	squarrosa	Sand Bottlebrush	1.5
Bolboschoenus	caldwellii	Marsh Club-rush	1
Calothamnus	quadrifidus	One-sided Bottlebrush	2
Darwinia	citriodora	Lemon Scented Darwinia	1
Melaleuca	lateritia	Robin Redbreast Bush	2
Verticordia	densiflora		1
Verticordia	plumosa	Plumed Feather Flower	1
Xanthorrhoea	gracilis	Graceful Grass Tree	1
Sedges & Grasses			
Anigozanthos	humilis	Catspaw	0.5
Anigozanthos	manglesii	Mangles Kangaroo Paw	0.5
Anigozanthos	viridis	Green Kangaroo Paw	0.5
Baumea	juncea	Bare Twig-rush	1
Conostylis	aculeata	Prickly Conostylis	0.5
Conostylis	candicans	Grey Cottonheads	0.5
Dianella	divaricata	Flax Lily	1
Ficinia	nodosa	Knotted Club Rush	1
Juncus	kraussii	Sea Rush	1.5
Juncus	pallidus	Pale Rush	2
Lepidosperma	longitudinale	Pithy Sword-sedge	2.0
Orthrosanthus	laxus	Morning Iris	0.5
[illegible]	[illegible]	Sedge	0.6
Schoenus	grandiflorus	Rush	1
Groundcovers			
Brachyscome	iberidifolia	Swan River Daisy	0.3
Dampiera	linearis	Common Dampiera	0.5
Dryandra	nivea	Couch Honeypot	0.4
Eremophila	glabra	Tar Bush	0.3
Hemiandra	pungens	Snake Bush	0.1
Hibbertia	racemosa	Stalked Guinea Flower	0.3
Hovea	pungens	Devil's Pins	0.5



TYPICAL SECTION AA

SOURCE: ECOSCAPE, (MAY 2009)

PRELIMINARY LANDSCAPE LAYOUT PLAN

FIGURE: 4.1
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: DC

EMERSON STEWART

SUBSOIL DRAINAGE LAYOUT

FIGURE: 5.1
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: AWB
CHKD: CL

EMERSON STEWART

LEGEND

PRE-DEVELOPMENT GROUND CONTOUR (mAHD)

12 PRE-DEVELOPMENT AAMGL CONTOUR (mAHD)

BROOKLEIGH ESTATE BOUNDARY

DEPTH TO AAMGL

- SURFACE WATER
- 0 -0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5 - 3.0m

PRE-DEVELOPMENT DEPTH TO AAMGL

FIGURE: 5.2
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE 1:4000
CO-ORDS NA
DRAWN RWB
CHKD CL

EMERSON STEWART

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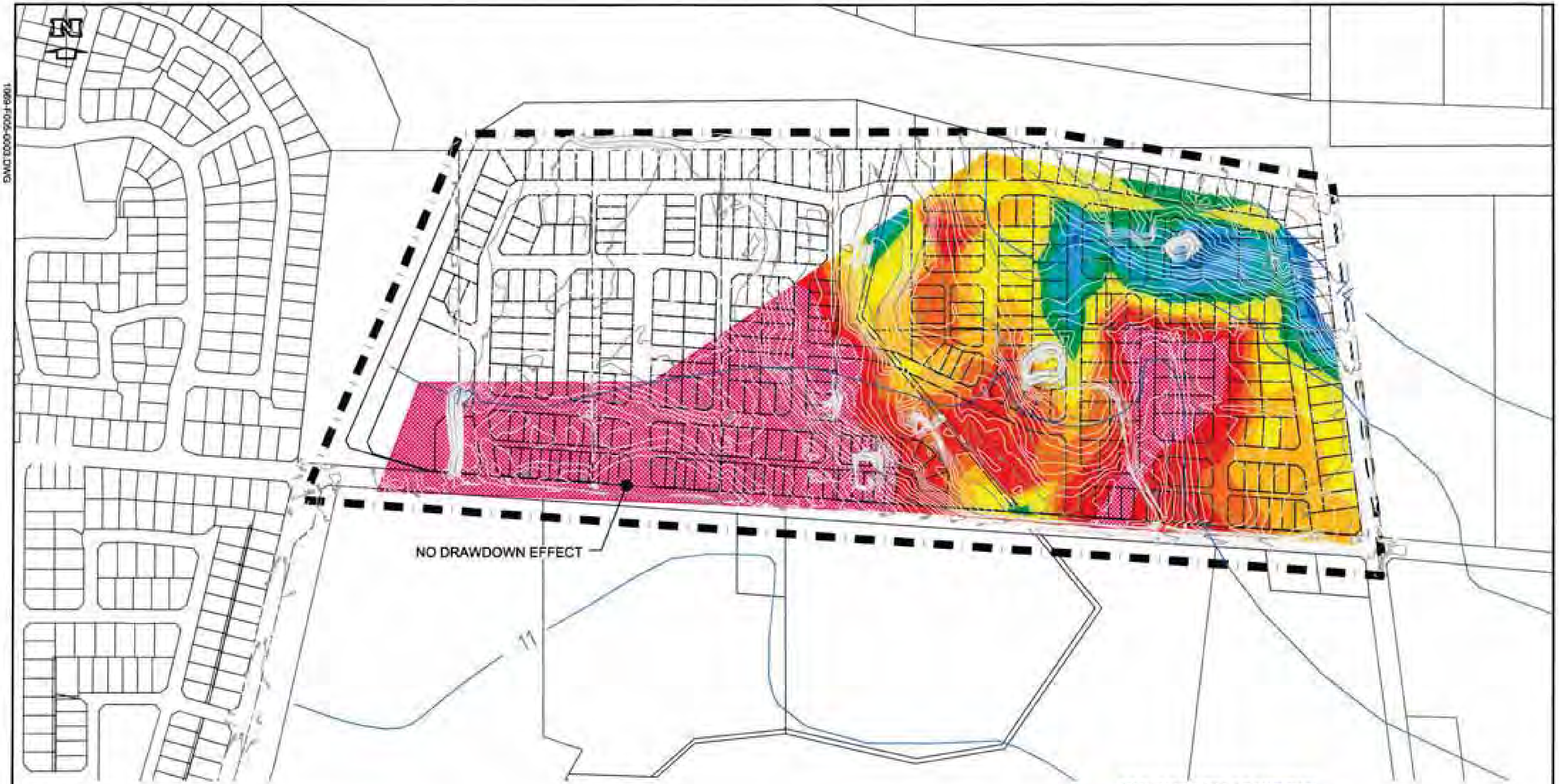

LEGEND

PRE-DEVELOPMENT GROUND CONTOUR (mAHD)

12 PRE-DEVELOPMENT AAMGL CONTOUR (mAHD) - CARDNO 2008

BROOKLEIGH ESTATE BOUNDARY

GROUNDWATER DRAWDOWN

0 - 0.1	0.5 - 0.6
0.1 - 0.2	0.6 - 0.7
0.2 - 0.3	0.7 - 0.8
0.3 - 0.4	0.8 - 0.9
0.4 - 0.5	0.9 - 1.0

GROUNDWATER DRAWDOWN

FIGURE: 5.3
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: 1:4000
CO-ORDS: NA
DRWN: RWB
CHKD: CL

EMERSON STEWART

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FIGURE: 5.4
REVISION: B

MINIMUM LOT LEVEL REQUIRED TO ACHIEVE GROUNDWATER SEPARATION

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

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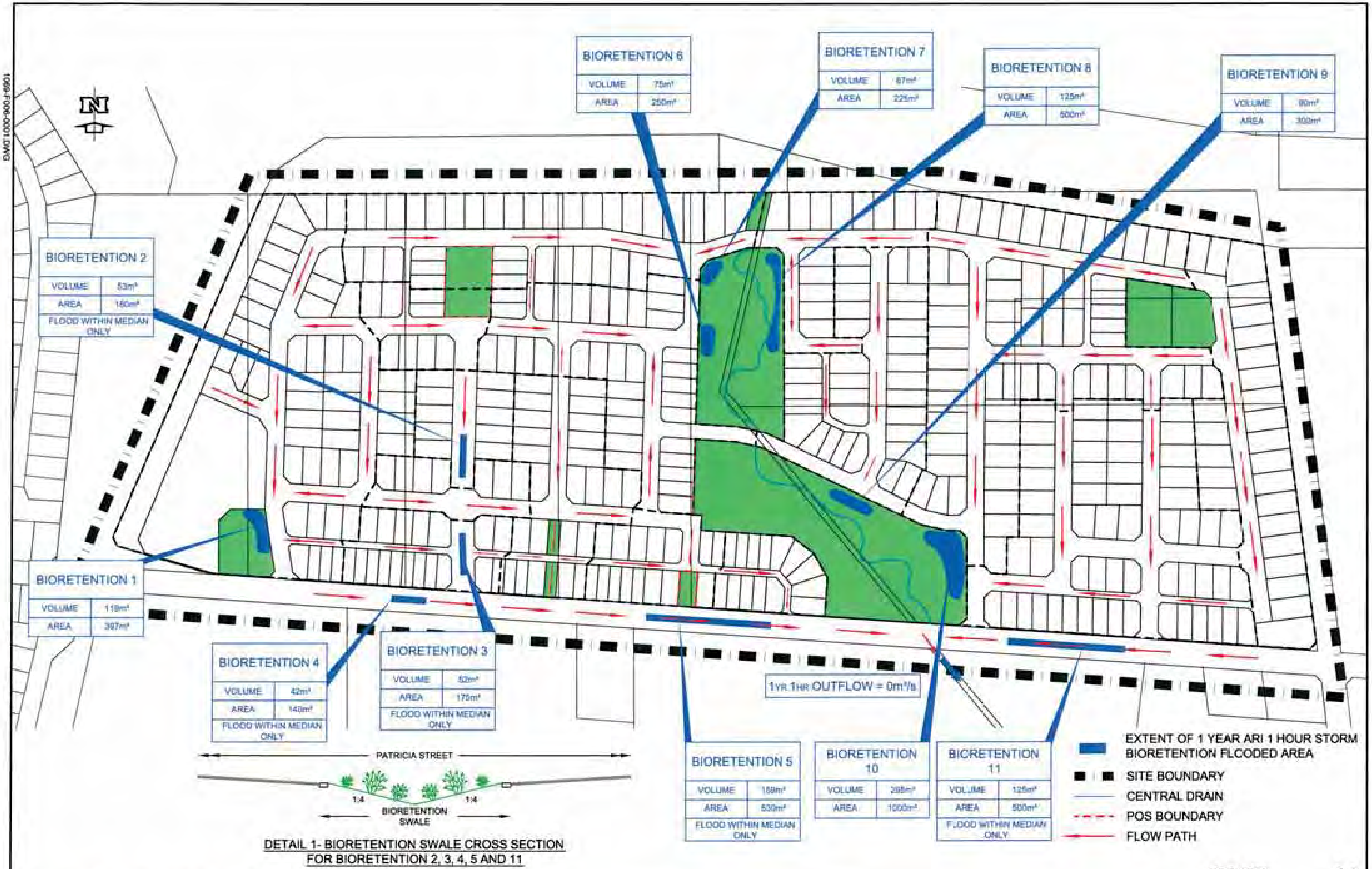

FIGURE: 6.1
REVISION: B

FLOW PATHS AND 1 YEAR 1 HOUR STORAGE VOLUMES

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: BWB
CHKD: CL

EMERSON STEWART

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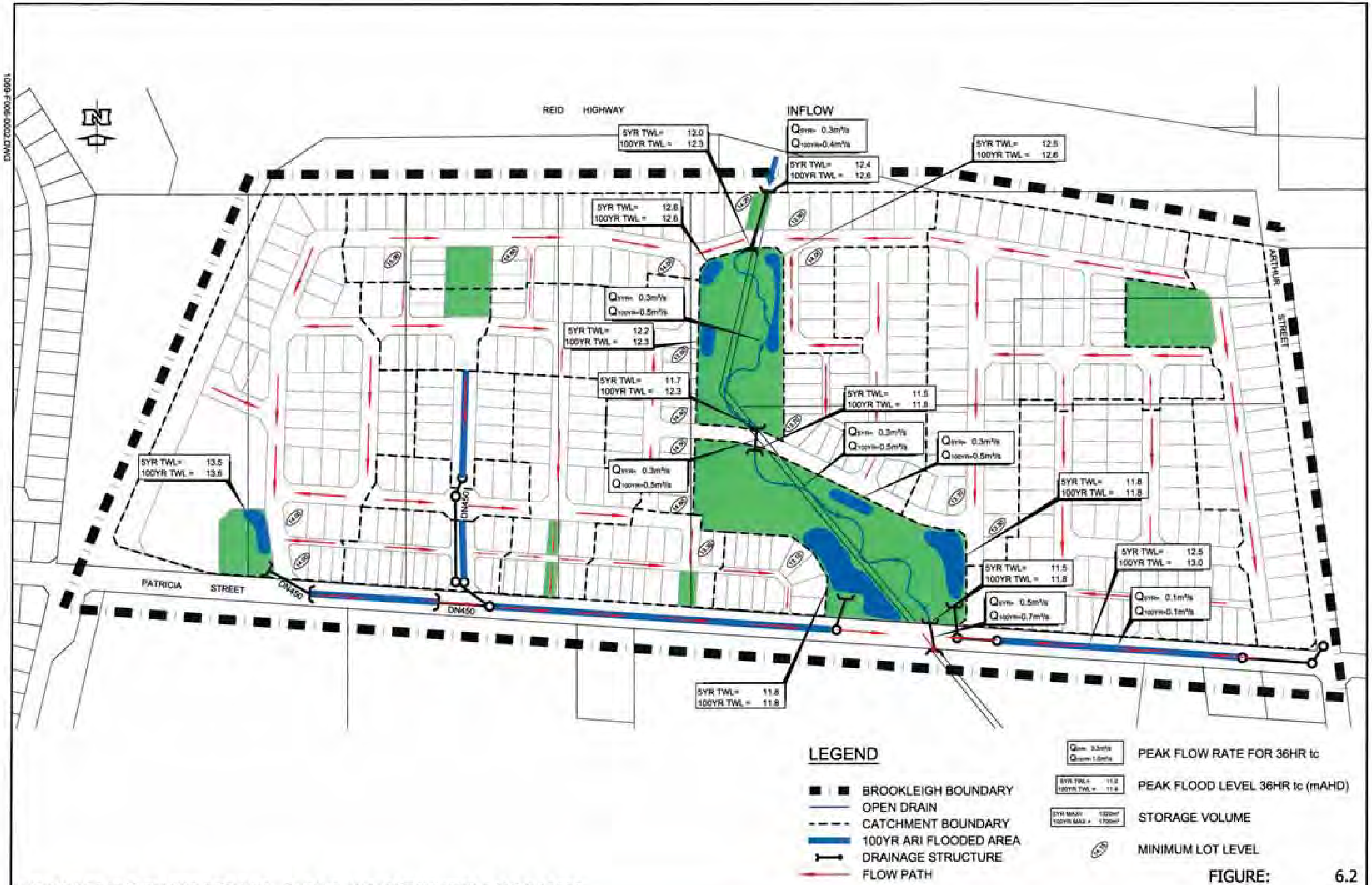

HYDRAULIC MODELLING RESULTS - FLOWS AND CATCHMENT BOUNDARIES

FIGURE: 6.2
REVISION: B

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRAWN: RWE
CHKD: CL

EMERSON STEWART

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FIGURE: 6.3
REVISION: B

5 YEAR 36 HOUR ARI FLOOD AREA & REQUIRED STORAGE VOLUME

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRAWN: BWE
CHKD: CL

EMERSON STEWART

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1069-F006-0004.DWG

FIGURE: 6.4
REVISION: B

100 YEAR 36 HOUR ARI FLOOD AREA & REQUIRED STORAGE VOLUME

1069
BROOKLEIGH ESTATE UWMP
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: CJ

EMERSON STEWART

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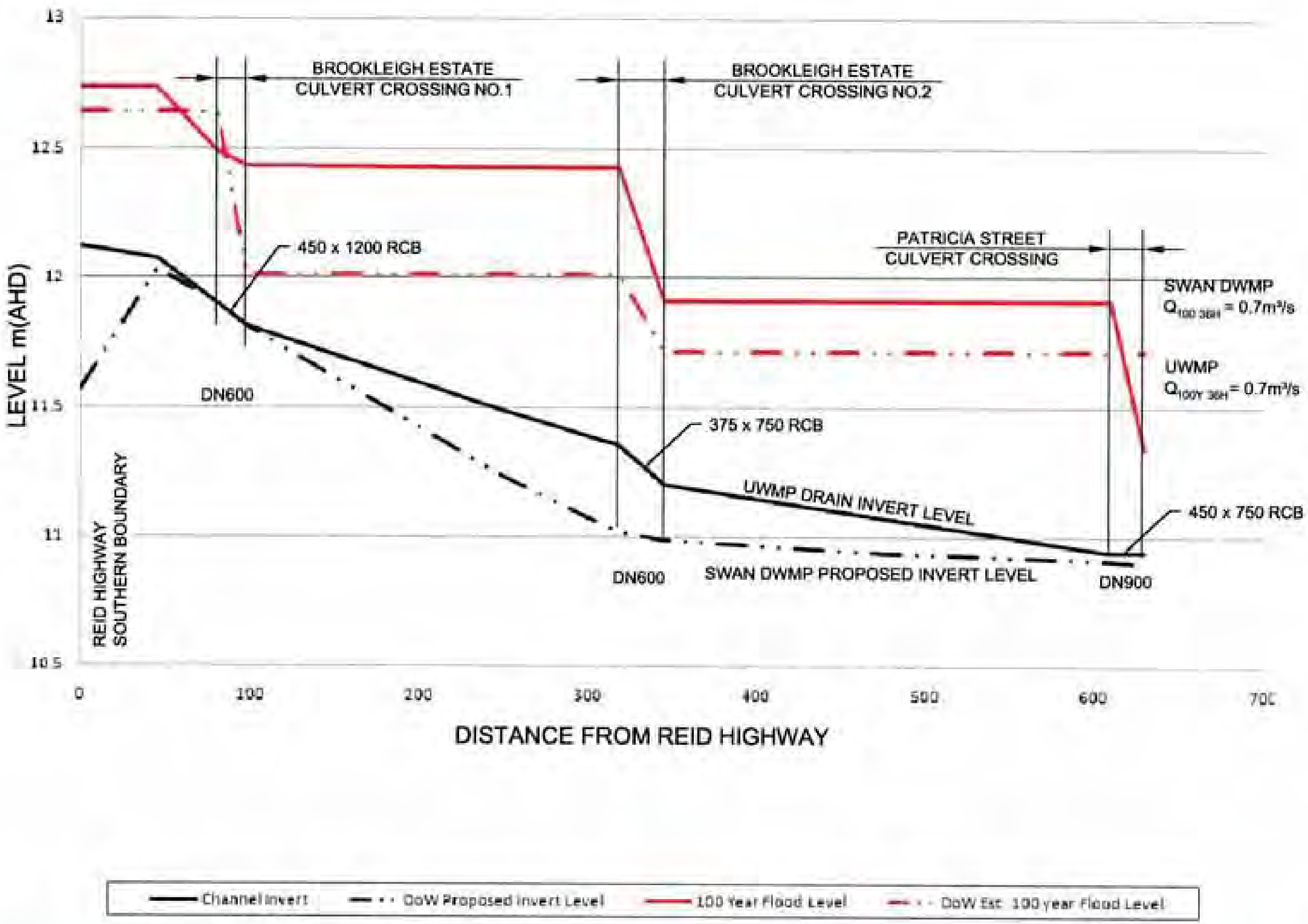

CAVERSHAM WEST CENTRAL DRAIN LONG SECTION - SWAN DWMP VS UWMP

FIGURE: 6.5
REVISION: B

1069
BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE:	NTS
CO-ORDS:	NA
DRWN:	TS
CHKD:	CL

EMERSON STEWART

Cad File: W:\Infrastructure\Infrastructure_Projects\1069_Caversham Subdivision - QUBE (ex 1080671)\08_CaddGis\Drawings\UWMP FIGURES\1069-F006-0005.DWG
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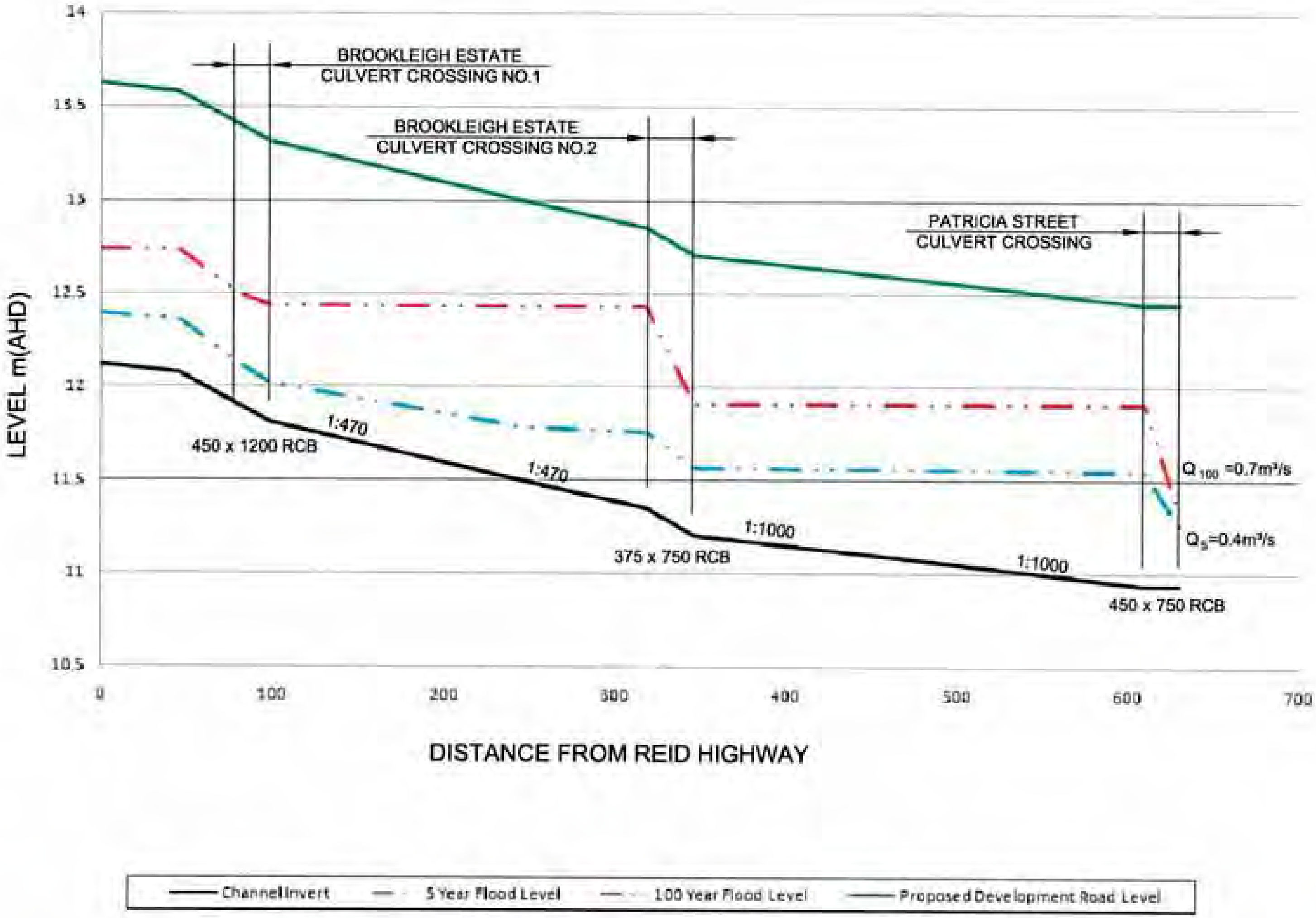

CAVERSHAM WEST - PROPOSED CENTRAL DRAIN LONG SECTION

FIGURE: 6.6
REVISION: B

1069
BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: CL

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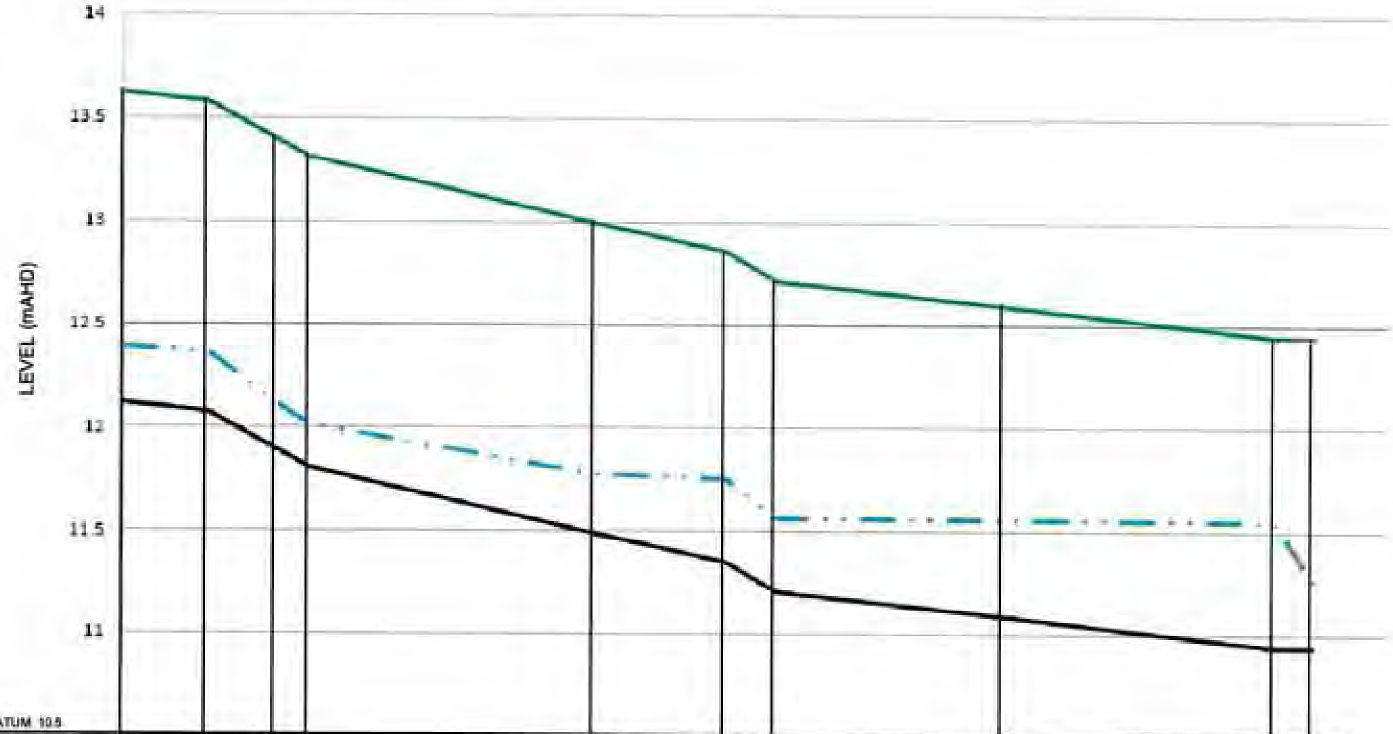
Plotted By: troy.stedman Plot Date: 03/12/09 - 10:25

1069-F006-0007.DWG



DATUM 10.5

CHAINAGE	0	45	80	98	248	318	345.5	465.5	609.8	629.5
INVERT RL	12.12	12.07	11.9	11.81	11.49	11.35	11.20	11.08	10.94	10.94
GRADE	1:1000	1:200	1:200	1:470	1:470	1:200	1:1000	1:1000		
VELOCITY	0.3	0.8	1.0	0.4	0.3	1.1	0.3	0.3	1.4	
MAX WATER LEVEL	12.4	12.4	12.1	12.0	11.8	11.7	11.5	11.5	11.5	11.2
FLOW (Q) m³/s 5 YEAR 36H	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	
DEPTH		0.3	0.3	0.2	0.3	0.4	0.4	0.4	0.6	0.6

5 YEAR, 36 HOUR ARI
CAVERSHAM WEST - CENTRAL DRAIN LONG SECTION

FIGURE: 6.7
REVISION: B

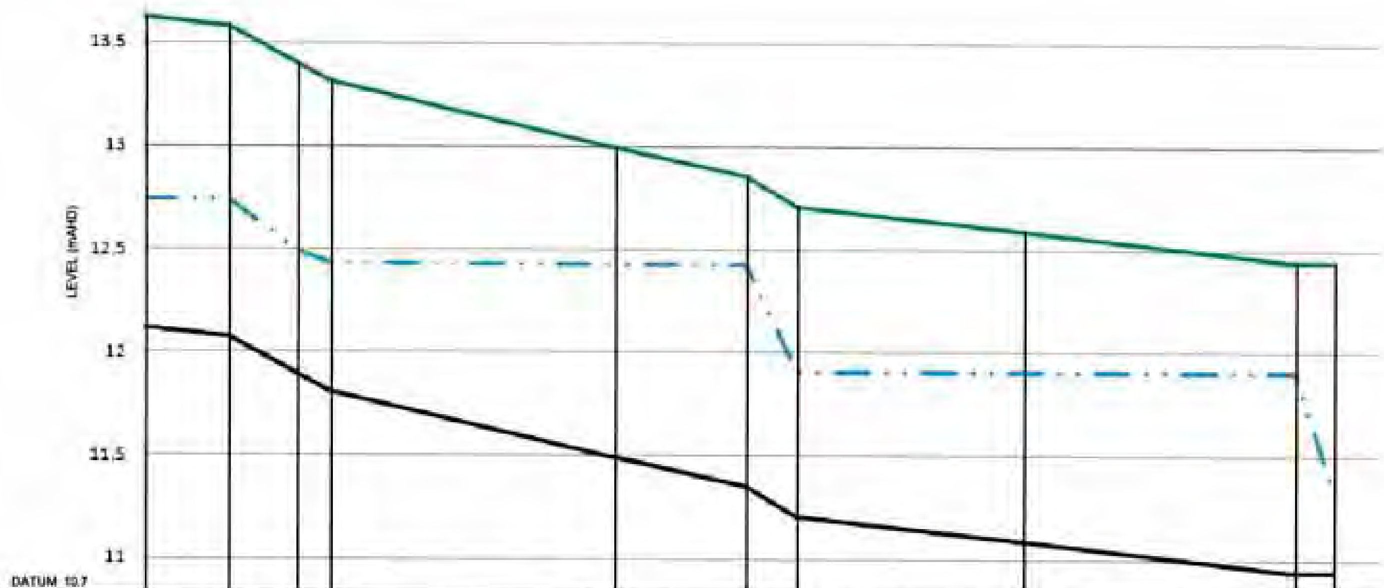
1069
CAVERSHAM SUBDIVISION
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: CL

EMERSON STEWART

Cad File: W:\Infrastructure\Infrastructure_Projects\1069_Caversham Subdivision - QUBE (ex 1080671)\08_CaddGis\Drawings\UWMP FIGURES\1069-F006-0007.DWG
Plotted By: troy.stedman Plot Date: 03/12/09 - 10:26

1069-F006-0008.DWG



CHAINAGE	0	48	80	98	248	318	348.5	465.5	609.5	629.5
INVERT RL	12.12	12.07	11.90	11.81	11.49	11.36	11.20	11.08	10.94	10.94
GRADE	1:1000	1:200	1:200	1:470	1:470	1:200	1:1000	1:1000		
VELOCITY	0.3	0.9	1.0	0.4	0.3	1.7	0.3	0.3	2.1	
MAX WATER LEVEL	12.6	12.6	12.4	12.3	12.3	12.3	11.9	11.9	11.8	11.3
FLOW (Q) m³/s 100 YEAR 36H	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.7	0.7
DEPTH		0.5	0.5	0.5	0.8	0.9	0.8	0.7	0.9	0.9
VELOCITY x DEPTH PRODUCT (m²/s)		0.1			0.1	0.3		0.1	0.2	

Channel Invert — 100 Year Flood Level — Proposed Development Road Level

100 YEAR, 36 HOUR ARI
CAVERSHAM WEST - CENTRAL DRAIN LONG SECTION

FIGURE: 6.8
REVISION: B

1069
CAVERSHAM SUBDIVISION
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: CL

EMERSON STEWART

Cad File: W:\Infrastructure\Infrastructure_Projects\1069_Caversham Subdivision - QUBE (ex 1080671)\08_CaddGis\Drawings\UWMP FIGURES\1069-F006-0008.DWG
Plotted By: troy.stedman Plot Date: 03/12/09 - 10:26

FIGURE: 9.1
REVISION: A

PROPOSED MONITORING LOCATIONS

1069
CAVERSHAM SUBDIVISION
QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: RODRIGUEZ
CHKD: C.LET

EMERSON STEWART

Cad File: W:\Infrastructure\Infrastructure_Projects\1069_Caversham Subdivision - QUBE (ex 1080671)\08_CaddGis\Drawings\UWMP FIGURES\1069-F009-0001.DWG
Plotted By: brett.worley Plot Date: 30/11/09 - 18:10

APPENDIX B
GEOTECHNICAL BORE LOGS

TEST PIT ENGINEERING LOG

TEST PIT NO.

BH01

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	23/11/07
Project:	Caversham North	Date Completed:	23/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	SE

Excavation Method: EVH 21000

Surface RL: 11.42 m
Co-ords: E 402674 N 6473875

Depth (m)	Field Test	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.30			CH	TOPSOIL, Clayey SAND, sand is medium to fine grained, dark grey, fines of high plasticity	D
0.30–2.20			SC	Gravelly Clayey SAND, medium to fine grained, light grey/brown, clay of low plasticity, gravel is cemented silty sand pieces to 26.5mm	M
2.20–2.60		U63	SC	Silty Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity	
2.60–5.50	3,4,7 N=11	U63; SPT	CH	Sandy CLAY, high plasticity, orange/brown and light grey mottled, sand is fine to medium grained ...as above, Silty CLAY	
5.50–6.70			SP	SAND, coarse to medium grained, grey and yellow/brown, some fine gravel	W
6.70–7.40	7,11,15 N=26	SPT	SM	Silty SAND, fine to medium grained, light grey and orange/brown mottled, some silt fines of low plasticity	M
7.40–9.10	4,6,5 N=11	SPT	CH	Silty Sandy CLAY, high plasticity, light grey with dark brown mottling, sand is fine grained. Lenses of Silty SAND throughout	
9.10–10.00	4,6,10 N=16	SPT	SM	Silty SAND, medium to fine grained, light grey and orange/brown mottled, silt and clay fines of low plasticity	W
10.00				END OF TEST PIT AT 10.00 m	

Water: 23/11/07 (at approx. 1.0 m); 23/11/07 (at approx. 3.5 m)

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP01

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	14.89 m
		Co-ords:	E 402903 N 6474161

1 WATER	2 RL(m)	2 DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.15				SP	SAND, medium to fine grained, dark grey	M			
				B		SP	SAND, medium to fine grained, light grey/brown				
	14	1									
	13	2					Becoming brown	W			
		2.50				SC	Clayey SAND, medium to fine grained, light grey and orange/brown, clay fines of medium plasticity				
NFGWE	12	3					END OF TEST PIT AT 3.00 m				Test pit collapsing
	11	4									
	10	5									
	9										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP02
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	14.83 m
		Co-ords:	E 402850 N 6474155

Water	RL(m)	Depth(m)	Field Test	Sample	Graphic Log	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density/Consistency	Hand Penetrometer (kPa)	Structure and Additional Observations
		0.00				SP	SAND, medium to fine grained, dark grey	M	F		Heavy tree roots and grass roots to 0.6m
▼ (~14)		0.40				SP	SAND, medium to fine grained, light grey/brown	M / W	F		
		2.00				SC	Clayey SAND, medium to fine grained, dark brown/orange/brown and grey, clay fines of medium plasticity	W	MD		
		2.50					END OF TEST PIT AT 2.50 m				Test pit collapsing

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP03
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	14.10 m
		Co-ords:	E 402793 N 6474154

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	14 / 0.15				SM	TOPSOIL, Silty SAND, medium to fine grained, dark grey	M			
	0.40				SP	SAND, medium to fine grained, light grey/brown				
	0.70		D		SP	SAND, fine to medium grained, brown and orange/brown, trace of silt fines				
	1 / 13 / 1.20		D		CI	Sandy CLAY, medium plasticity, brown. Sand is fine to medium grained				
	1.60		D		SC	Silty Clayey SAND, fine to medium grained, light grey/orange/brown mottled, clay fines of low to medium plasticity				
	2 / 12 / 2.40				SC	Gravelly Clayey SAND, fine to medium grained, red/brown, clay fines of low to medium plasticity, ferrigunous				
NFGWE	3		D		SC	Silty Clayey SAND, fine to medium grained, orange/brown and light grey, clay fines of medium plasticity				Refusal - limit of excavator
	11 / 4 / 10 / 5 / 9					END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP04

SHEET 1 OF 1

Client:	**Cardno BSD**		Date Commenced:	**5/11/07**
Project:	**Caversham North**		Date Completed:	**5/11/07**
Test Pit Location:	**Caversham**		Recorded By:	**PN**
Project Number:	**2100593A**		Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**		Surface RL:	**14.13 m**
			Co-ords:	**E 402744 N 6474148**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	14	0.20				SM	TOPSOIL, Silty SAND, medium to fine grained, light grey/brown	D			
		0.40				SP	SAND, medium to fine grained, light grey/brown	M			
		0.70		D		SC	Clayey SAND, fine to medium grained, light brown and orange brown, clay fines of high plasticity				
	13	1.10				SC	Silty Clayey SAND, fine to medium grained, light grey with some orange/brown mottling, clay fines of medium plasticity				
	12					SC	Silty Clayey SAND, fine to medium grained, orange/brown and light grey, clay fines of medium plasticity				
NFGWE	11	3					END OF TEST PIT AT 3.00 m				
	10	4									
	9	5									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP05

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**5/11/07**
Project:	**Caversham North**	Date Completed:	**5/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **13.04 m**
Co-ords: **E 402744 N 6474106**

Depth (m)	RL (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density / Consistency	Structure and Additional Observations
0.00–0.15	13.04		SM	TOPSOIL, Silty SAND, medium to fine grained, grey	D		
0.15–0.90			SM	Silty SAND, fine to medium grained, grey/brown and orange/brown, silt fines of low plastcity	M		
0.90–1.20			CH	Silty CLAY, high plasticity, brown			
1.20–2.60		U60	CH	Sandy Silty CLAY, high plasticity, light brown and yellow/brown. Sand is fine to medium grained			
2.60–3.60		D	CI	Silty Sandy CLAY, medium plasticity, light grey and orange/brown, sand is fine to medium grained, some red/brown ferrigunous gravel pieces to 19mm			
3.60				END OF TEST PIT AT 3.60 m			

Water: NFGWE

Column headings: 1 WATER; 2 RL(m) DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD; 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP06

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.19 m
		Co-ords:	E 402792 N 6474102

1 WATER	2 RL(m)	2 DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
	13	0.20				SM	TOPSOIL, Silty SAND, fine to medium grained, grey	D	L		
	12	1				SP	SAND, medium to fine grained, light brown	M / W (from 1.00)	MD		
▼		1.60				GP	Sandy GRAVEL, fine to medium sized, grey		D		
	11	1.70 / 2				SC	Gravelly Clayey SAND, medium to fine grained, light grey and orange/brown, clay fines of medium plasticity		D		
	10	3					END OF TEST PIT AT 3.00 m				
	9	4									
	8	5									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP07

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator

Surface RL: 13.38 m

Co-ords: E 402845 N 6474101

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.00–0.15		SM	TOPSOIL, Silty SAND, fine to medium grained, grey	D	
0.15–0.55		SP	SAND, medium to fine grained, light grey/brown	M	
0.55–0.70	D	CH	Silty CLAY, high plasticity, dark brown, some fine grained sand		
0.70–2.80	D	SC	Silty Clayey SAND, fine to medium grained, yellow and orange/brown, clay fines of medium plasticity Ferruginous bands to 150mm		Very slow digging ~~Refusal - limit of excavator~~
2.80			END OF TEST PIT AT 2.80 m		

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

WATER: NFGWE

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP08

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**5/11/07**
Project:	**Caversham North**	Date Completed:	**5/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**13.68 m**
		Co-ords:	**E 402914 N 6474086**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.15				SM	TOPSOIL, Silty SAND, fine to medium grained, grey	M			
	13	0.80				SP	SAND, medium to fine grained, light grey/brown				
		0.90				SM	Silty SAND (coffee rock), fine to medium grained, dark brown, trace of silt fines of low plasticity. Cemented ferruginised red/brown pieces				
▼		1		D		CH	Sandy CLAY, high plasticity, light grey, yellow and orange/brown, sand is fine to medium grained				
	12	1.60				SC	Silty Clayey SAND, medium to fine grained, light grey, yellow and orange/brown, clay fines of medium plasticity				
	11	2									
		3					END OF TEST PIT AT 3.00 m				
	10	4									
	9	5									
	8										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP09

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.33 m
		Co-ords:	E 401964 N 6473921

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.15		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M
0.15–0.60		SP	SAND, medium to fine grained, light grey/brown	
0.60–1.00		SC	Clayey SAND, fine to medium grained, orange/brown, clay fines of medium plasticity	
1.00–1.70	D	CH	Sandy CLAY, high plasticity, light brown and orange/brown, sand is fine to medium grained	W
1.70–3.20	D	SC	Gravelly Silty Clayey SAND, fine to medium grained, light grey/brown, clay fines of low to medium plasticity, Gravel is angular pieces of ironstone	
			END OF TEST PIT AT 3.20 m	

Column headings: Test Pit Information (1 WATER, 2 RL(m) / DEPTH(m), 3 FIELD TEST, 4 SAMPLE); Field Material Description (5 GRAPHIC LOG, 6 USC SYMBOL, 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 8 MOISTURE, 9 RELATIVE DENSITY /CONSISTENCY VS S F FB VL L ST MD VST D H VD, 10 HAND PENETROMETER (kPa), 11 STRUCTURE AND ADDITIONAL OBSERVATIONS)

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP10

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.40 m
		Co-ords:	E 401967 N 6474018

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.00–0.20		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M	
0.20–0.50		SP	SAND, fine to medium grained, light grey/brown		
0.50–0.75		SC	Silty Clayey SAND, fine to medium grained, grey/brown and orange/brown, clay fines of low plasticity		
0.75–1.10		SC	Gravelly Clayey SAND, fine to medium grained, orange/brown and red/brown, clay fines of medium plasticity		
1.10–1.90	U60	CH	Silty Sandy CLAY, high plasticity, light grey/brown, sand is fine to medium grained, some fine sized gravel		
1.90–2.40		SC	Silty, Clayey SAND, fine to medium grained, light grey and orange/brown, clay fines of medium plastcity Cemented, less clay	W	Refusal - limit of excavator
2.40			END OF TEST PIT AT 2.40 m		

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP11
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.55 m
		Co-ords:	E 401980 N 6474121

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.20				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M			
	13 / 0.70				SP	SAND, fine to medium grained, light grey/brown				
	0.80				SP	Ferruginised layer of Gravelly SAND, dark brown and light grey/brown, pieces to 100mm				
	1 / 12 / 1.90				CH	Gravelly Sandy CLAY, high plastcity, light brown and orange/brown, sand is fine to medium grained, fine to medium sized gravel pieces to 19mm				
▽ ▼	2 / 11				SM	Gravelly Silty SAND, fine to medium grained, light grey/brown and orange/brown mottled, clay and silt fines of low plasticity, weakly cemented Becoming strongly cemented	W			
	3 / 10 / 4 / 9 / 5 / 8					END OF TEST PIT AT 2.70 m				Refusal - limit of excavator

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP12

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.30 m
		Co-ords:	E 401982 N 6474219

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density/Consistency	Structure and Additional Observations
0.00–0.15		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M		
0.15–0.55		SP	SAND, fine to medium grained, light grey/brown			
0.55–0.90	D	SC	Silty Clayey SAND, fine grained, light grey/brown, clay fines of medium to high plasticity			
0.90–2.40	D	SC	Gravelly Clayey SAND, fine grained, light grey, clay fines of medium plasticity, gravel is fine to medium sized pieces			
2.40–3.20		CI	Silty CLAY, medium plasticity, light grey/brown, sand is fine grained	W		
3.20			END OF TEST PIT AT 3.20 m			

Column headings: 1 WATER, 2 RL(m) / DEPTH(m), 3 FIELD TEST, 4 SAMPLE, 5 GRAPHIC LOG, 6 USC SYMBOL, 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 8 MOISTURE, 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD), 10 HAND PENETROMETER (kPa), 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP13
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator

Surface RL: 13.21 m
Co-ords: E 402092 N 6474208

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	13 / 0.15				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M			
			U60		SC	Silty Clayey SAND, fine to medium grained, light grey/brown, clay fines of high plasticity				
	12 / 1.00				SC	Gravelly Clayey SAND, fine grained, light grey, clay fines of medium plasticity, gravel is fine to medium sized pieces	W			
	11 / 2.00				SM	Silty SAND, fine to medium grained, light grey and orange/brown, trace of silt fines of low plasticity, cemented				Very slow digging
						END OF TEST PIT AT 2.80 m				~~Refusal - limit of excavator~~

RL(m): 13, 12, 11, 10, 9, 8
DEPTH(m): 1, 2, 3, 4, 5

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP14

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	5/11/07
Project:	Caversham North	Date Completed:	5/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator

Surface RL: 13.56 m
Co-ords: E 402094 N 6474105

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.15	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M
0.15–0.40	SP	SAND, fine to medium grained, light grey/brown	
0.40–0.90	SM	Gravelly, Silty SAND, medium to fine grained, light grey and orange/brown, ferruginous rounded gravel to 19mm	
0.90–1.70	CH	Silty CLAY, high plasticity, light grey/brown, sand is fine grained	
1.70–2.80	CL	Silty CLAY, low plasticity, light grey, some fine grained sand	
2.80–3.00	SC	Clayey SAND, medium to fine grained, light grey/brown and orange/brown, clay fines of medium plasticity	
3.00		END OF TEST PIT AT 3.00 m	

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

Water: N F G W E

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP15

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**5/11/07**
Project:	**Caversham North**	Date Completed:	**5/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**13.58 m**
		Co-ords:	**E 402099 N 6474012**

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.20	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	M
0.20–0.50	SP	SAND, fine to medium grained, light grey/brown	
0.50–0.90	CH	Silty CLAY, high plasticity, light grey/brown and orange/brown, sand is fine to medium grained	
0.90–1.10	CI	Gravelly Silty CLAY, medium plasticity, light grey/brown, sand is fine to medium grained, gravel pieces to 19mm	
1.10–1.30	SM	Cemented Silty SAND, fine to medium grained, light grey	
1.30–2.40	CI	Gravelly Silty CLAY, medium plasticity, light grey/brown. Sand is fine to medium grained, gravel is fine to medium sized pieces	W
2.40–3.00	CL	Silty Sandy CLAY, low plasticity, light brown and orange/brown, sand is fine grained	
3.00		END OF TEST PIT AT 3.00 m	

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY/CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

RL scale: 13, 12, 11, 10, 9, 8. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP16
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.24 m
		Co-ords:	E 402116 N 6473913

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	13	0.20				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey/brown	M			
		0.60				SP	SAND, fine to medium grained, light grey/brown				
		0.80				SC	Silty Clayey SAND, medium to fine grained, brown / light grey, clay fines of low plasticity				
	12	2.40				CL	Silty CLAY, low plasticity, brown and orange/brown, sand is fine grained				
	11					CI	Silty CLAY, medium plasticity, light grey and orange/brown, sand is fine to medium grained				
NFGWE	10	3					END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP17
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.13 m
		Co-ords:	E 402216 N 6473912

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	13	0.00–0.20				SM	Silty SAND, fine to medium grained, dark brown	M	MD		
		0.20–1.10				SM	Silty SAND, medium to fine grained, brown	M / W	MD		
	12	1.10–1.40				CH	Sandy CLAY, high plasticity, light grey/brown, sand is fine to medium grained	M	ST		
NFGWE	11	1.40–2.30				SC	Gravelly, Clayey SAND, fine to medium grained, light grey/brown and orange/brown, clay fines of low plasticity, cemented Strongly cemented		VD		Very slow digging ~~Refusal - limit of excavator~~
		2.30					END OF TEST PIT AT 2.30 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO. **TP18**

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **14.01 m**

Co-ords: **E 402236 N 6474034**

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D
0.10–0.40	CH	Sandy CLAY, high plasticity, brown, sand is fine to medium grained	M
0.40–2.70	SC	Silty Clayey SAND, medium to fine grained, light grey and brown, clay fines of low plasticity, weakly cemented	D
2.70–3.20	CI	Silty CLAY, medium plasticity, dark brown, some fine grained sand	M
		END OF TEST PIT AT 3.20 m	

Water: NFGWE

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO. **TP19**

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.81 m
		Co-ords:	E 402235 N 6474130

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.20				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey/brown	M			
		0.50				SP	SAND, medium to fine grained, light grey/brown				
	13	1		D		CH	Silty CLAY, high plasticity, light grey/brown and orange/brown mottled, sand is fine grained. Lenses of white				Fissured and slickensided
	12	2									
NFGWE	11	2.40 / 3		D		CH	Silty CLAY, high plasticity, dark brown, some fine grained sand				
	10	4					END OF TEST PIT AT 3.00 m				
	9	5									
	8										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP20

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator

Surface RL: 14.20 m

Co-ords: E 402213 N 6474217

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	14.2	0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey/brown	D			
		0.80				SP	SAND, fine to medium grained, light grey/brown		L–MD		
		1.30				CH	Sandy CLAY, high plasticity, light grey/brown and orange/brown mottled. Sand is coarse to fine grained	M	ST		
NFGWE		3.00				SC	Silty Clayey SAND, medium to fine grained, light grey/brown, clay fines of low plasticity, weakly cemented Becoming grey/brown	D	D–VD		
							END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP21

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.30 m
		Co-ords:	E 402327 N 6474228

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.10		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey/brown	D	
0.50		SM	Silty SAND, fine to medium grained, grey		
1.00	D	SC	Silty Clayey SAND, fine grained, dark grey/brown, clay fines of high plasticity	M	Fissured and slickensided
2.20		SC	Gravelly Clayey SAND, coarse to fine grained, light grey/brown, clay fines of medium plasticity		
3.40	D	CI-CH	Silty Sandy CLAY, medium to high plasticity, light grey/brown, sand is fine grained Becoming light grey/brown and orange/brown	W	
			END OF TEST PIT AT 3.40 m		

Column headings: 1 WATER, 2 RL(m) / DEPTH(m), 3 FIELD TEST, 4 SAMPLE, 5 GRAPHIC LOG, 6 USC SYMBOL, 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 8 MOISTURE, 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD), 10 HAND PENETROMETER (kPa), 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP22
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.69 m
		Co-ords:	E 402330 N 6474102

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey/brown	D
0.10–0.50	SM	Silty SAND, fine to medium grained, grey	
0.50–0.90	CH	Silty CLAY, high plasticity, dark grey/brown	M
0.90–2.90	CL	Silty Sandy CLAY, low plasticity, light grey/brown, sand is fine to medium grained	
		Becoming dark orange/brown	D
2.90–3.20	SM	Silty SAND, fine to medium grained, dark brown and light grey, fines of low plasticity, cemented	
		END OF TEST PIT AT 3.20 m	

Columns: 1 WATER, 2 RL(m), 3 DEPTH(m), FIELD TEST, 4 SAMPLE, 5 GRAPHIC LOG, 6 USC SYMBOL, 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 8 MOISTURE, 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD), 10 HAND PENETROMETER (kPa), 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

Water: NFGWE

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP23
SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**13.77 m**
		Co-ords:	**E 402334 N 6474016**

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F St VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	0.50				SP	SAND, fine to medium grained, light grey				
	0.80				CH	Sandy CLAY, high plasticity, light grey/brown. Sand is fine to medium grained	M			
	13 / 1.90				SC	Silty Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity, weakly cemented				
	12 / 2.80				CL	Silty, Sandy CLAY, low plasticity, light grey, sand is fine to medium grained	W			
						Becoming dark orange/brown	M			
N F G W E	11 / 3				CI	Sandy CLAY, medium plasticity, light grey/brown, sand is fine to medium grained				
						END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP24

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **13.40 m**

Co-ords: **E 402339 N 6473906**

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	13				SM	Silty SAND, fine to medium grained, orange/brown, silt and clay fines of low plasticity				
	0.90 / 1				SC	Gravelly, Clayey SAND, medium to fine grained, light grey/brown and orange/brown and red/brown, clay fines of low plasticity, ferruginised with cemented pieces to 50mm				
	12					Clay fines of medium plasticity, no red/brown	M			
	1.90 / 2				SM	Silty SAND, medium to fine grained, light grey and orange/brown, silt fines of low plasticity, weakly cemented				
NFGWE	11					Becoming strongly cemented, ferruginised pieces to 100mm	D			Very slow digging
						END OF TEST PIT AT 2.60 m				Refusal - limit of excavator
	3									
	10									
	4									
	9									
	5									
	8									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP25

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **13.72 m**

Co-ords: **E 402410 N 6473922**

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	0.40				CH	Silty CLAY, high plasticity, dark grey/brown	M			
	2.40				SC	Gravelly Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity, some cemented gravel pieces	D / M			
	2.80				CI	Silty CLAY, medium to low plasticity, orange/brown and grey/brown. Some fine to medium grained sand				
NFGWE	3.00				SM	Cemented Silty SAND, fine to medium grained, orange/brown and light grey mottled. Strongly cemented pieces to 50mm, ferruginised	D			~~Very slow digging~~
						END OF TEST PIT AT 3.00 m				

RL scale: 13, 12, 11, 10, 9, 8. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP26

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **12.50 m**
Co-ords: **E 402412 N 6474028**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.10				SM-SC	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
		0.45				CH	Silty CLAY, high plasticity, dark grey/brown	M			
	12					SC	Gravelly Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity, some cemented sand gravel pieces to 100mm				
	10	2.40				CL	Silty Sandy CLAY, low plasticity, orange/brown, sand is fine to medium grained				
NFGWE		3					END OF TEST PIT AT 3.00 m				

RL scale: 12, 11, 10, 9, 8, 7. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP27
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator
Surface RL: 12.46 m
Co-ords: E 402413 N 6474122

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.15				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	0.40				SP	SAND, fine to medium grained, light grey	M			
	0.50				CH	Silty CLAY, high plasticity, dark brown, some fine grained sand				
	1.20				CI	Silty Sandy CLAY, medium plasticity, light grey and dark brown, sand is fine to medium grained. Some cemented sand pieces to 26mm				
	2.20				CL	Silty, Sandy CLAY, low plasticity, light grey. Sand is fine to medium grained				
NFGWE	3.00		D		CI	Silty CLAY, medium plasticity, light grey and orange/brown mottled, some fine grained sand				
						END OF TEST PIT AT 3.00 m				

RL scale: 12, 11, 10, 9, 8, 7. Depth scale: 1, 2, 3, 4, 5.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP28

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **12.59 m**
Co-ords: **E 402407 N 6474215**

Test Pit Information | **Field Material Description**

1 WATER	2 RL(m) / DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.00–0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	0.10–0.35				SP	SAND, fine to medium grained, light grey	M			
	0.35–0.65				CH	Sandy CLAY, high plasticity, dark grey/brown, sand is fine to medium grained				
	0.65–0.85		D		SM	Cemented Silty SAND, fine grained, light grey and light brown, very strong, extremely weathered, laminar, tending to limestone				
	0.85–2.30				SC	Gravelly Clayey SAND, fine to medium grained, light grey, clay fines of low plasticity, gravel is cemented sand pieces to 9.5mm				
	2.30–3.00				CI	Silty CLAY, medium plasticity, light grey and orange/brown, sand is fine to medium grained				
NFGWE	3.00					END OF TEST PIT AT 3.00 m				

RL scale: 12, 11, 10, 9, 8, 7. Depth scale: 1, 2, 3, 4, 5.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP29

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**11.84 m**
		Co-ords:	**E 402484 N 6474017**

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.00–0.15				SC	TOPSOIL, Clayey SAND, fine to medium grained, dark grey	M			
	0.15–1.30		D		CH	Sandy CLAY, high plasticity, dark grey/brown, sand is fine to medium grained Becoming brown				
	1.30–3.00		D		CH	Silty CLAY, high plasticity, light grey and yellow/brown, some fine grained sand				Slickensided
NFGWE	3.00					END OF TEST PIT AT 3.00 m				

RL scale: 11, 10, 9, 8, 7, 6. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP30

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **12.34 m**
Co-ords: **E 402506 N 6473914**

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density / Consistency
0.00–0.15	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D	MD
0.15–0.70	SP	SAND, fine to medium grained, light grey/brown	M	MD
0.70–1.40	CI	Sandy CLAY, medium plasticity, light grey/brown, sand is fine to medium grained		ST
1.40–2.90	SC	Gravelly Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity, some cemented sand gravel pieces to 26.5mm		D
2.90–3.20	CI	Silty CLAY, medium to low plasticity, light grey and orange/brown, some fine to medium grained sand		ST
		END OF TEST PIT AT 3.20 m		

Water: NFGWE

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP31
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**
Surface RL: **11.43 m**
Co-ords: **E 402586 N 6473901**

1 WATER	2 RL(m)	DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / VL L MD D VD FB)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.10				SC	TOPSOIL, Silty, Clayey SAND, fine to medium grained, dark grey, fines of medium plasticity	M			
	11					CH	Silty CLAY, high plasticity, dark grey/brown				
				U60			Becoming orange/ brown with some fine grained sand and some fine sized gravel				
	10	1									
		2									
	9	2.30				CH	Silty, Sandy CLAY, high plasticity, light grey and orange/brown, sand is fine to medium grained				
NFGWE		3					END OF TEST PIT AT 3.00 m				
	8										
	7	4									
	6	5									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP32
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**
Surface RL: **12.19 m**
Co-ords: **E 402587 N 6474032**

Depth (m)	Graphic Log / USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D
0.10–0.60	SP	SAND, fine to medium grained, light grey/brown	
0.60–0.90	CH	Sandy CLAY, high plasticity, grey/brown, sand is medium to fine grained, some fine sized gravel	M
0.90–2.80	SC	Silty Clayey SAND, medium to fine grained, light grey, clay fines of low plasticity, some cemented sand gravel to 26.5mm Becoming weakly cemented with clay fines of medium plasticity	
2.80–3.20	CI	Silty CLAY, medium plasticity, light grey and orange/brown, sand is fine to medium grained Becoming dark grey	W
3.20		END OF TEST PIT AT 3.20 m	

Columns: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP33

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**7/11/07**
Project:	**Caversham North**	Date Completed:	**7/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**11.41 m**
		Co-ords:	**E 402633 N 6473867**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F St VSt H / VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.15				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	11	0.55				CH	Sandy CLAY, high plasticity, dark grey/brown, sand is medium to fine grained	M			
		1 / 1.30				CI	Gravelly Silty CLAY, medium plasticity, light grey/brown, sand is medium to fine grained, weakly cemented sand gravel pieces to 26.5mm				
	10	2 / 2.40				CI	Sandy CLAY, medium to high plasticity, light brown and orange/brown, sand is fine to medium grained				
NFGWE	9	3				CI-CH	Silty Sandy CLAY, medium to high plasticity, light grey and orange/brown, sand is fine to medium grained				Slickensided
	8	4					END OF TEST PIT AT 3.00 m				
	7	5									
	6										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP34

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	7/11/07
Project:	Caversham North	Date Completed:	7/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	12.34 m
		Co-ords:	E 402667 N 6473952

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density/Consistency
0.00–0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D	
0.10–0.65	SP	SAND, medium to fine grained, light grey/brown		
0.65–1.10	SC-CI	Clayey SAND, medium to fine grained, orange/brown and grey/brown, clay fines of medium plasticity, some fine to medium sized gravel (cemented sand)	M	
1.10–2.60	SC	Weakly cemented Clayey SAND, fine to medium grained, orange/brown and grey mottled, clay fines of low to medium plasticity. Cemented sand gravel pieces to 37.5mm		
2.60–3.00	CL	Silty Sandy CLAY, low to medium plasticity, light grey/brown, sand is fine to medium grained, some fine sized gravel		
		END OF TEST PIT AT 3.00 m		

Water: NFGWE

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP35

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**13.28 m**
		Co-ords:	**E 402968 N 6473881**

1 WATER	2 RL(m)	DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.10				SM	TOPSOIL, Silty SAND, medium to fine grained, dark grey	D			
	13	0.40				SM	Silty SAND, medium to fine grained, grey				
		0.60				SC	Gravelly Clayey SAND, medium to fine grained, yellow and orange/brown, clay fines of low plasticity, some fine sized gravel				
	12	1.80		D		SC	Silty Clayey SAND, fine to medium grained, light grey/brown and yellow/brown, clay fines of medium plasticity	M			
		2.20		D		CH	Sandy CLAY, high plasticity, grey/brown and yellow brown, sand is fine to medium grained				
	11	2.60				CH	Sandy CLAY, high plasticity, light grey/brown and orange/brown, sand is medium to fine grained				Fissured and blocky
NFGWE		3.00				SC	Clayey SAND, medium to fine grained, light grey and red/brown, clay fines of medium plasticity				
	10						END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP36

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **12.83 m**
Co-ords: **E 402877 N 6473856**

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture	Relative Density / Consistency	Structure and Additional Observations
0.00–0.10	SM	TOPSOIL, Silty SAND, medium to fine grained, dark grey	D		
0.10–0.30	SM	Silty SAND, medium to fine grained, grey		MD	
0.30–2.20	SM	Cemented Gravelly Silty SAND, medium to fine grained, light grey/brown and orange/brown, strongly cemented pieces to 26.5mm	M	VD	
2.20–2.60	SC	Gravelly Clayey SAND, medium to fine grained, light grey/brown and red/brown, clay fines of medium plasticity		D	
2.60–2.80	SM	Cemented Silty SAND, fine to medium grained, grey/brown and red/orange/brown, cemented pieces to 100mm	D	VD	Very slow digging; Refusal - limit of excavator
		END OF TEST PIT AT 2.80 m			

WATER: NFGWE

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP37

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **11.88 m**

Co-ords: **E 402782 N 6473867**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
		0.60				SM	Silty SAND, fine to medium grained, orange/brown, silt and clay fines of low plasticity				
N F G W E	11	0.80				CH	Silty CLAY, high plasticity, light grey/brown and yellow/brown, sand is fine to medium grained	M			
		1					Limestone, fine grained, light grey and light brown, very strong, extremely weathered, cemented sand				Refusal - limit of excavator
							END OF TEST PIT AT 0.81 m				
	10	2									
	9	3									
	8	4									
	7	5									
	6										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP38
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	12.25 m
		Co-ords:	E 402791 N 6473954

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D	
0.70	SM	Silty SAND, fine to medium grained, orange/brown, silt fines of low plasticity		
1.00	CI	Sandy CLAY, medium plasticity, yellow/brown and grey/brown, sand is fine to medium grained	M	
1.60	CI	Silty CLAY, medium plasticity, red/brown and light grey/brown, sand is fine to medium grained		
		Limestone, fine grained, light grey and light brown, very strong, extremely weathered, cemented sand		
1.80		END OF TEST PIT AT 1.80 m		Refusal - limit of excavator

Water: NFGWE

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP39

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	12.63 m
		Co-ords:	E 402861 N 6473957

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F St VSt H / VL L MD D VD FB)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
		0.55				SM	Silty SAND, fine to medium grained, light brown, silt fines of low plasticity				
	12	1.00				SC	Gravelly Clayey SAND, medium to fine grained, orange/brown, clay fines of medium plasticity	M			
		1.60				SC-CH	Gravelly Silty CLAY, high plasticity, light grey/brown and orange/brown, sand is fine to medium grained, some fine sized cemented sand gravel				
NFGWE	11	2.10				SM	Cemented Silty SAND, medium to fine grained, light grey, red and orange/brown	D			Refusal - limit of excavator
							END OF TEST PIT AT 2.10 m				

RL scale: 12, 11, 10, 9, 8, 7. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP40

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: **Kubota 4.5 Tonne excavator**

Surface RL: **13.04 m**

Co-ords: **E 402954 N 6473957**

Test Pit Information				Field Material Description						
1 WATER	2 RL(m)	DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
	13	0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
		0.40				SM	Silty SAND, medium to fine grained, grey/brown, silt fines of low plasticity				
	12	1.50				CI	Silty Sandy CLAY, medium plasticity, orange/brown and light grey, sand is fine to medium grained	M			
		1.90		D		CH	Silty Sandy CLAY, high plasticity, light grey/brown, sand is fine to medium grained				
NFGWE	11	2.40				SC	Cemented Clayey SAND, medium to fine grained, red/brown and light grey, clay fines of low plasticity	D			Refusal - limit of excavator
							END OF TEST PIT AT 2.40 m				

RL(m) scale: 13, 12, 11, 10, 9, 8; Depth(m) scale: 1, 2, 3, 4, 5

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP41

SHEET 1 OF 1

Client:	Cardno BSD		Date Commenced:	8/11/07
Project:	Caversham North		Date Completed:	8/11/07
Test Pit Location:	Caversham		Recorded By:	PN
Project Number:	2100593A		Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator		Surface RL:	13.47 m
			Co-ords:	E 402932 N 6474046

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.00–0.15				SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D			
	0.15–0.60				SM	Silty SAND, fine to medium grained, orange/brown, silt fines of low plasticity	M			
	0.60–1.70				SC	Silty Clayey SAND, fine to medium grained, light grey/brown and yellow/brown, clay fines of low plasticity With some red/brown gravel pieces to 9.5mm	W			
	1.70–2.70				SC	Gravelly Clayey SAND, medium to fine grained, light grey and red/brown, clay fines of medium plasticity	M			
N F G W E	2.70–3.00				SM	Cemented Silty SAND, fine to medium grained, light grey and red/brown, ferruginised, very strong	D			
	3.00					END OF TEST PIT AT 3.00 m				

RL scale: 13, 12, 11, 10, 9, 8. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP42
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	12.80 m
		Co-ords:	E 402852 N 6474048

Test Pit Information				Field Material Description						
1 WATER	2 RL(m) / DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.00–0.10				SM	TOPSOIL, Silty SAND, fine to medium grained, grey/brown	D			
	0.10–0.70				SP	SAND, fine to medium grained, brown	M			
	0.70–0.90 (RL 12)		U63		CH	Silty CLAY, high plasticity, light grey/brownand orange/brown mottled, some fine grained sand				
	0.90–1.80				SC	Silty Clayey SAND, fine to medium grained, light grey and yellow/red/brown, clay fines of low plasticity				
NFGWE	1.80–2.00 (RL 11)				SM	Cemented Silty SAND, fine to medium grained, light grey and red/brown, ferruginised	D			
	2.00					END OF TEST PIT AT 2.00 m				~~Refusal - limit of excavator~~

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO. **TP43**

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**12.25 m**
		Co-ords:	**E 402762 N 6474047**

Depth (m)	Moisture	USC Symbol	Soil/Rock Material Field Description	Structure and Additional Observations
0.00–0.15	D	SM	TOPSOIL, Silty SAND, fine to medium grained, dark brown	
0.15–0.60	M	SP	SAND, coarse to medium grained, brown	
0.60–0.90		CH	Silty Sandy CLAY, high plasticity, light grey/brown, sand is fine to medium grained	
0.90–2.20		SM	Cemented Gravelly Silty SAND, medium to fine grained, light grey/brown and yellow/orange/brown, silt and clay fines of low plasticity, ferruginised	Very slow digging
	D		Becoming red/brown and very strongly cemented	
2.20			END OF TEST PIT AT 2.20 m	Refusal - limit of excavator

Water: NFGWE

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP45

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**

Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**12.93 m**
		Co-ords:	**E 402662 N 6474084**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11

WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.00–0.20				SM	TOPSOIL, Silty SAND, medium to fine grained, grey/brown	D			
		0.20–0.50				SM	Silty SAND, medium to fine grained, brown				
		0.50–0.70				GP	Sandy GRAVEL, fine to medium sized, dark red/brown, rounded ferricrete gravel, sand is medium to fine grained	M			
	12	0.70–1.20				SC	Gravelly Clayey SAND, medium to fine grained, grey/brown and orange/brown, clay fines of medium plasticity Becoming orange/brown				
		1.20–1.90				CH	Silty CLAY, high plastcity, light grey/brown, some fine grained sand				Fissured and blocky
	11	1.90–3.00				CL	Silty CLAY, low plasticity, light grey, some fine grained sand				
NFGWE	10	3.00					END OF TEST PIT AT 3.00 m				

RL scale: 12, 11, 10, 9, 8, 7. Depth scale: 1, 2, 3, 4, 5.

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP46

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator

Surface RL: 12.19 m

Co-ords: E 402512 N 6474217

Depth (m)	Graphic Log / USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.10	SM	TOPSOIL, Silty SAND, fine to medium grained, dark brown	D	
0.55	CH	Sandy CLAY, high plasticity, dark grey, some fine grained sand		
2.70	CL-CI	Gravelly, Silty CLAY, low to medium plasticity, light grey and dark brown, sand is fine to medium grained, gravel is cemented silty sand pieces to 100mm Becoming light grey/brown with fines of medium plasticity and cobbles to 200mm	M / W	
4.00	CH	Silty CLAY, high plastcity, light grey and yellow/brown, some fine to medium grained sand	M	Fissured and slickensided

END OF TEST PIT AT 4.00 m

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP47

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	13.20 m
		Co-ords:	E 402606 N 6474221

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
0.00–0.15	SM	TOPSOIL, Silty SAND, medium to fine grained, grey/brown	D
0.15–0.50	SM	Silty SAND, medium to fine grained, grey	
0.50–0.70	CH	Sandy CLAY, high plasticity, dark grey/brown, sand is fine to medium grained	M
0.70–1.20	CI	Gravelly Silty CLAY, medium plasticity, light grey and dark brown, sand is fine to medium grained, gravel is cemented silty sand to 2.36mm	
1.20–2.60	CI	Silty CLAY, medium plasticity, light grey. Some fine grained sand	
2.60–3.20	CI	Sandy CLAY, medium plasticity, light orange/brown, sand is medium to fine grained	
3.20		END OF TEST PIT AT 3.20 m	

Column headings: Test Pit Information — 1 WATER, 2 RL(m) / DEPTH(m), 3 FIELD TEST, 4 SAMPLE; Field Material Description — 5 GRAPHIC LOG, 6 USC SYMBOL, 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 8 MOISTURE, 9 RELATIVE DENSITY /CONSISTENCY (VS S F St VSt H / VL L MD D VD), 10 HAND PENETROMETER (kPa), 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP48

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	14.47 m
		Co-ords:	E 402690 N 6474216

Depth (m)	Sample	USC Symbol	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
0.15		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey	D	
0.60		SP	SAND, fine to medium grained, light grey/brown	M	
1.00		CI	Gravelly, Silty CLAY, medium plasticity, light grey and dark brown. Sand is fine to medium grained, gravel is fine sized		
2.00	D	SC	Clayey SAND, medium to fine grained, brown, clay fines of medium plasticity		
2.60		CI	Sandy CLAY, medium plasticity, orange/brown, sand is medium to fine grained		
3.00		CI	Silty CLAY, medium plasticity, light grey and orange/brown, some fine to medium grained sand		Slickensided and fissured
			END OF TEST PIT AT 3.00 m		

Water: NFGWE

Column headings: 1 WATER; 2 RL(m), DEPTH(m); 3 FIELD TEST; 4 SAMPLE; 5 GRAPHIC LOG; 6 USC SYMBOL; 7 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 8 MOISTURE; 9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 10 HAND PENETROMETER (kPa); 11 STRUCTURE AND ADDITIONAL OBSERVATIONS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.
TP49
SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ

Excavation Method: Kubota 4.5 Tonne excavator
Surface RL: 13.15 m
Co-ords: E 402698 N 6474135

Water (1)	RL(m) (2)	Depth(m) (3)	Field Test (3)	Sample (4)	Graphic Log (5)	USC Symbol (6)	Soil/Rock Material Field Description (7)	Moisture (8)	Relative Density/Consistency (9)	Hand Penetrometer (kPa) (10)	Structure and Additional Observations (11)
	13	0.20				SM	TOPSOIL, Silty SAND, fine to medium grained, grey/brown	D			
						SP	SAND, fine to medium grained, brown	W			
▷	12	1.20				CH	Silty CLAY, high plasticity, light grey and yellow/brown, some fine to medium grained sand	M			
	11						Seams of white Clayey SILT (ML),				
		3.00					END OF TEST PIT AT 3.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP50

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**13.13 m**
		Co-ords:	**E 402625 N 6474121**

1 WATER	2 RL(m)	2 DEPTH(m)	3 FIELD TEST	4 SAMPLE	5 GRAPHIC LOG	6 USC SYMBOL	7 SOIL/ROCK MATERIAL FIELD DESCRIPTION	8 MOISTURE	9 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	10 HAND PENETROMETER (kPa)	11 STRUCTURE AND ADDITIONAL OBSERVATIONS
	13	0.15				SM	TOPSOIL, Silty SAND, medium to fine grained, grey	D			
		0.70				SM	Silty SAND, medium to fine grained, brown	M			
	12	1.50				SC	Gravelly Clayey SAND, medium to fine grained, orange/brown and light grey/brown, clay fines of low plasticity, gravel is cemented silty sand to 9.5mm				
	11	2.40				CH	Sandy CLAY, high plasticity, grey/brown and orange/brown, sand is medium to fine grained				
NFGWE		3				SC-CL	Weakly cemented Silty/Clayey SAND, fine to medium grained, grey/brown, clay fines of low plasticity, friable	W			
	10						END OF TEST PIT AT 3.00 m				
	9	4									
	8	5									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP51

SHEET 1 OF 1

Client:	Cardno BSD	Date Commenced:	8/11/07
Project:	Caversham North	Date Completed:	8/11/07
Test Pit Location:	Caversham	Recorded By:	PN
Project Number:	2100593A	Log Checked By:	JJ
Excavation Method:	Kubota 4.5 Tonne excavator	Surface RL:	11.88 m
		Co-ords:	E 402513 N 6474108

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
				D		SC	Topsoil, Clayey SAND, medium to fine grained, black, clay fines of high plasticity	D / M			
	11	0.50 / 1				CH	Silty CLAY, high plasticity, light grey/brown, sand is fine to medium grained, some fine sized cemented silty sand gravel to 2.36mm				
▽						CI-CH	Becoming light grey/brown and yellow/brown				
	10	2 / 2.10				CI	Silty CLAY, medium plasticity, light grey and yellow/brown, some fine grained sand				
	9	3									
	8						Lenses of grey silty sand				
	7	4 / 5					END OF TEST PIT AT 4.00 m				
	6										

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP52

SHEET 1 OF 1

Client:	**Cardno BSD**	Date Commenced:	**8/11/07**
Project:	**Caversham North**	Date Completed:	**8/11/07**
Test Pit Location:	**Caversham**	Recorded By:	**PN**
Project Number:	**2100593A**	Log Checked By:	**JJ**
Excavation Method:	**Kubota 4.5 Tonne excavator**	Surface RL:	**11.54 m**
		Co-ords:	**E 402679 N 6473872**

Test Pit Information				Field Material Description						
1	2		3	4	5	6	7	8	9	10	11
WATER	RL(m)	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		0.30				CH	TOPSOIL, Sandy CLAY, high plasticity, black. Sand is medium to fine grained	M			
	11 / 10	2.00				SC	Gravelly Clayey SAND, medium to fine grained, light grey/brown, clay fines of low plasticity, gravel is cemented silty sand to 26.5mm	W			
		2.50				CI	Sandy CLAY, medium plasticity, grey/brown and orange/brown, sand is medium to fine grained	M			
	9 / 8	4				CL	Silty CLAY, low plastcity, orange/brown, some fine sand				
	7 / 6	5					END OF TEST PIT AT 4.00 m				

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

Explanatory Notes - Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer.

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core ~52mm
NQ	Diamond Core ~47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample ~50mm
U75	Undisturbed Sample ~75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, 'Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index', as follows:

Term	Symbol	Point Load Index $I_{S(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

CLAY

SILT

SAND

GRAVEL

BOULDERS / COBBLES

PEAT (Organic)

Minor Components

Clayey

Silty

Sandy

Gravelly

Other Symbols

TOPSOIL

FILL

ASPHALT

CONCRETE

NO CORE

Rock Symbols

Sedimentary Rocks

SANDSTONE

SILTSTONE

CLAYSTONE, MUDSTONE

SHALE

LAMINITE

CONGLOMERATE

BRECCIA

TILL

COAL

LIMESTONE

Igneous Rocks

PLUTONIC IGNEOUS (eg Granite)

VOLCANIC IGNEOUS (eg Basalt)

PYROCLASTIC IGNEOUS (eg Ignimbrite)

Metamorphic Rocks

SLATE, PHYLLITE, SCHIST

GNEISS

QUARTZITE

EMERSON
IMPLEMENTEURS
STEWART

APPENDIX C

RPS ENVIRONMENTAL ASSESSMENT

2.0 EXISTING ENVIRONMENT

2.1 Topography

The land is generally undulating, and slopes gently from an elevation of 18m AHD in the north-east corner of the site to an elevation of 8m AHD in the south-west.

2.2 Soils and Landforms

The site is located on the Guildford Formation, which is characterised by soils of alluvial origin ranging from silty clay to pebbly silt, and is characteristically low lying and poorly drained. Elevated areas of the site contain a thin veneer of overlying Bassendean sands.

2.3 Hydrology

2.3.1 Groundwater

The estimated maximum (late winter) groundwater table at the site is generally located close to the surface, varying between 1-2m below the surface level (Water and Rivers Commission, 1997). Exceptions to this occur at the high-point of the site in the north-east corner where the groundwater is 4m below the surface, and along the two drainage lines where the groundwater becomes a surface expression (see Section 2.3.3).

During autumn, when the groundwater table is at its lowest elevation, the separation distance between groundwater and the surface level at the site is approximately 4m (Department of Environment, 2004). Exceptions to this occur at the high-point of the site where the groundwater is approximately 8m below the surface and along the two drainage lines where the groundwater is approximately 1-2m below the surface.

The site is located on the south-eastern edge of the Gnangara Mound, and as such the groundwater flow is in a southerly direction towards the Swan River (Davidson, 1995).

A monthly groundwater monitoring program was commenced following the installation of bores in February 2006 (see Section 3.1). Results of the program to date generally indicate fluctuating groundwater levels consistent with expected seasonal variations (i.e. increased depths during the summer and decreased depths during the winter), and ground surface to groundwater vertical separation distance of between 1m and 8m (depending on the location of the bore). These results are presented in Tables 1a & b.

Table 1a: Groundwater Levels

Bore	Monitor Date – Groundwater Depth Below Ground Level			
	15/02/06	15/03/06	12/04/06	15/05/06
CGW-1	1.690m	1.840m	1.975m	2.038m
CGW-2	1.702m	1.806m	1.937m	2.000m
CGW-3	3.134m	3.420m	3.610m	3.808m
CGW-4	8.547m	8.452m	8.497m	8.419m
CGW-5	2.326m	2.671m	2.906m	2.896m
CGW-6	3.768m	4.204m	4.190m	3.678m
CGW-7	2.022m	2.180m	2.258m	2.310m
CGW-8	4.351m	4.760m	5.059m	5.213m
CGW-9	1.082m	1.163m	1.085m	0.989m
CGW-10	2.322m	2.499m	2.697m	2.749m
CGW-11	2.020m	2.205m	2.414m	2.288m
CGW-12	2.258m	2.420m	2.623m	2.806m

Table 1b: Groundwater Levels

Bore	Monitor Date – Groundwater Depth Below Ground Level			
	14/06/06	13/07/06	17/08/06	13/09/06
CGW-1	2.100m	2.035m	1.729m	1.500m
CGW-2	2.127m	2.080m	1.711m	1.546m
CGW-3	4.406m	4.188m	2.866m	1.624m
CGW-4	8.522m	8.644m	8.573m	8.589m
CGW-5	2.903m	2.911m	2.735m	2.427m
CGW-6	3.642m	3.385m	3.060m	2.762m
CGW-7	2.290m	2.082m	1.697m	1.587m
CGW-8	5.367m	5.482m	5.479m	5.243m
CGW-9	1.107m	1.019m	0.799m	0.801m
CGW-10	2.834m	2.673m	2.195m	1.817m
CGW-11	2.278m	2.207m	1.580m	1.294m
CGW-12	3.003m	3.109m	2.583m	1.772m

2.3.2 Wetlands

A large portion of the site is mapped by Hill *et al.* (1996) at regional scale as a regional sumpland (a sumpland is a seasonally inundated basin).

The sumpland mapped within the site was assigned a Resource Enhancement management classification by the DoE, however following the reclassification request the wetland was reclassified as Multiple Use (and following further reclassification requests a small area of remnant vegetation was reclassified as Dryland and removed from the wetland database).

Figure 4 illustrates the extent of the sumpland within the site and the updated management category assigned by the Department of Environment following a recent reclassification request (see Appendix A).

2.3.3 Drainage and Watercourses

Two drains flow across the site (Figure 4); one drain originates to the north of the site and drains land to the north of Reid Highway, flowing through the western portion of the site in a north/south alignment before it enters Bennett Brook to the south of the site. The other drain originates to the east of the site and briefly flows through the south-eastern portion before exiting the site south of Benara Road to enter Bennett Brook. Both drains are ephemeral and dry during the summer. Both drains were most likely natural watercourses which were altered to some extent to drain the surrounding agricultural land.

Other than the scattered *Melaleuca* spp. which occur along the western drain, these agricultural-style drains do not support significant ecological values with minimal hydrological values.

2.4 Vegetation and Flora

Prior to European settlement of the area, the native vegetation within the site was representative of the Southern River Complex, which consists of open woodland of *Eucalyptus calophylla – Eucalyptus marginata – Banksia spp.* with fringing woodland of *Eucalyptus rudis – Melaleuca rhaphiophylla* along creek beds.

Of the original area of the Southern River Complex on the Swan coastal Plain, 17% currently remains while 10% is proposed for protection, which meets the criteria for levels of protection identified within the Bush Forever documentation (Government of Western Australia, 2000).

Examination of the earliest available aerial photography, taken in 1953, shows the site was cleared previous to that time, with the exception of two small areas to the north of Patricia Street (Figure 5).

Of these two areas, Lots 214 and P94 Patricia Street appear to have been cleared in the mid 1980's and then left to regrow before being cleared once more in the late 1990's. Lot 214 does not currently appear to contain remnant native vegetation of any significance, while a small group of mature *Eucalyptus* spp. remain on Lot P94.

The other area of remnant native vegetation, on the northern portion of Lots P85-P87 and P214 Patricia Street, has remained uncleared since prior to 1953.

On-site examination of the remnant native vegetation within Lots P85-P87 and P214 Patricia Street indicates a Jarrah/Marri/Banksia/Sheoak woodland – low forest with a degraded understorey. Overall, the vegetation in the northern portion of Lots P85-P87 and P214 Patricia Street is in degraded condition.

Some remnant native vegetation also occurs throughout the remainder of the site as scattered individual trees. These trees are *Melaleuca* spp. along parts of the western drainage line and Marri and *Eucalyptus* spp. scattered throughout the remainder of the site.

2.5 Fauna

A search of the Department of Conservation and Land Management's Threatened Fauna Database of an area within 10km of the site suggests a number of threatened fauna species inhabit or may once have inhabited the general area.

Species identified on the database (and their designated level of conservation priority) include:

- Chuditch (Schedule 1 – Fauna that is rare or is likely to become extinct)

- Western Ringtail Possum (Schedule 1)
- Baudin's Black Cockatoo (Schedule 1)
- Carnaby's Black Cockatoo (Schedule 1)
- White-tailed Black Cockatoo (Schedule 1)
- Graceful Sunmoth (Schedule 1)
- Peregrine Falcon (Schedule 4 – Other specially protected fauna)
- Major Mitchell's Cockatoo (Schedule 4)
- Black Bittern (Priority 2 – Taxa with few, poorly known populations on conservation lands)
- Western Brush Wallaby (Priority 4 – Taxa in need of monitoring)
- Water Rat (Priority 4)
- Grey Falcon (Priority 4)
- Bush Stonecurlew (Priority 4)
- Guildford Springtail (Priority 4)
- Quenda (Priority 5 – Taxa in need of monitoring (conservation dependent))

The degraded area of remnant native vegetation within Lots P85-P87 and P214 Patricia Street presents the only area of vegetation within the site which could provide habitat for any of the identified species. However based on the size and condition of this area of vegetation, the likelihood of any of these still inhabiting the site is relatively low.

2.6 Acid Sulfate Soils

The Western Australian Planning Commission (2003) Bulletin No. 64 regional mapping indicates that a small portion of the south-western corner of the site associated with the western drain contains soils that are Medium to High risk of containing Potential Acid Sulfate Soils (PASS) across the site (Figure 6). These soils are most likely peaty deposits associated with the drainage channel.

An area to the north of Patricia Street which correlates with the extent of remnant native vegetation is mapped by WAPC (2003) as Low to Moderate risk of containing PASS. The remainder of the site is mapped as Low to no risk of containing PASS.

2.7 Aboriginal Heritage

Two Aboriginal sites listed on the Department of Indigenous Affairs (DIA) database occur within the site (Figure 7).

Site 3746 is known as Moore's Camp and was used by Jack Moore during the 1930's and 1940's. Mythology suggests Jack Moore was the last known person to have seen the Wagyl. The site is as 'Stored Data' and it is not on the Permanent Register.

Site 3744 is known as Marshall's Paddock and is a burial site or contains skeletal remains. The site is listed on the Permanent Register of the DIA database and is considered a closed site, which means that public access to information about the site is restricted.

2.8 Dampier-Bunbury Natural Gas Pipeline

The Dampier-Bunbury Natural Gas Pipeline (DBNGP) lies along the eastern boundary of the site (Figure 8). The DBNGP was constructed during the early 1980's and is sunken below ground surface.

2.9 Reid Highway and Proposed Perth-Darwin Highway

The site is bound to the north by Reid Highway and to the west by the proposed Lord Street extension, generating traffic noise into the periphery of some areas of the site.

2.10 Perth International Airport Flight-Path

Perth International Airport is located approximately 5km south of the site. Planes approach the airport from the north along West Swan Road. The 20 Australian Noise Exposure Forecast (ANEF) contour from the Airport lies adjacent to the eastern boundary of the site (Figure 8).

2.11 Surrounding Land Uses

2.11.1 Viticulture/Horticulture

Land both within and adjacent to the south and east of the site is currently used for viticulture and other intensive horticulture, such as the growing of table grapes and melons.

Most vineyards which are currently operating within the site intend to cease operation once residential development within the site commences, however some operators within the site, such as the Pinnelli Vineyard, intend to continue practising viticulture for the foreseeable future (Figure 9).

Vineyards located to the south and east of the site along Benara Road and West Swan Road are likely to continue operation for the foreseeable future.

2.11.2 Residential Development

Immediately west of the site's western boundary lies residential development which has only recently been completed (Figure 9). This area of residential development is relatively small and is tightly bound by Reid Highway to the north, Bennett Brook to the west, Benara Road to the south and the Lord Street extension to the east.

2.11.3 Poultry Farm

A poultry farm exists on the western side of Bennett Street, adjacent to the south-west corner of the site (Figure 9). This farm produces chicken meat and has operated since the 1960's. It is the intention of the current operators of the farm to continue operations for the foreseeable future.

2.11.4 Austral Brick and Tile Factory

A brick and tile factory operated by Austral Bricks is located approximately 700m south of the site. The factory produces bricks and roof tiles but has a relatively small capacity compared to other brick factories in the area (eg. Midland Brick).

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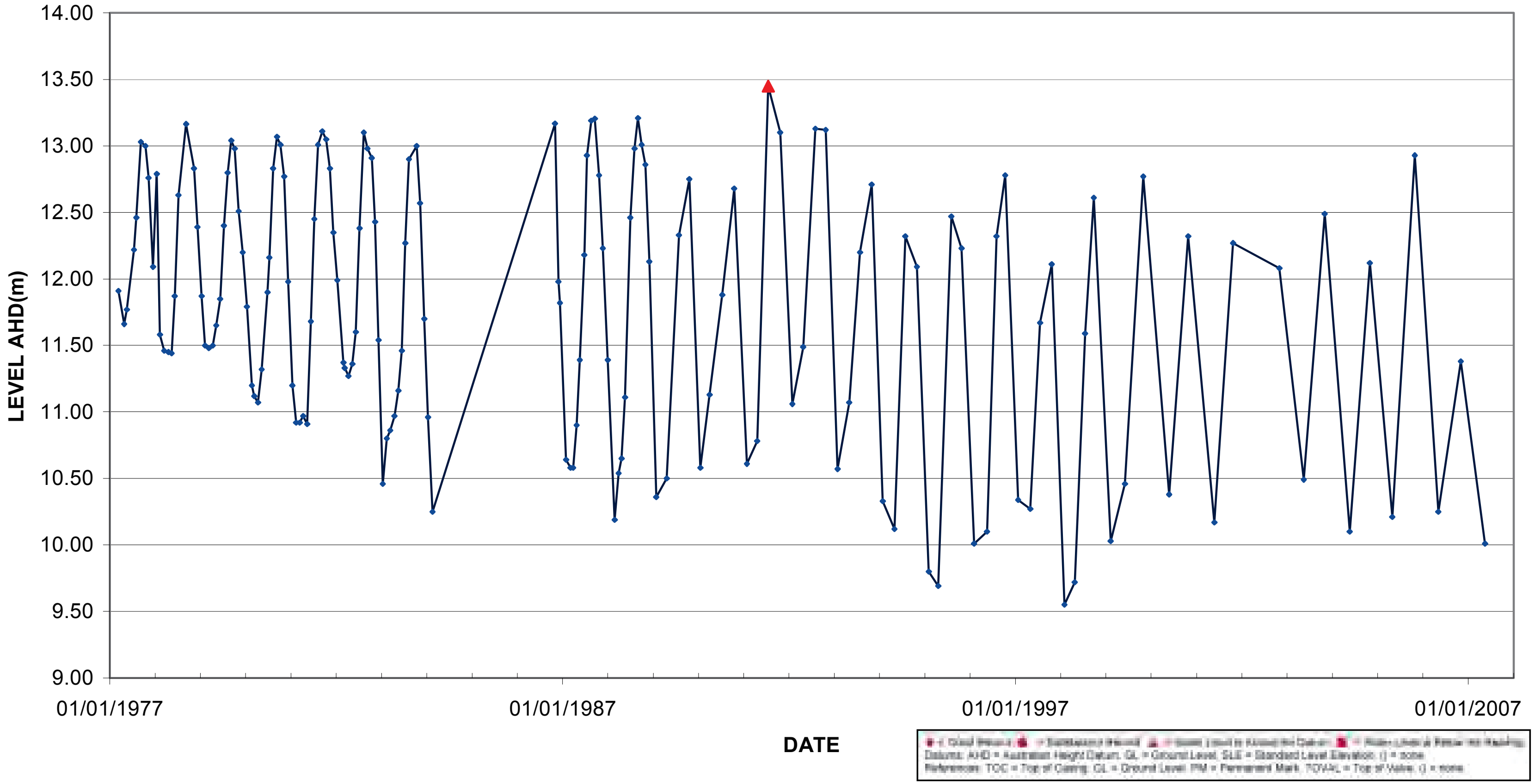
APPENDIX D

LWMS GROUNDWATER LEVEL DATA

61610545 MIRRABOOKA MONITORING MM45

Easting = 402194.00 Northing = 6473890.00 Zone = 50 TOC = 13.45mAHD WIN SITE ID = 4886



Date	Bore ID											
	CGW-1	**CGW-2**	**CGW-3**	**CGW-4**	**CGW-5**	**CGW-6**	**CGW-7**	**CGW-8**	**CGW-9**	**CGW-10**	**CGW-11**	**CGW-12**
	Groundwater Levels (mAHD)											
15/02/2006	13.43	13.80	9.81	*3.93*	10.22	7.48	8.56	7.87	7.27	9.88	11.23	11.26
15/03/2006	13.28	13.69	9.53	*4.03*	9.87	7.05	8.40	7.46	7.19	9.71	11.05	11.09
12/04/2006	13.15	13.56	9.34	*3.98*	9.64	7.06	8.32	7.16	7.27	9.51	10.84	10.89
15/05/2006	13.08	13.50	9.14	*4.06*	9.65	7.57	8.27	7.01	7.36	9.46	10.97	10.71
14/06/2006	13.02	13.37	8.84	*3.90*	9.58	7.54	8.22	6.78	7.24	9.30	10.90	10.45
13/07/2006	13.09	13.42	8.70	*3.78*	9.57	7.80	8.43	6.67	7.33	9.46	10.97	10.34
17/08/2006	13.39	13.79	10.02	*3.85*	9.75	8.12	8.81	6.67	7.55	9.94	11.60	10.87
13/09/2006	13.62	13.95	11.27	*3.83*	10.05	8.42	8.92	6.91	7.55	10.31	11.89	11.68
12/10/2006	13.46	13.83	10.88	*3.78*	10.33	8.34	8.69	7.08	7.38	10.04	11.62	11.63
20/11/2006	13.30	13.63	9.99	*3.54*	10.20	7.82	8.32	7.01	7.26	9.45	11.21	11.18
20/12/2006	13.64	13.50	9.34	*3.31*	9.92	7.12	8.11	6.84	7.19	9.16	10.93	10.88
11/01/2007	13.14	13.34	9.13	*3.12*	9.61	7.11	7.99	6.64	7.15	9.00	10.75	10.69
21/02/2007	12.83	13.11	8.84	*3.00*	9.24	6.79	7.81	6.38	6.98	8.78	10.32	10.41
16/03/2007	12.85	13.01	8.68	*3.00*	8.97	6.14	7.66	6.23	6.91	8.71	10.17	10.28
11/04/2007	12.68	12.94	8.57	*3.06*	8.83	6.32	7.61	6.11	6.84	8.68	10.11	10.17
9/05/2007	12.75	13.07	8.46	*3.09*	8.86	7.10	8.06	6.02	7.22	8.91	10.56	10.06
7/06/2007	12.67	13.18	8.52	*3.21*	9.26	7.43	8.32	6.09	7.37	9.15	10.82	10.05
3/07/2007	12.93	13.41	9.09	*3.16*	9.25	7.58	8.58	6.04	7.57	9.31	11.16	11.52
8/08/2007	13.52	13.91	11.65	*3.26*	9.61	8.70	9.66	6.28	7.90	10.78	12.44	11.96
7/09/2007	13.64	13.96	***9.27***	*3.31*	9.45	9.05	8.75	6.82	7.67	10.77	12.30	12.30
18/10/2007	13.50	13.82	11.32	*3.41*	9.49	9.08	9.34	7.13	7.41	10.44	11.91	12.11
13/11/2007	13.36	13.67	10.70	*3.43*	***10.76***	8.34	8.91	7.21	7.29	10.17	11.66	11.79
12/12/2007	13.24	13.73	11.29	*3.10*	9.62	8.85	9.37	7.33	7.43	10.00	11.51	12.01
17/01/2008	DRY	13.40	9.55	*2.84*	9.97	DRY	***9.51***	6.94	6.39	9.45	11.11	11.33
Monitoring data AAMGL referenced to long term WIN bore	14.78	15.15	12.20	*na*	11.65	9.66	10.01	8.40	8.70	11.36	12.94	12.95

Data in italics has been omitted as it appears to be inaccurate.

APPENDIX E

HYDROLOGIC AND HYDRAULIC MODELLING

HYDROLOGIC AND HYDRAULIC MODELLING

Modelling of the drainage system for Brookleigh Estate has been undertaken using the computer software package XP-Storm. XP-Storm is an urban drainage design software package capable of carrying out both hydrologic and hydraulic modelling of urban catchments. The following sections outline the assumptions made and results calculated from the modelling.

HYDROLOGIC MODELLING

General

Hydrologic models to estimate sub-catchment runoff from Brookleigh Estate were created for design storms with an ARI between 1 year and 100 years. Design storm durations investigated varied between 1 hour and 72 hours.

Design rainfall

Design rainfall for the hydrologic model was determined for Caversham based on AR&R (EA, 2001) Intensity Frequency Duration (IFD) data. The IFD data used to generate runoff for hydrologic and hydraulic analysis is presented in Table C.1 below.

Table C.1- Caversham design Intensity Frequency Duration data

ARI (years)	Duration						
	Intensity (mm/hr)						
	1 hour	6 hour	12 hour	24 hour	36 hour	48 hour	72 hour
1	15.93	-	-	-	-	-	-
5	26.70	8.17	5.26	3.39	2.60	2.13	1.58
100	47.41	13.76	8.62	5.69	4.42	3.67	2.77

Runoff generation

Infiltration losses

Runoff is generated when the infiltration capacity of the soil is exceeded. Different soil types and land uses have different infiltration characteristics. The land uses adopted in the hydrologic model were derived from the CLSP LWMS (Cardno, 2008). These land uses, where appropriate, comprised:

- Caversham Soil with Sparse Vegetation (multiple use corridors, and detention basins)
- roads and road reserve
- residential
- public open space

Post-development land uses and catchment areas for Brookleigh Estate are shown in Table C. 2 below.

Table C. 2 - Post-development land uses

	Land use (ha) 1. Roads and road reserves 2. Residential 3. Multiple Use Corridors & Detention Basins 4. Public open space				
Subcatchment	**1**	**2**	**3**	**4**	**Total Area (ha)**
Brookleigh Estate	7.7	21.14	2.78	0.90	32.52

Loss models assigned to the pervious areas (Table C. 3) are based on land use type and previous experience with similar studies.

The losses adopted in this model differ to the values adopted in the Swan Urban Growth Corridor Drainage and Water Management Plan (DoW/GHD 2009). The underlining reason for this is that:

- DoW & GHD utilised a different hydraulic modelling package called Infoworks CS for the Swan DWMP analysis.
- It is assumed that the groundwater levels in the developed areas will be controlled by a subsoil drainage system.
- Additionally, minimum fill for foundation requirements will increase infiltration rates through imported fill.

Table C. 3- Post-development loss models for pervious areas

Land use type	Initial loss (mm)	Continuing Loss (%)
Impervious	1.0	0
Roads and road reserves	1.0	50%
Residential lots	1.5	75%
POS & Multiple Use Corridor	10	60%

Land uses

Table C.4 below presents the assumed impervious portions of the various land use zones within the Structure Plan area:

Table C. 4 - Land use impervious areas

Land Use	Assumed Impervious Portion
Road reserves	80%
Residential	36%
Public open space	0%

A depression storage loss of 1 mm was applied to hardstand impervious areas.

HYDRAULIC MODELLING

Subcatchment hydrographs calculated in the runoff module of XP-SWMM for the post-development models were routed through the development and storage areas in the hydraulic module. The following section provides results of the hydraulic modelling.

Post-development hydraulic modelling

Figure 6.2 presents the results of the hydraulic modelling, including:

- post-development sub-catchments
- flow directions
- extent of flooding in POS areas
- peak 5 year and 100 year ARI outflows at Patricia Street culvert crossing

The strategy adopted for stormwater quantity management is to provide storage for the 1 year 1 hour ARI event within bio-retention swales located adjacent to the central drain. Pipes from the road conveyance system will bubble-up into these bio retention swales, with excess runoff from larger events overtopping the bio-retention swales and discharging to the central drain.

The peak 5 year ARI discharge from the site will be restricted to 0.4m^3/s and the peak 100 year ARI discharge will be restricted to 0.7m^3/s at the Patricia Street culvert crossing south of the site, in accordance with modelling completed for the entire Swan Urban Growth Corridor area.

Modelling Inputs & Constraints

Post Development incoming flows from the West Swan Catchment area, via the Reid Highway culvert crossing, were supplied by GHD/DoW, for various duration of the 5 year and 100 year storm event. Incoming flow hydrographs are presented in the Diagram C.1 and C.2.

In accordance with the revised Figure 10-11.16b of the DWMP, provided by GHD on 11 June 2009, the outfall conditions at the Patricia Street culvert crossing were set as constant backwater levels of 11.06 mAHD and 11.15 mAHD for the 5 year and 100 year ARI event, respectively.

Size and invert levels of critical hydraulic control structures at Patricia Street and upstream of the development are included in Figure 6.6.

Diagram C. 1 –5 Year ARI inflow hydrographs – downstream of Reid Hwy

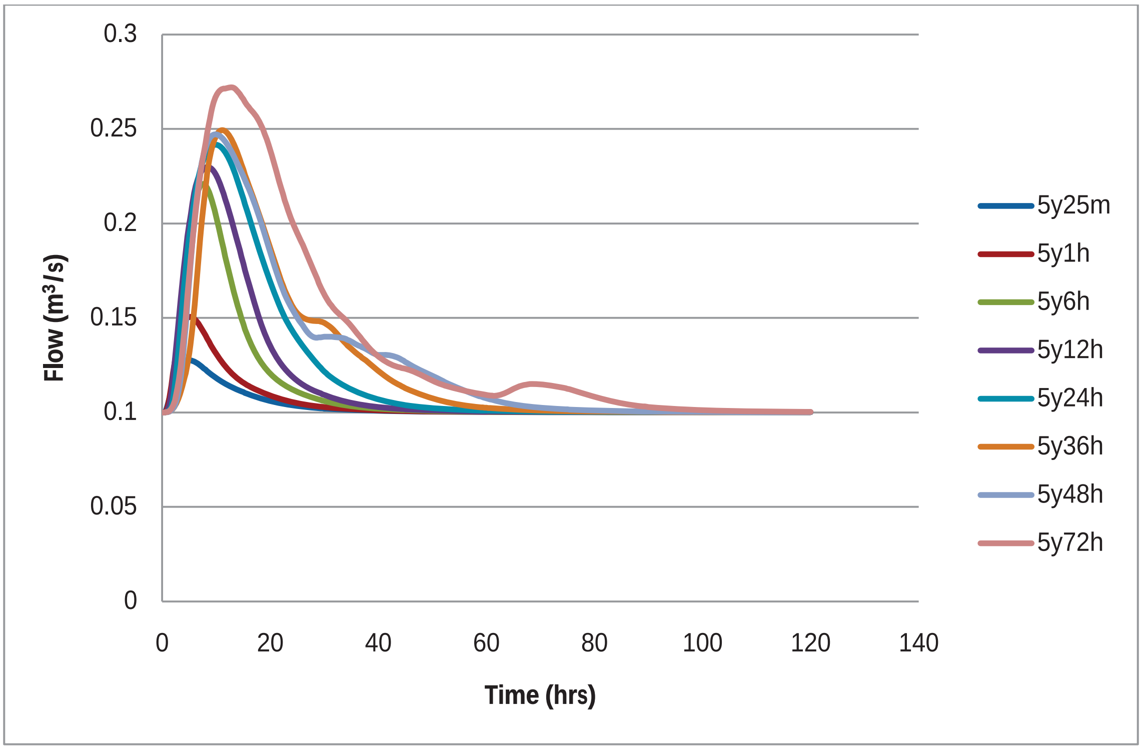
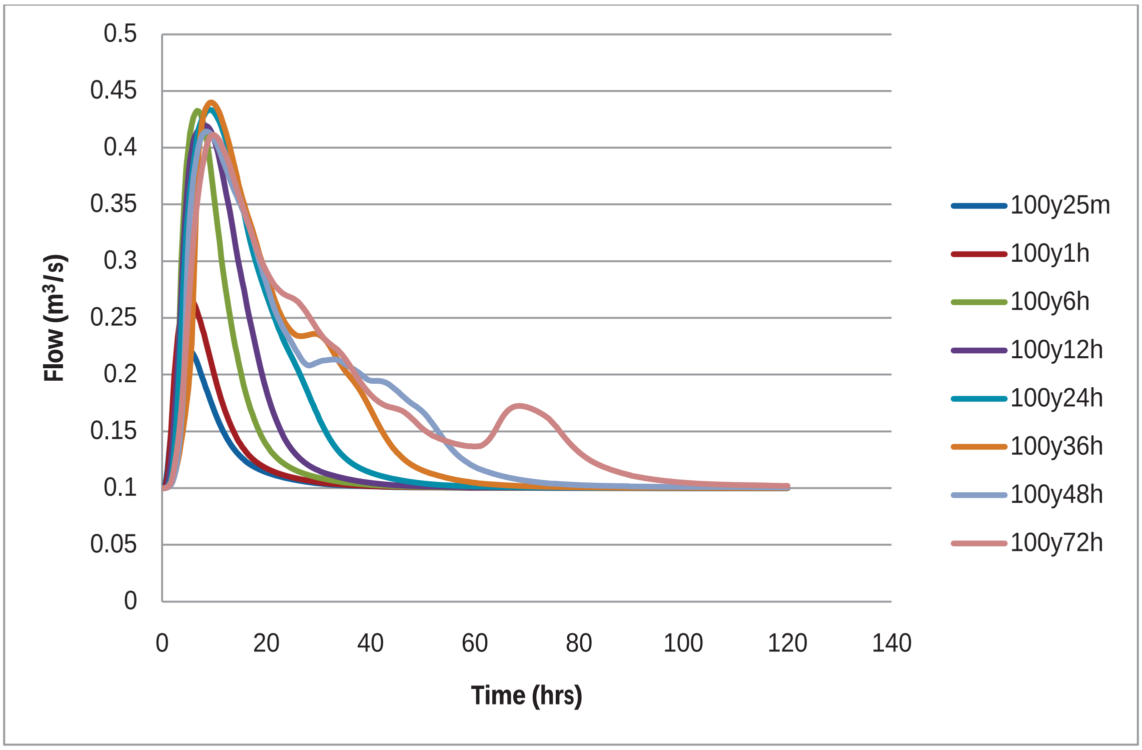


Diagram C. 1 –100 Year ARI inflow hydrographs – downstream of Reid Hwy



Modelling results

Key hydraulic modelling results (including maximum storage volumes) for the 1 year 1 hour ARI event are illustrated in Figure 6.2. Runoff from the 1 year 1 hour ARI event is completely contained within the bioretention swales, with no overflow to the central drain.

Key modelling results for the peak 5 year and 100 year ARI events are presented in Table C. 5 and Table C.6 below.

Table C. 5 - 5 year ARI hydraulic modelling results

Storage area	Overflow to central drain (m^3/s)	Critical duration storm event
Bioretention swale 1	0.02	48 hr
Storage Basin 12	0.06	36 hr
Bioretention swale 6	0.09	12 hr
Bioretention swale 7	0.03	36 hr
Bioretention swale 8	0.02	36 hr
Bioretention swale 9	0.02	36 hr
Bioretention swale 10	0.06	36 hr
Peak outflow crossing the Patricia Street culvert crossing	**0.4**	**36hr**

Table C. 6 - 100 year ARI hydraulic modelling results

Storage area	Overflow to central drain (m^3/s)	Critical duration storm event
Bioretention swale 1	0.04	24 hr
Storage Basin 12	0.15	48 hr
Bioretention swale 6	0.35	1 hr
Bioretention swale 7	0.04	36 hr
Bioretention swale 8	0.03	36 hr
Bioretention swale 9	0.03	36 hr
Bioretention swale 10	0.1	36 hr
Peak outflow crossing the Patricia Street culvert crossing	**0.7**	**36hr**

Inundation of POS areas

After a large rainfall event, part of the POS areas will be inundated for a period of time depending on the intensity of the storm event.

The period of inundation depends on the depth to groundwater at the time of the storm, infiltration capacity of the soil, the recurrence interval and duration of storm and whether or not the storage areas receive stormwater from upstream catchments. Water will not be held in the bioretention swales for extended periods of time.

The hydraulic modelling results showed that flood levels in the central drain will reduce to minimum levels within 24-48 hours after a 5 year or 100 year ARI storm event.

Safety

To prevent pedestrians being swept along streets and other drainage paths during major storm events, the product of water velocities and depths in streets and major waterway generally should not exceed $0.4m^2/s$ in accordance with Urban Stormwater Management of AR&R (Volume 1).

In comparison, the Water Corporation's Urban Main Drainage Manual specified a maximum velocity x depth product of $0.32m^2/s$ for floodway that are designated as pedestrian access way, and a maximum velocity x depth product of $0.4m^2/s$ for trafficable floodways.

The hydraulic modelling results showed that the maximum velocity x depth product along the Caversham Central Drain is $0.1 m^2/s$ during the 100 year 36 hr ARI storm event, and will comply with the Water Corporation and AR&R specifications. The maximum velocity x depth product along the Caversham Central Drain is presented in Figure 6.8.

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APPENDIX F

PREDEVELOPMENT SURFACE WATER QUALITY MONITORING (CARDNO 2009)

Our Ref V9059--SLC90019.10--DPC

Contact Dave Coremans

6 October 2009

Cardno (WA) Pty Ltd
ABN 77 009 119 000

Cardno
2 Bagot Road, Subiaco WA 6904
PO Box 155, Subiaco
Western Australia 6904 Australia
Telephone: 08 9273 3888
Facsimile: 08 9388 3831
International: +61 8 9273 3888
Email: perth@cardno.com.au
www.cardno.com.au

Mr Nathan James
QUBE Property Group
PO Box 1161
NEDLANDS
WA 6909

Dear Nathan

PRE-DEVELOPMENT SURFACE WATER MONITORING AT CAVERSHAM

As you are aware, pre-development surface water monitoring was a requirement of the Department of Water (DoW) to provide baseline surface water quality data for the Caversham Local Water Management Strategy (LWMS). This letter report fulfils the requirements in reporting the results of the surface water quality monitoring program that may be utilised in future during detailed design stages and other management documents that may be required.

1. Introduction

1.1. Project background

The Caversham study area encompasses 178ha of land situated between the proposed Lord Street extension to the west, Reid Highway to the north, the Dampier-Bunbury Natural Gas Pipeline (DBNGP) and private properties fronting West Swan Road to the east and Benara Road to the south. The site is predominately zoned 'Rural' under the Metropolitan Region Scheme (MRS) with portions of are to the north-west zoned 'Urban' and 'Urban Deferred'. The LWMS was created to support the rezoning of the portions of the site currently zoned 'Rural' to 'Urban' and the lifting of the 'Urban Deferred' zoning under the MRS. The location of the site is shown in **Figure 1**.

1.2. Project Objective

Cardno was engaged to develop and implement a surface water Sampling and Analysis Plan (SAP) to provide baseline surface water quality data within the study area prior to development. The objective of this project is to characterise the pre-development hydrological environment. Baseline data will provide a basis for future performance criteria to ensure that any future development is able to fulfil the stormwater management requirements of the Department of Water (DoW).

1.3. Purpose of this Report Letter

The purpose of this report letter is to document the results of the three months of surface water quality monitoring, undertaken between July 2009 and September 2009.

2. Methodology

2.1. Surface Water

Surface water sampling aimed to capture five rainfall events within the three months of monitoring. Surface water samples were proposed to be collected from five (5) locations selected to provide an indication of the surface water quality conditions both upstream and downstream of future urban development.

The impact of Caversham on surface water quality was assessed at five (5) locations:

- Western streamline entering the study area, south of Reid Highway;
- Western streamline north of Patricia Street;
- Western streamline exiting the study area;
- Eastern streamline upstream of the study area, west of West Swan Road; and
- Eastern streamline near the exit of the study area.

The locations of the surface water monitoring sites are shown in **Figure 2**.

Several parameters of surface water quality were measured *in situ* utilising a Hydrolab Quanta water quality meter and included:

- Temperature (Temp);
- Dissolved Oxygen (DO);
- Reduction/Oxidation Potential (Eh);
- Salinity;
- pH; and
- Electrical Conductivity (EC).

Upon collection, surface water samples were placed directly into laboratory prepared and supplied sample containers. Surface water samples were placed on ice immediately following collection and transported to a NATA registered laboratory under standard chain of custody procedures as soon as possible. The analytes selected for surface water analysis were:

- Total Nitrogen (TN);
- Total Phosphorous (TP);
- Orthphosphate (ORP);
- Oxides of Nitrogen (NO_x);
- Total Kjeldahl Nitrogen (TKN); and
- Ammonium (NH_4).

2.2. Chain of Custody

Standard chain of custody forms were completed for all samples transferred to the laboratory detailing the sample identification, collection date and the requested analysis. Upon receipt of the samples the laboratory completed the chain of custody forms and provided a copy to Cardno for confirmation.

2.3. Laboratory Analysis

The laboratory used for this investigation was the ALS Laboratory Group. ALS is a National Association of Testing Authorities (NATA) accredited laboratory (NATA Accreditation No. 825) and is accredited for compliance with ISO/IEC 17025. All primary and QA/QC samples were submitted to ALS for analysis.

3. Assessment criteria

In order to provide an indication of the relative concentration of nutrients within surface water, comparison with the default trigger values for slightly disturbed ecosystems – Lowland River (ANZECC 2000) is made in the following sections. These default trigger values are summarised in **Table 3.1**.

Table 3.1 Default trigger values for slightly disturbed ecosystems (ANZECC 2000)

TN (µg/L)	TP (µg/L)	ORP (µg/L)	NH_4 (µg/L)	NO_x (µg/L)	DO (% Sat)	pH	Salinity (µS/cm)
1,200	65	40	80	150	80-120	6.5-8.0	120-300

The default trigger values are specifically intended for application to nutrient concentrations within surface water features.

Discussion of the nutrient concentrations in the following sections refers to their relative concentration compared to the default trigger values. The terms 'low', 'moderate', 'high' and 'very high' are used in the following manner:

- 'Low' – nutrient concentration below, equal to or marginally above the default trigger value;
- 'Moderate' – nutrient concentration up to five times the default trigger value;
- 'High' – nutrient concentration between five and 10 times the default trigger value; and
- 'Very High' – nutrient concentrations more than 10 times the default trigger value.

Principlally, comparison is made for the TN and TP concentrations. However, some comment is also provided for nutrient species (ORP, NH_4, NO_x) where these form a substantial portion of the overall nutrient concentrations

4. Monitoring Results

The SAP set the objective of sampling surface water in response to rainfall events. While sampling was attempted throughout July and September 2009, not all of the sampling locations maintained a surface water flow. Subsequently, surface water samples could not be collected from all the proposed locations during each monitoring event.

4.1. SWQ1

Surface sample location SWQ1 is situated within the western streamline south of Reid Highway where the streamline enters the study area. Results of the *in situ* and laboratory analysis are shown in **Table 4.1**.

Table 4.1 *In situ* and Laboratory Analysis Results for Surface Water Location SWQ1

	30th Jul	13th Aug	21st Aug	9th Sep	17th Sep
Field Chemistry Parameter					
Temperature (°C)	No flow to sample	No flow to sample	18.39	19.56	16.72
Conductivity (mS/cm)			0.638	0.97	1.238
pH			7.36	7.37	7.67
Redox (mV)			128	128	112
DO (%)			51.3	70.8	73.8
DO (mg/L)			4.9	6.52	7.17
Salinity (mS/cm)			0.4	0.47	0.61
Laboratory Analyte					
TN (mg/L)			3.5	3.2	3.1
TP (mg/L)			0.54	0.37	0.36
Ortho-P (mg/L)			0.3	0.21	0.22
NH_4 (mg/L)			0.09	0.02	0.04
$N0_3+N0_2$ (mg/L)			0.18	0.08	0.58
TKN (mg/L)			3.3	3.0	2.5

A comparison of the results with the default trigger values for slightly disturbed ecosystems provided in the *National Water Quality Management Strategy* (ANZECC 2000) indicates:

- 'Low' TP, NH_4 and NO_x concentrations that were generally slightly above or below the default trigger values;
- 'Moderate' TN concentrations; and
- 'High' ORP concentrations that were over five times the default trigger value.

The recorded pH values were within the default trigger value ranges. The DO values recorded were less than the trigger values while the salinity values were slightly higher than the default trigger criteria.

4.2. SWQ2

Surface sample location SWQ2 is situated within the western streamline north of Patricia Street. Results of the *in situ* and laboratory analysis are shown in **Table 4.2**.

Table 4.2 ***In situ*** **and Laboratory Analysis Results for Surface Water Location SWQ2**

	30^{th} Jul	**13^{th} Aug**	**21^{st} Aug**	**9^{th} Sep**	**17^{th} Sep**
Field Chemistry Parameter					
Temperature (^oC)		19.67	16.67	17.89	18.19
Conductivity (mS/cm)		0.655	0.520	0.517	1.393
pH		7.39	7.28	7.33	7.76
Redox (mV)		114	127	129	122
DO (%)		68.7	34.9	77.0	89.4
DO (mg/L)		5.93	3.42	7.34	8.36
Salinity (mS/cm)		0.32	0.30	0.25	0.69
Laboratory Analyte					
TN (mg/L)	0.7	0.9	3	0.9	2.4
TP (mg/L)	0.1	0.08	0.5	0.07	0.35
Ortho-P (mg/L)	0.65	0.07	0.38	0.06	0.30
NH_4 (mg/L)	0.39	0.05	0.03	0.02	0.07
$N0_3$+$N0_2$ (mg/L)	0.78	0.15	0.18	0.28	0.37
TKN (mg/L)	-	0.7	2.8	0.6	2.0

A comparison of the results with the default trigger values for slightly disturbed ecosystems provided in the *National Water Quality Management Strategy* (ANZECC 2000) indicates:

- 'Low' TN and NH_4 concentrations;
- 'Low' to 'moderate' TP and NO_x concentrations; and
- A high variation of ORP concentrations ranging from 'very high' to 'low'.

The pH and salinity values were generally within the ranges of the default trigger values while DO values were less than the trigger values.

4.3. SWQ3

Surface sample location SWQ3 is situated within the western streamline at the point where the streamline exits the study area. Results of the *in situ* and laboratory analysis are shown in **Table 4.3**.

Table 4.3 ***In situ*** **and Laboratory Analysis Results for Surface Water Location SWQ3**

	30th Jul	**13th Aug**	**21st Aug**	**9th Sep**	**17th Sep**
Field Chemistry Parameter					
Temperature (°C)		16.43	16.77	16.35	16.42
Conductivity (mS/cm)		1.063	0.329	0.995	0.876
pH		7.00	7.07	7.23	7.5
Redox (mV)		125	122	125	106
DO (%)		43.4	43.8	60	65.3
DO (mg/L)		4.14	4.41	5.88	6.36
Salinity (mS/cm)		0.52	0.2	0.49	0.43
Laboratory Analyte					
TN (mg/L)	1.7	1.5	2.6	1.9	2.0
TP (mg/L)	0.24	0.21	0.64	0.3	0.35
Ortho-P (mg/L)	0.12	0.12	0.36	0.17	0.22
NH_4 (mg/L)	0.03	0.07	0.03	0.14	0.02
$N0_3$+$N0_2$ (mg/L)	0.025	0.03	0.02	0.08	0.06
TKN (mg/L)	-	1.5	2.6	1.8	2.0

A comparison of the results with the default trigger values for slightly disturbed ecosystems provided in the *National Water Quality Management Strategy* (ANZECC 2000) indicates:

- 'Low' TN, NH_4 and NO_x nutrient concentrations; and
- 'Moderate' ORP nutrient concentrations; and
- 'Moderate' to 'high' TP concentrations.

The pH values were within the default trigger ranges. The DO values were less than the trigger criteria while the salinity values were generally above the default trigger value ranges.

4.4. SWQ4

Surface sample location SWQ4 is situated within the eastern streamline upstream of the study area situated to the west of West Swan Road. Results of the *in situ* and laboratory analysis are shown in **Table 4.4**.

Table 4.4 *In situ* and Laboratory Analysis Results for Surface Water Location SWQ4

	30th Jul	13th Aug	21st Aug	9th Sep	17th Sep
Field Chemistry Parameter					
Temperature (^oC)		21.02	18.17	17.49	18.88
Conductivity (mS/cm)		0.639	0.41	0.495	0.819
pH		6.96	7.29	7.32	8.19
Redox (mV)		131	136	143	119
DO (%)		85.2	63.8	90.5	126.3
DO (mg/L)		6.82	6.11	8.69	11.96
Salinity (mS/cm)		0.31	0.3	0.24	0.4
Laboratory Analyte					
TN (mg/L)	5.6	1.8	3	1.3	3.4
TP (mg/L)	0.14	0.19	0.49	0.28	0.26
Ortho-P (mg/L)	0.03	0.08	0.42	0.32	0.20
NH_4 (mg/L)	0.018	0.08	0.08	0.02	0.04
$N0_3$+$N0_2$ (mg/L)	2.6	0.05	1.08	0.06	1.11
TKN (mg/L)	-	1.8	1.9	1.2	2.3

A comparison of the results with the default trigger values for slightly disturbed ecosystems provided in the *National Water Quality Management Strategy* (ANZECC 2000) indicates:

- 'Low' NH_4 and NO_x concentrations;
- 'Moderate' TN concentrations;
- 'Moderate' to 'high' TP concentrations ranging up to 12 times greater than the default trigger values; and
- 'High' ORP concentrations that were up to 10 times the default trigger criteria.

The pH, DO and salinity *in situ* parameters values were predominately within their respective default trigger ranges.

4.5. SWQ5

Surface sample location SWQ5 is situated within the eastern streamline near the exit of the streamline from the study area. Results of the *in situ* and laboratory analysis are shown in **Table 4.5**.

Table 4.5 *In situ* and Laboratory Analysis Results for Surface Water Location SWQ5

	30th Jul	13th Aug	21st Aug	9th Sep	17th Sep
Field Chemistry Parameter					
Temperature (^oC)		19.85	17.20	17.83	18.88
Conductivity (mS/cm)		0.65	0.247	0.399	0.381
pH		7.19	7.07	7.84	8.58
Redox (mV)		115	129	125	112
DO (%)		57.3	55.1	99.1	118.8
DO (mg/L)		5.11	5.37	9.41	11.32
Salinity (mS/cm)		0.31	0.20	0.19	0.17
Laboratory Analyte					
TN (mg/L)	11.0	2.5	4.5	1.2	4.7
TP (mg/L)	0.15	0.21	0.43	0.11	0.46
Ortho-P (mg/L)	0.07	0.09	0.32	0.10	0.22
NH_4 (mg/L)	0.18	0.17	0.07	0.07	0.04
$N0_3$+$N0_2$ (mg/L)	8.00	1.05	2.68	0.29	2.36
TKN (mg/L)	-	1.4	1.8	0.9	2.3

A comparison of the results with the default trigger values for slightly disturbed ecosystems provided in the *National Water Quality Management Strategy* (ANZECC 2000) indicates:

- 'Low' NH_4 concentrations;
- A high variation in TN concentrations ranging from 'medium' to 'high';
- 'Moderate' TP and ORP concentrations; and
- 'High' NO_x concentrations.

The pH, DO and salinity *in situ* parameter values are predominately within their respective default trigger values.

5. Discussion

The first monitoring occasion conducted did not include *in situ* physiochemical data as the sampling occasion occurred in response to the first rainfall event (since Cardno was engaged) and due to the spontaneous nature of mobilisation, field chemistry measurement equipment was unavailable. The SWQ1 monitoring location is situated within a swamp area and was not sampled in the sampling occasion as the water was ponding and not flowing. The first sampling occasion contained generally higher nutrient concentrations.

Sampling within the different locations of the western streamline (SWQ1, SWQ2 and SWQ3) show that the TN concentrations upstream are greater than those downstream. TP concentrations increase between SWQ2 and SWQ3 suggesting a potential source of phosphorous between the two locations. All other nutrient concentrations remain stable throughout each location. Sampling within the eastern streamline (SWQ4 and SWQ5) show the TN and TP concentrations remain consistent with 'moderate' nutrient concentration values. An increase in NO_x concentrations between the two sampling locations suggests a potential source of NO_x on site.

The nutrient concentration values recorded are consistent with the dominant land-uses of the region. Vineyards are abundant in the region and use fertilisers that contain many of the nutrients sampled. The poor condition of the streamlines also means that the nutrient removal efficiencies of these areas is low. 'Duck weed' was located within the drains at all sampling locations and is consistent with the high nutrient concentrations recorded.

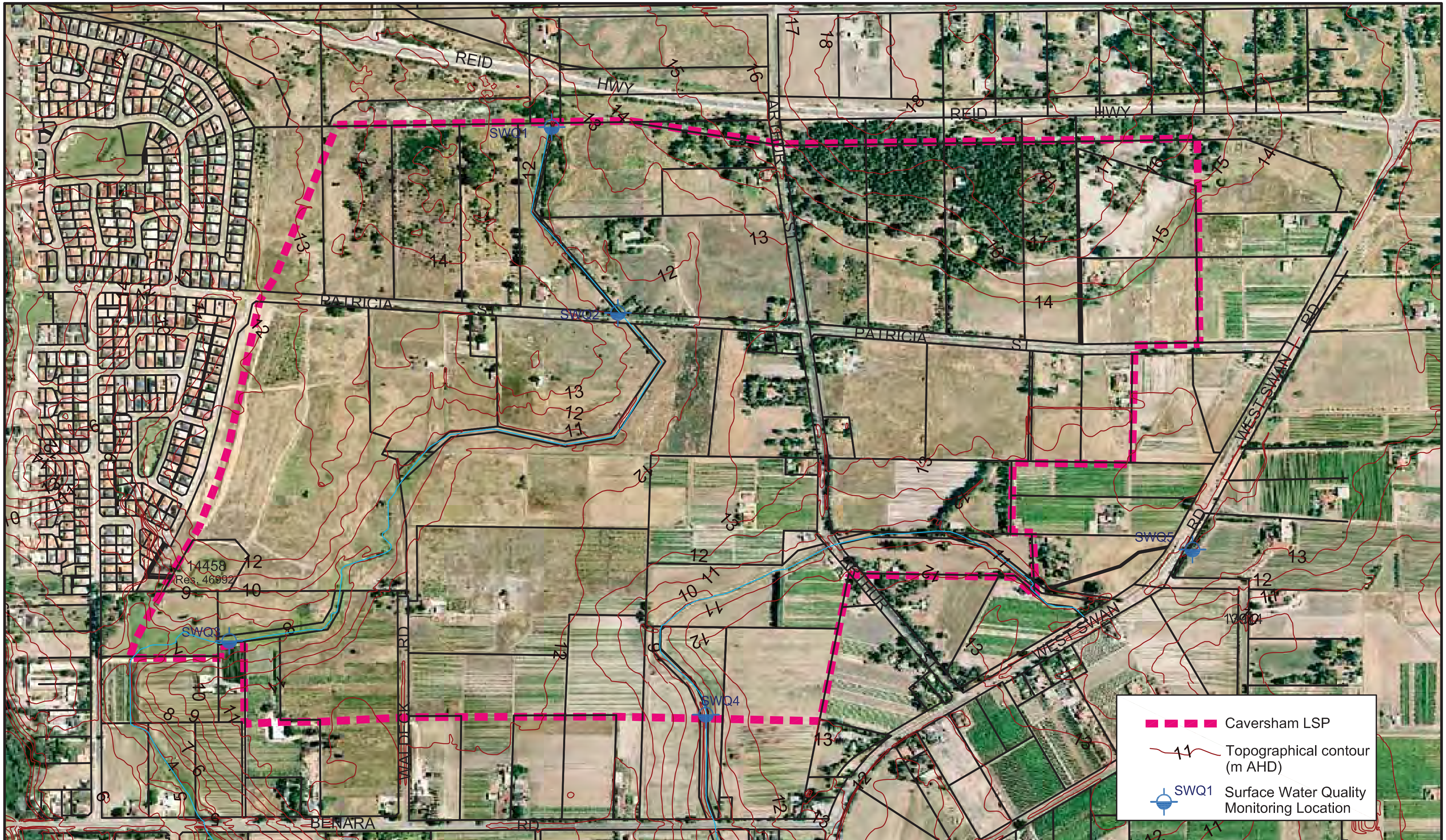
6. Conclusions and Recommendations

Variation is evident in the samples but the results suggest that they are consistent spatially and temporally. The results are therefore considered accurate and hence it is deemed unnecessary to conduct more sampling occasions.

Should you have any queries or concerns, please do not hesitate to contact me directly on 9273 3888.

Yours sincerely

David Coremans
Senior Environmental Scientist
for **Cardno**



PROJECT **Caversham LWMS**

DRAWING TITLE **Figure 1: Surface Water Quality Monitoring Locations**

PRINCIPAL **Caversham Main Landowners Group**

SCALE: **1:10000** 0 0.1km 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0km

Cardno
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno BSD Centre 2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Project Number	Drawing Number	Revision	Original
V6028	SK14	3	A4
Designed JN	Checked	Date 14.7.09	
Drawn MGW	Approved	Sheet 1	Of 1
Local Authority City of Swan			

Caversham Community and Economic Development Plan

Caversham Main Landowners Group

October 2009

creating communities

Caversham LSP Details

Prepared for:	**Client**	Caversham Main Landowners Group
	Contact Details	Jim Richards
	Address	Western Corporate
		PO Box 479, Claremont. 6910
	Phone	9286 1411
	Fax	9286 1422
Prepared by:	**Consultant**	Creating Communities Australia Pty Ltd
	Caversham LSP Project Team	Allan Tranter, Director
		Lynden Prince, Social Planning Manager
		Carole Lambert, Facilities Planning Manager
	Address	100 Jersey Street
		Jolimont WA 6014
	Phone	9284 0910
	Fax	9284 0912
	Email	allan@creatingcommunities.com.au
		lynden@creatingcommunities.com.au

Document prepared August 2009.

Contents

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Executive Summary

This document is the Community and Economic Development Plan for the Caversham Local Structure Plan (LSP). As required by the City of Swan, it outlines the foundations for social planning and community development strategies for the area. It also includes a Community Facilities Needs Analysis and Plan.

The Caversham LSP is a proposed residential development, comprising approximately 198 hectares. It is bounded by Reid Highway and the proposed Lord Street extension and abuts lots fronting Benara Road and West Swan Road on the edge of the Swan Valley within the City of Swan. The LSP has an estimated yield of 1,814 lots and 2,165 dwellings (including a retirement village) and with an anticipated population at completion of approximately 5,500 residents. The majority of the land within the LSP is owned by members of the Caversham Main Landowners Group – namely Western Corporate, Qube Property Group, Lester Group and Estates Development Company.

The area sits at the southern end of the Urban Growth Corridor of the City of Swan and is adjacent to both the urban development areas that fall within the Altone Place Plan and the semi rural areas of the Swan Valley Place Plan. Consequently, it is at the intersection of areas that are quite different in character, and offers good access to the many excellent recreational opportunities of the Swan Valley with the convenience, lifestyle and housing choice of urban living. It is also in close proximity to the employment centres of Midland, Morley, Malaga and Ellenbrook.

It is expected that the demographic profile of the area will be a mix of couples with young families purchasing their first home - similar to those in the neighbouring areas of Beechboro and Kiara - along with older couples from the surrounding areas who are wishing to purchase homes more suited to their current needs but wish to remain in their locality. There is also a retirement village planned within the LSP. Currently, there is a culturally diverse community in the region and this is expected to also be the case in relation to the Caversham LSP.

The surrounding community values the semi rural environment of the Swan Valley and its urban convenience. It also values the strong sense of community in the area and this is likely to flow across to the LSP area with the aid of initiatives that assist the development of relationships within the community. Good connections to the wider region in order to access the recreational facilities, tourism destinations and employment centres will also be essential to achieving a high quality lifestyle in this development. These connections include the physical links of quality roads, cycle and pedestrian paths that connect into the current trail network and public transport to all the major destinations, as well as social connections via links to existing community services and community and sporting groups, as well as the wide array of education facilities found throughout the region.

This CEDP focuses on putting in place the solid foundations for a strong community across the whole LSP area, which in turn will provide unity and cohesion across the wider area. There is then scope at the subdivision stage for each of the developer groups using this CEDP as a foundation for community development work to offer additional strategies as development timelines become clearer and as the community evolves. These foundational strategies fall into two major components: connection to the region and connection to each other. Each of these components has a number of initiatives that form the framework for the community development activities.

Both the Altone and Swan Valley Place Plans developed by the City of Swan list a number of strategies that are relevant to the Caversham LSP. There has been a strong emphasis in this CEDP on supporting these priorities and adding value to the strategies already determined by the City of Swan.

These include:

- Supporting the establishment of a community newsletter;
- Hosting local community events;
- Establishing a residents' reference group to increase the sense of ownership of their own community;
- Lobbying for increased public transport and exploring interim transport options; and
- Information packs for residents about recreation options, community groups and sporting clubs, services, tourism destinations etc.

Economic development for the LSP will depend upon access to the commercial and employment centres of Midland, Morley, Malaga and Ellenbrook; while some local employment will be available through the neighbourhood centre, retirement village, primary school and support for home-based businesses.

The Community Facility Provision Strategy recommended for Caversham is based on the creation of a local community hub. At this hub facilities are co-located to create a focal point for community social and economic activity and integration with existing facilities. It also includes multipurpose and shared use facilities while targeting local needs.

The recommended provisions, detailed in the Caversham Community Facilities Provision Strategy include:

- A local multipurpose community centre;
- A shared use oval and sports courts;
- Local parks – eight passive parks greater than 3,000 square metres (excluding drainage sites);
- Walking and cycle paths;
- Shared-use of District Active Open Space located in West Swan East;
- Broadband internet access; and
- Commercial and economic facilities – including a neighbourhood shopping centre, retirement village, health and medical centre and child care facility.

As the community in the Caversham LSP area becomes established there is the opportunity for them to become the drivers of future community development with the support of the developers and the City of Swan.

1. Introduction

1.1 This Document

This document articulates the initial Community and Economic Development Plan for the Caversham LSP. It should be read alongside the Caversham Community Audit (for complete document see Appendix 1), which provides a profile of the surrounding community and its facilities and services, as well as a demographic report and analysis.

This CEDP does not follow the pattern of many CEDPs, as the Caversham LSP has multiple landowners with different development timelines and development priorities. This CEDP, therefore, provides a unified vision for the area and an overarching strategy for supplying the fundamental building blocks for a thriving and cohesive community. This strategy can then be expanded further with subsequent social development and community action plans - developer led with the involvement of the new residents, as well as the surrounding community.

1.2 Project Background

In the Caversham LSP is a proposed residential development, comprising approximately 198 hectares. It is bounded by Reid Highway, the proposed Lord Street extension and abuts lots fronting Benara Road and West Swan Road on the edge of the Swan Valley within the City of Swan. The LSP has an estimated yield of 1,814 lots and 2,165 dwellings (including a retirement village).

The land sits at the eastern fringe of the urban development front and forms part of the south western gateway to the Swan Valley. It is also the southern portion of the City of Swan's Urban Growth Corridor. Its proximity to the Swan Valley, Whiteman Park, historical Guildford and employment centres of Midland (three kilometres), Malaga (five kilometres), Ellenbrook (nine kilometres), Morley (seven kilometres) and Perth central business district (13 kilometres south-west) all contribute to the sense of place for the Caversham LSP area.

Figure 1: Location Map of Caversham Local Structure Plan Area

The majority of land within the LSP is owned by four major landowners who have established an informal working group to resource a coordinated planning approach to this development. This group is known as the Main Landowners Group (MLG). Through this group the proposed Caversham Structure Plan has been prepared along with associated studies, including the development of a Community Audit and this resulting CEDP.

2. Purpose of CEDP

The Caversham CEDP details the foundational social and economic facilities and services to be provided with the estate, as well as associated costs of infrastructure provision.

Specific areas addressed in the plan include:

- The social and economic environments within the Caversham LSP;
- Relevant social and economic opportunities and constraints associated with the development and how they will be addressed;
- Strategies and timeframe for the provision of initial community and economic development within the Caversham LSP;

- Identification of potential partnership opportunities;
- Detailed community facilities and infrastructure program; and
- Indicative costing for the provision of community facilities within the Caversham LSP area.

2.1 CEDP Objectives

The community and economic development objectives for the Caversham LSP are to investigate and propose mechanisms to:

- Create an attractive and desirable estate;
- Establish local facilities and services to meet the initial and ongoing needs of the Caversham LSP community;
- Support and coordinate provision of district facilities and services;
- Facilitate sustainable community development initiatives that provide the basis for establishing an active, cohesive and integrated community; and
- Maximise employment and local economic development opportunities within Caversham LSP and support the regional employment centres of Midland, Malaga and Morley.

2.2 Guiding Policies and Strategies

The Caversham CEDP has been prepared after detailed review and consideration of the following available guidelines and literature (summaries of these documents are found in Appendix A).

- Swan Valley Place Plan July 2008 – 2009, City of Swan, July 2008.
- Altone Place Plan July 2009 - 2012 (draft), City of Swan, July 2009.
- Swan Urban Growth Corridor Sub Regional Structure Plan (SSRSP), Western Australian Planning Commission, February 2009.
- Economic Futures Discussion Paper, City of Swan, March 2009.
- Swan Urban Growth Corridor Sub-Regional Plan. Land Use and Economic Workshop – Summary of Outcomes, October 2007.
- Urban Growth Corridor – Sub Regional Planning Community Facilities Analysis, City of Swan, January 2008.
- Draft Swan Urban Growth Corridor Infrastructure Strategy for Development Contributions, April 2009.
- City of Swan Play Space Strategy, October 2006.
- Lilac Hill Recreation Reserve Indicative Concept Plan, August 2005.
- Swan Valley Cycle Trail Pathways Extensions Stage 2 – Future Connections, City of Swan, March 2006.
- Altone Walk and Cycle Trails Plan – Part Two, March 2009.

2.3 Supporting Documents

The following documents support this CEDP.

- Caversham Local Structure Plan Community Audit, Creating Communities Australia, July 2009. This document provides a social and economic snapshot of the project area and its regional context.

- Caversham Local Structure Plan Facilities Provision Strategy, Creating Communities Australia, July 2009.

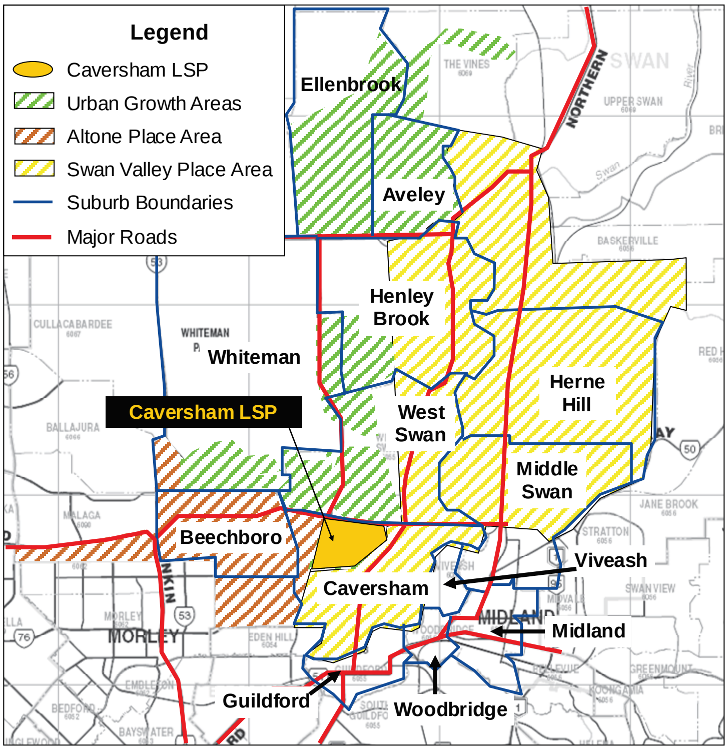
3. Local Context

3.1 About the Area

Detailed information about the area is contained in the Caversham LSP Community Audit (see Appendix A), including a full demographic analysis and significant features and heritage of the area. The LSP area sits between two quite different environments. To the west is urban development with a culturally diverse population largely made up of families with dependent children and whose parents are employed in construction, manufacturing and retail. To the north and north-east of the LSP is a semi rural environment with older residents and a significant teenage population. Currently, the LSP area is used for viticulture activities and these activities will continue in areas surrounding the LSP. There is also retirement accommodation planned for the LSP area.

In terms of the City of Swan's place planning process, Caversham's LSP borders sit just outside Altone Place Plan and Swan Valley Place Plan. It is part of the Urban Growth Corridor, which as yet does not have its own place plan.

Figure 2: Caversham LSP area and Surrounding Context (indicative only)



3.1.1 Demographic Projections

Using the maximum number of dwellings forecast in the Caversham LSP, the forecast population at full development is 5,495 people, with 89 per cent living in the main residential area and 11per cent living in the proposed retirement village.

Table 1: Indicative Population in the Caversham LSP Area

	Maximum Dwellings[1]	Persons/ Dwelling[2]	Maximum Population
Main	1,815	2.7	4,900
Retirement Village	350	1.7	595
Total	**2,165**		**5,495**

The Caversham LSP area is the intersection between the existing Altone (Beechboro) community, the City of Swan's new development areas and the semi rural areas of the Swan Valley, and as such will attract residents who are either looking to purchase their first home or move from their existing home into a new dwelling that better suits their needs, particularly as they age.

Therefore, the following demographic characteristics may be expected in the Caversham LSP area.

- A high proportion of younger families and first home buyers in the area; however, all household types will be represented, including:
  - Second and third homebuyers from surrounding areas; and
  - Older residents looking to downsize or move into the retirement village.
- An ethnically and culturally diverse society, yet the majority of residents will hold Australian citizenship.
- Dwellings will be largely owner occupied, and only a slightly lower level of rental properties in the area compared to the City of Swan overall.
- Households will have a slightly higher median weekly household income compared to the City of Swan.
- The top four industries of employment are likely to be manufacturing, retail, construction and health care/social assistance.
- A slightly lower level of unemployment compared to the City of Swan.
- The majority of households will own either one or two vehicles.

It is important to note that while the specific demographic characteristics identified above are anticipated within Caversham LSP area, the community will consist of a broad demographic mix.

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1 Please note these figures were correct at the time of writing this report, however they may be subject to review at a later date.
2 Sourced from the Shrapnel Urban Planning, Swan Urban Growth Corridor Sub-Regional Plan Land Use & Economic Workshop Summary of Outcomes.

4. Stakeholder Feedback

The scope of the consultancy has enabled a series of meeting with stakeholders that has included local grape growers, a residents' group, not for profit community service groups and state and local government representatives (see Appendix B for details).

The main consultation process has identified the following key areas under which the strategies for the Caversham LSP community and economic program can be grouped.

- Connection to each other within the local area that creates a strong sense of community within a diverse population.
- Connection to the district and region and its wide selection of recreational and economic opportunities.

These areas offer the foundation for a framework of strategies designed to maximise opportunities for residents to interact with each other on an informal basis and through organised activities. The consultation also indicated that connection to the social and economic resources outside the Caversham LSP area will be critical to the estate's success. The needs and opportunities identified in this consultation have also been incorporated into the CEDP.

The values identified through the consultation include:

- Appreciation of cultural diversity;
- Neighbourhood safety;
- Connection to each other within the community;
- Good connectivity to regional services, facilities, recreation and employment opportunities;
- Importance of parks and recreational opportunities;
- Proximity to urban facilities; and
- Proximity to the semi rural environment of the Swan Valley.

5. Social and Economic Analysis

5.1 Social Viability

The philosophy driving this CEDP is that places do not automatically transform into functioning communities unless both the urban planning and social planning aspects of projects are developed in unison. Well-planned neighbourhoods provide the essential raw materials to establish a community; however, the planning of robust communities also requires a comprehensive sociological and economic response.

5.1.1 Implications for Community Development and Local Structure Plan

Social assessment of the structure plan and projected demographics for Caversham LSP suggests the following implications for community development.

- Facilities, services and programs for young families and youth are likely to be required. There is likely to be a high proportion of these cohorts within the structure plan area and there is already a shortfall of these facilities and services through the district.
- Additional childcare facilities are needed to support young families who move to the area.
- Good linkages to the facilities and services are already provided in the district.
- There is a range of lot sizes and housing types needed to cater for community diversity, particularly for older residents wishing to downsize and remain within their local area. Community programming will need to cater for this diversity.
- Provision of good public transport to enable access to recreational and commercial centres - particularly for young people and the elderly - will be extremely important to the success of this development.
- Good provision of pedestrian and cycle paths throughout the LSP, as well as to recreational opportunities in the wider district (such as Whiteman Park), is important.
- Orientation and integration of the new residents into the many existing community programs and services already running in the Altone and Swan Valley area is required.
- A small local neighbourhood hub will be important for residents of the Caversham LSP area.

5.2 Economic Viability

5.2.1 Analysis of the District Structure Plan

The design of the District Structure Plan provides the essential physical elements to support and enhance the appropriate level of local economic activity within Caversham LSP, and provides required connections to district and regional activity centres.

Local economic elements within the plan include:

- A centrally located medium-sized neighbourhood centre, as identified in the City of Swan Commercial Centres Strategy (2004);
- A primary school and a retirement village within the LSP (to provide further local employment opportunities); and
- Easy access in and out of the LSP area supporting connections to the key employment centres of Midland, Malaga, Morley and Ellenbrook.

5.2.2 Employment Self Sufficiency[3]

Caversham LSP is likely to achieve an employment self sufficiency[4] of 24.3 per cent. This is a good achievement given that the Caversham LSP area does not contain any district or regional employment centres; therefore only providing a local employment centre that caters for the Caversham population. It also achieves a higher employment self sufficiency than the 18.5% initially predicted in the Swan Urban Growth Corridor Sub-Regional Plan Land Use & Economic Workshop – Summary of Outcomes (Shrapnel Urban Planning 2008).

Further to this local provision the Caversham LSP significantly contributes to the district structure plan (DSP) employment self sufficiency target of between 30% and 60% specified in Liveable Neighbourhoods (WAPC, 2009); with a target of 60% employment self sufficiency expected in a large DSP or sub-regional plan. For Caversham this would include the Albion District Centre, Ellenbrook Regional Centre, Midland Strategy Regional Centre and Malaga Industrial Area. Note Liveable Neighbourhoods does not set an employment self sufficiency target for a LSP.

On a higher level, Directions 2031 (WAPC, 2009) indicates the North East Metropolitan Planning Corridor, which includes City of Swan and Shires of Kalamunda and Mundaring, achieved an employment self sufficiency of 63% in 2008 and sets a target of 75% by 2031. Note Directions 2031 does not set an employment self sufficiency target for any structure planning document.

Detailed analysis of Caversham LSP's workforce and employment generators is shown in the tables below.

Employment Self Sufficiency

Caversham LSP Workforce	2,360
Caversham LSP Employment	573
Self Sufficiency	24.3%

[3] Please note all employment figures were correct at the time of writing this report, however they may be subject to review at a later date.
[4] Employment self sufficiency is the total jobs available in a particular area as a proportion of the number of people in the workforce living in that area. The higher the proportion the more opportunity there is for people to work close to their home.

Caversham LSP Workforce

	Dwellings	Persons/Dwelling[5]	Population	Workforce
Main	1,815	2.7	4,900	2,360
Retirement Village	350	1.7	595	0
Total	**2,165**		**5,495**	**2,360**
Workers per Dwelling				1.3[6]

Caversham LSP Employment Generators

Employment Driver	Capacity	Ratio	Projected Jobs
Neighbourhood Centre	4,750m² floor space	30m² per employee[7]	160
Primary School	540 students	1 employee per 16 students[7]	34
Retirement Village	595 persons	1 employee per 0.2 persons[7]	119
Home Based		12% of dwellings will contain a home-based business[8]	260
Total			**573**

[5] Sourced from the Shrapnel Urban Planning, Swan Urban Growth Corridor Sub-Regional Plan Land Use & Economic Workshop Summary of Outcomes. These figures are consistent with the City of Swan Population & Household Forecasts for West Swan
[6] Liveable Neighbourhoods, 2009.
[7] Sourced from Swan Urban Growth Corridor Sub-Regional Plan, Land Use and Economic Workshop – Summary of Outcomes, October 2007
[8] This ratio is based on Liveable Neighbourhoods (WAPC, 2009) which indicates that "up to 16% of dwellings now have a home based business". Given the anticipated demographics in Caversham, including a retirement village, it is estimated that 12% of all dwellings will house a home based business.

5.2.3 Implications for Economic Development

Based on the structure plan and employment provision for Caversham LSP, the following economic development implications have been identified.

- Whilst a small amount of local employment will be available within the structure plan area the most important factor for the economic development of the Caversham LSP community will be having excellent connectivity to the major employment centres of Midland, Morley and Malaga.
- Transport network should facilitate convenient and timely connection to these centres. Well designed cycle paths, particularly connecting to Reid Highway and to public transport nodes such as Midland, would also facilitate this.
- Through the development of detailed area plans DAP the use of dwellings for home offices will be permitted as of right without the need to obtain planning approval for all dwellings within 400 metres of the Neighbourhood Centre. In relation to home businesses, consideration will be given
- to the formulation of DAP provisions which encourage such development in areas coded R30 and above within 400 metres of the Neighbourhood Centre.

6. Facilities and Infrastructure Needs Analysis

The table below identifies specific community facilities and infrastructure required to service the Caversham population.

Table 2: Community Facilities Needs Matrix

	Facility Hierarchy Classification	Research Source				
		Literature Review	Demographic Analysis	Review of Existing Facilities	Standards Review	Consultation
Public Primary School	Local					
Multipurpose Neighbourhood Community Centre	Local					
Sporting Oval/ Active POS – Shared Oval with Primary School	Local					
Change Rooms	Local					
Facilities and Amenity for Youth	Local					
Walking and Cycle Paths	Local					
Passive Parks Landscaped with Community Amenity (x3)	Local					
Multipurpose Sports Courts (x4)	Local					
Shared Use of District Active Open Space	District					
Childcare Centre	Local					
Health and Medical Centre	Local					
Broadband Internet Connection	Local					
Neighbourhood Shops/ Café/ Restaurant	Local					

7. Community Facilities Provision Strategy

The following table outlines indicative capital costs for all local public community facilities that will service the needs of the future Caversham community.

Local Facilities	No.	Rate	Elemental Cost (ex GST)	Fee & Contingency Allowance	Item Cost	Timeframe
Local Landscaped Parks	85,000m^2	$50	$4,250,000	$425,000	$4,675,000	2010 onwards
Walking and Cycle Paths (2.5m wide)	2,500m	$63	$157,500	$15,750	$173,250	2010 onwards
Broadband Internet Access	1,814 lots	$2,600		included	$4,716,400	2010 onwards
Shared Use Oval – earthworks, turf and irrigation	9,912m^2	$35	$346,920	$48,309	$395,229	2012
Shared Use Oval - Floodlighting	2 Poles	$25,000	$50,000	$5,000	$55,000	
Local Community Centre	605m^2	$2,600	$1,573,000	$314,600	$1,887,600	2013
Local Community Centre land	4,000m^2	$100			$400,000	
Shared-use Sports Courts – plexipave with fencing and lighting	4	$71,000	$284,000	$39,548	$323,548	2017
Gross Local Facility Project Costs (at current prices)					**$12,626,027**	

Funding of the abovementioned local facilities will involve partnerships with government funding programs, the WA Department of Education and Training, and the City of Swan.

The abovementioned indicative costing excludes the following items:

- Parking;
- External services on site;
- facilities;
- Headworks and statutory charges;
- External spaces within built facilities; and
- Landscaping around built facilities.

8. Social Planning and Community Development Approach

The community development and social planning for Caversham LSP proposes strategies based on the results of:

- Consideration of the strengths and possibilities of the area;
- The values and aspirations of those living in the surrounding areas and those who are responsible for service delivery in the district;
- City of Swan priorities for the area;
- The projected demographic profile, and
- The opportunities offered by the structure plan.

To ensure thorough planning that incorporates all the foundational elements for a sustainable quality of life, as well as encouraging personal and community growth, these proposed strategies have been reviewed through:

- CCA's Sociology of Community (Healthy Community, Figure 1);
- Creating Communities Australia's (CCA) Intentional Communities Matrix (Figure 2); and
- The City of Swan's draft Altone Place Plan and Swan Valley Place Plan.

This process also develops the social capital necessary to form the basis for economic development. Local economic development depends on the development of trusting relationships within the community and good links to resources in the broader region that facilitate economic growth.

Figure 1: Sociology of community

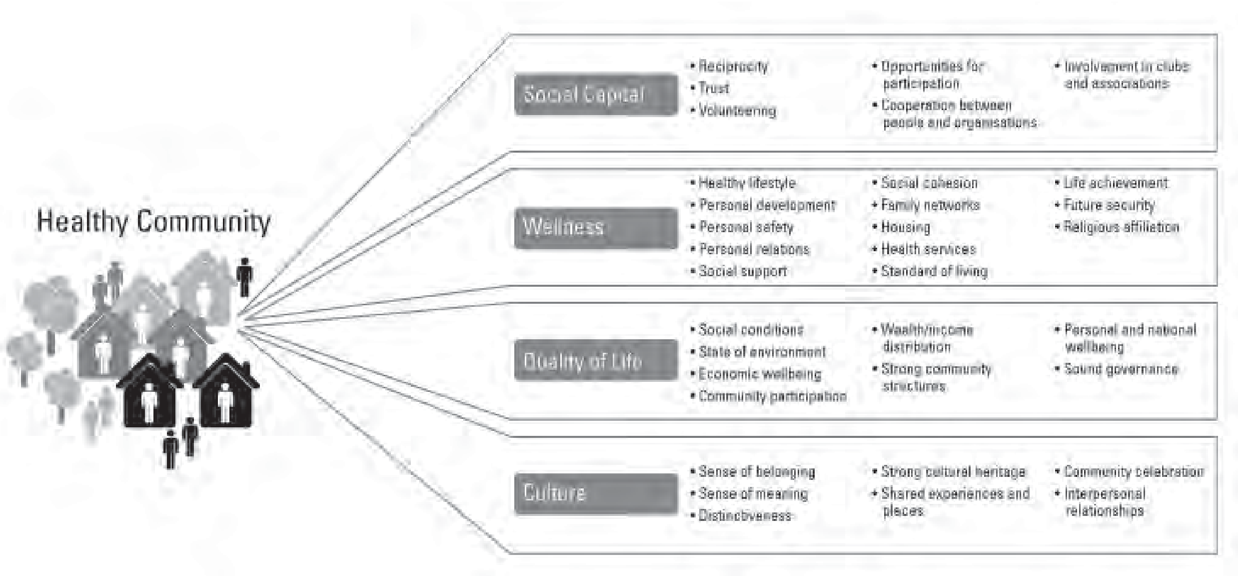

Figure 2: Intentional Communities Matrix

Ourselves	Our community	Our endeavours	Our place
Individual wellness (physical, mental, spiritual)	Cultural heritage	Diverse industry	Safety and security
Personal development	Collective identity	Competitive advantage	Functional planning
Self-determination	Ownership	Innovation and entrepreneurship	Aesthetic attributes
Access and amenity	Cooperative spirit	Nexus	Civic attractors
Personal worth	Civic creativity	Growth and renewal	Respite spaces
	Community giving	Sustaining structures	
	Tolerance/honesty/trust		
	Group cohesiveness		

9. Caversham LSP CEDP Strategies

This Plan focuses on providing the foundation building blocks essential for a healthy and vibrant community. These fundamental building blocks will be established in a coherent process involving all the developers in the Caversham LSP, with the option of each developer adding further strategies as the community evolves and the development timeline becomes certain. This could occur most naturally at the subdivision stage.

Caversham LSP officially sits in the Urban Growth Corridor between the Swan Valley Place Plan and the Altone Place Plan areas, and will therefore be impacted upon by initiatives from both plans. However, it is anticipated that given the barrier of Reid Highway, the urban nature of the Caversham LSP development and the pull of the strong urban population to the east of the LSP, the residents will be most affected by many of the initiatives that fall within the Altone Place Plan. This is particularly likely given the absence of a City of Swan Urban Growth Corridor Place Plan.
The strategies for the Caversham are strongly linked to supporting and contributing to the implementation of these Place Plans.

The CEDP consists of two components as the basis for social planning and community and economic development.

1. Connection to the Wider Region

This component is strongly focused on integration of the Caversham LSP into the life of the region. Through the consultation and research phase this was identified as a key factor in the potential success of this development. The region is rich in opportunities, particularly due to its proximity to some of the metropolitan area's best recreational facilities. It also has a large and diverse number of education and training facilities that are important attractors to the area for families.

The Altone and Swan Valley Place Plans offer a number of priorities for the broader area that are relevant to Caversham LSP. These include a focus on improved public transport throughout the area; establishing a community newsletter; increased focus and funding for youth services; showcasing the diversity of the area with such events as a Harmony Day celebration; and holding 'Altone-wide' events such as a Christmas celebrations and a community art project. There is also a priority in giving the community the opportunity to interact with local government decision making concerning their community and improving communication channels to facilitate this.

Effective economic connections to the wider region will also be essential to the sustainability of the Caversham LSP area. Improved public transport and other transport links are also crucial for accessing employment opportunities in the wider region, including Midland, Malaga, Morley and Ellenbrook. Linking Caversham LSP residents into the other initiatives proposed by the Altone and Swan Place Plans - such as a local business database, support for home-based offices, business attraction schemes and promoting City of Swan youth development and employment schemes - is also key to establishing an economically robust community.

2. Connection to Each Other Within the Caversham LSP

Whilst strong connections to the broader region are important there is also a need to develop a strong sense of neighbourhood and strong community relationships within the smaller LSP area. This creates mutual trust relationships where people feel they know their neighbours. This is essential in promoting a feeling of community safety, an active, vibrant community and a sense of belonging and ownership in their community. Again the Altone and Swan Valley Place Plans have a number of priorities that can form strategies to be implemented in the Caversham LSP area. Examples of these include local community events such as Picnic in the Park, getting the local school involved in community projects and promotion of Neighbourhood Watch. Swan Valley and Altone place- wide strategies, such as a community newsletter, can also have a Caversham LSP focus, with a Caversham LSP one-page insert or Caversham LSP information included in an Altone community welcome and information pack. In addition, it is proposed that a number of initiatives be instigated to activate the community hub around the neighbourhood shopping centre, school and a small community centre.

The table below outlines the CEDP framework.

Indicative Community and Economic Development Activation Plan

Development Aims	Strategy/Initiative	Potential Partners*	Facility/Infrastructure Required	Timeframe
Component 1: Connection to the wider region				
Access to Recreational Opportunities	Information in welcome pack detailing recreational facilities, parks, recreational activities, vineyards etc.	MLG, CoS,		Year 1 onwards
	Pedestrian/cycle paths connecting recreational destinations	MLG, Other developers in the Altone area; DSR, CoS	DUPs	Year 1 onwards
Community Participation	Annual calendar of Altone and Swan Valley community events	CoS, MLG		Year 1 onwards
	Information on community groups and sporting clubs in region included in Welcome Packs Volunteering opportunities promoted in community newsletter	MLG, CoS,DSR		Year 1 onwards
Celebration of Diversity	Participation in CoS Harmony Day	CoS, Developers		Year 2 onwards
Community Celebration	Participate in Annual Altone Christmas party As Caversham LSP develops host own or Urban Growth Corridor Christmas event	Developers CoS	POS of 3,000 m2	Year 1 onwards
Social Support	Information in welcome packs on services provided by CoS and NGOs including aged care support, health services, youth services etc	MLG, CoS,		Year one onwards

Development Aims	Strategy/Initiative	Potential Partners*	Facility/Infrastructure Required	Timeframe
Component 2: Connection to each other				
Sense of Belonging	Biennial Picnics in the Park	CoS MLG	POS of 3,000m2	Year 2 onwards
Social Cohesion	Caversham LSP Community news sheet	MLG		Year 1 onwards
Social Support	Local play groups/mothers groups/ retirees groups established	Local churches, Play Group Association, Brockman House WA Dept of Health Blue Sky Community Group CoS	Local community centre	Year 3 onwards
	After school care established		Local community centre	Year 3 onwards
	Promotion of youth activities within the region Negotiate with NGO or local church to initiate local youth activity	CoS YMCA Brockman House Local churches	Local community centre	Year 1 onwards Year 3
Community Safety	Neighbourhood Watch	Office of Crime Prevention CoS		Year 1 on wards
Shared Experiences, Places and History	Community art project	CoS MLG DET	Local community centre	Year 4
Community Self Determination	Establish Caversham LSP Community Reference Group that can become a residents' association in affiliation with other existing residents' groups in the Altone and Swan Valley areas	MLG Swan Valley Progress Association CoS	Local community centre with meeting rooms (meet in neighbouring facility until community centre is established)	Year 1 onwards

CoS- City of Swan

DET – Department of Education and Training

DSR – Department of Sport and Recreation

MLG- Caversham Main Landowners Group

*NB Potential partnerships are indicative. Negotiations are still to be completed.

10. Budget and Staging

This CEDP provides the foundational strategies for building a strong community. All developers within the Caversham LSP will provide these initial strategies that will provide unity and cohesion across the LSP area. However, the time of subdivision presents the best opportunity for each developer to provide additional initiatives for each area within the Caversham LSP area. These additional initiatives could include welcome events and resident information evenings, street parties, gardening workshops, community art projects, children's fun days, community fairs, swap meets etc.

The following is the estimated budget for the foundation strategies outlined above. Additional initiatives negotiated at the time of subdivision would require further budgeting.

Stage	**Year**	**Indicative budget**
Year1	2010	$85,000
Year 2	2011	$95,000
Year 3	2012	$105,000
Year 4	2013	$115,000
Year 5	2014	$125,000
Year 6	2015	$125,000
Year 7	2016	$110,000
	TOTAL	$760,000
	Total/lot	$400

The details for the budget and staging for the facilities development are contained within the Facilities Provision Strategy.

11. Monitoring and Evaluation

The Community and Economic Development Plan is intended to guide the development of the local structure plan, the developer contribution plan and subsequent stages of subdivision. The implementation of this plan will be monitored on a regular basis through input from the Community Reference Group as well as the normal City of Swan Community Development review processes. It is also recommended there be an annual stakeholders workshop including both these groups, service providers and representatives of local business to review the progress and to assess the changing needs of the community.

Appendix A - Guiding Policies and Strategies

The Caversham LSP CEDP has been prepared after detailed review and consideration of the following available guidelines and literature.

Swan Valley Place Plan July 2008 - 2009 – City of Swan, July 2008

The Swan Valley Place includes a number or areas to the north of the structure plan, including the south-west corner of Caversham, which borders the Caversham LSP. Using a place-centred planning approach the document identifies opportunities for the Swan Valley area and outlines priorities for the city's provision of services to the Swan Valley area. This has been done in consultation with the community and discussion internally within the City of Swan. The Caversham LSP should be consistent with the implementation of this plan.

Altone Place Plan July 2009 - 2012 (draft) – City of Swan, July 2009

A similar place planning document has been prepared for the Altone area (which Caversham LSP adjoins). This document provides a wholistic and integrated guide for the city's provision of services to the Altone area. Through a process of community engagement the city has identified the community's vision for the area, as well as its needs and opportunities.

It is anticipated that this Place Plan will have significant impact on the residents of the Caversham LSP. Therefore, the CEDP should also be consistent with and contribute to the implementation of this plan where it is relevant to the structure plan area.

Swan Urban Growth Corridor Sub Regional Structure Plan (SSRSP), Western Australian Planning Commission, February 2009

This Plan has been prepared by the Western Australian Planning Commission in conjunction with the City of Swan, the community and participating landowners, including the Caversham Main Land Owners Group. Its purpose is to guide land development and the preparation of district structure plans for the Henley Brook (Albion), West Swan and Caversham areas.

Specifically in terms of the Caversham LSP area, provision is made for:

- Residential development over the entire LSP area;
- A primary school on the south side of Patricia Street;
- A neighbourhood centre adjoining the proposed primary school on Patricia Street;
- An Arthur Street 'flyover';
- A pumping station site near Bennett Street in the south-west margins of the site; and
- An activity/public transport corridor from Arthur Street flyover west into Patricia Street.

Economic Futures Discussion Paper, City of Swan, March 2009

This discussion paper presents the early findings from the initial research and consultation conducted by consultant's engaged by the City of Swan to develop their Economic Vision and Strategy.

Six strategic 'economic futures' themes have been identified based on the research finding investment attraction and new business development; skills enhancement and employment growth; lifestyle and identity; strategic infrastructure; place making; and leadership and governance.

The Caversham LSP area will provide local level facilities and associated employment options for residents, with support of and connectivity to the main employment centres being the main economic focus.

Swan Urban Growth Corridor Sub-Regional Plan. Land Use and Economic Workshop – Summary of Outcomes, October 2007

The sub-region of Caversham/ Henley Brook/ West Swan has excellent access to a variety of convenient employment opportunities.

These include:

- The Midland and Morley strategic regional centres;
- Ellenbrook regional centre;
- Swan Valley;
- Perth Airport; and
- The Malaga, Bassendean, Midland and Hazelmere industrial/ mixed business areas.

The Caversham, West Swan and future Albion urban districts should provide added catchment area support to these planned major centres. They should not seek to establish an excessive level of economic activity that would undermine the viability of these centres. They should only provide local activity centres to provide retail and commercial economic activity for the convenience of the local population.

Urban Growth Corridor – Sub Regional Planning Community Facilities Analysis, City of Swan, January 2008

This paper addresses the likely community facility needs for the Swan Urban Growth Corridor and states the City of Swan's position on the provision of suitable spaces for facility development. The paper covers the Urban Growth Corridor areas of Caversham, West Swan and Albion and is expected to eventually accommodate approximately 12,500 dwellings and 33,000 residents.

New local facilities will be required in the Urban Growth Corridor; however, there will not be any requirements for the following district and regional facilities: libraries, performing arts centres, aquatic centre, indoor recreation centres and regional sports complexes.

The Caversham LSP is consistent with proposed community facilities to be provided within Caversham. The facilities are recognised as community ‘hubs’ for the development and will be noted as such in the CEDP and used for community activation initiatives.

Draft Swan Urban Growth Corridor Infrastructure Strategy for Development Contributions, April 2009

This document outlines the policy for the developer contributions to community infrastructure, including community facilities. A DCP for community facilities consistent with this policy will be included in the Caversham LSP CEDP.

City of Swan Play Space Strategy, October 2006

This document outlines a City of Swan strategy based on the concept of play spaces rather than playgrounds, recognising that spaces for play can be incorporated into the whole site. This plan is not relevant to the Caversham LSP but its principles will be noted for future planning stages.

Lilac Hill Recreation Reserve Indicative Concept Plan, August 2005

This plan has been noted and connections to this facility will be of great value to the residents of Caversham LSP.

Swan Valley Cycle Trail Pathways Extensions Stage 2 – Future Connections, City of Swan, March 2006

This document outlines the next stages of the Swan Valley Cycle Trail Pathway. It is an excellent piece of infrastructure and will provide residents of Caversham will an alternate transport network (i.e. walk/cycle) to access surrounding areas. Where appropriate, pathways within the Caversham LSP will connect into the existing Swan Valley Cycle Trail.

Altone Walk and Cycle Trails Plan – Part Two, March 2009

This plan identifies 60 recommendations for additional cycle and walk path infrastructure both within and outside Altone.

Where appropriate, pathways within the Caversham LSP will connect into the existing and planned Altone walk and cycle trails.

Appendix B - Stakeholder Consultation List

Meeting	Attendees	Location	Time
City of Swan	City of Swan (CoS): John Elliott, Linda Richardson, Anthony Kelly, Brian Blechynden, Kelly Walsh Caversham Main Landowners Group (CMLG): Nathan Butson, Mark Hector, Tony Aleksovski Creating Communities Australia, Carole Lambert, Nyssa Searles	City of Swan Offices, Midland	May 27, 2009
City of Swan	Brian Blechynden – Coordinator Community Facilities Planning, Community Planning Carole Lambert – Facility Planning Specialist, Creating Communities Australia Mark Davis – Journalist, Creating Communities Australia	City of Swan Offices, Midland	June 18, 2009 11am – 12.30pm
City of Swan	Roz Bailey – City of Swan Community Development Coordinator (Altone Place Office) Peter Bracegirdle – City of Swan Altone Place Manager (Altone Place Office) Carole Lambert – Facility Planning Specialist, Creating Communities Australia Mark Davis – Journalist, Creating Communities Australia	City of Swan - Altone Place Office	June 22, 2009 9 – 10:15am
Blue Sky Community Group Inc. and Brockman House Inc (Family and Community Centre)	Neville Wilcock – Blue Sky Community Group Coordinator Fiona Duffield – Brockman House Manager Joanne – Brockman House Family Support Officer Carole Lambert – Facility Planning Specialist, Creating Communities Australia Mark Davis – Journalist, Creating Communities Australia	Blue Sky Community Centre	June 25, 2009 9:30 – 11:30am

Meeting	Attendees	Location	Time
Department of Education	Richard Bloor, Principal Consultant Asset Planning, DET Jim Richards, Western Corporate Ross Lee, Lester Group Tony Aleksovski, EDC Carole Lambert – Facility Planning Specialist, Creating Communities Australia Mark Davis – Journalist, Creating Communities Australia	DET Offices, East Perth	June 26, 2009 3 – 3:30pm
Swan Valley Progress Association and Swan Valley Grape Growers Association	Peter Enright – Swan Valley Progress Association Chairperson Sue Hurt – Swan Valley Progress Association Secretary Matt Katich – Swan Valley Grape Growers Association, Swan Valley Progress Association Darryl Trease - Swan Valley Grape Growers Association, Swan Valley Progress Association Carole Lambert – Facility Planning Specialist, Creating Communities Australia Mark Davis – Journalist, Creating Communities Australia	Penny Gardens Cafe	June 27, 2009 10am – 12pm

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Caversham Community Facilities Provision Strategy

Caversham Main Landowners Group

October 2009

Project Details

Prepared for:	**Client**	Caversham Main Landowners Group
	Contact Details	Jim Richards
		Director, Western Corporate
	Phone	9286 1411
	Address	211 Stirling Hwy
		Claremont WA 6010
Prepared by:	**Consultant**	Creating Communities Australia Pty Ltd
	Project Team	Allan Tranter, Project Director
		Lynden Prince, Project Manager
		Carole Lambert, Facilities Planning Specialist
		Nyssa Searles, Research Officer
	Address	100 Jersey Street
		Jolimont WA 6014
	Phone	9284 0910
	Fax	9284 0912
	Email	allan@creatingcommunities.com.au
		lynden@creatingcommunities.com.au

Document prepared August 2009.

Contents

1. Purpose of the Document

The timely provision of well-planned community and economic infrastructure such as shopping centres, primary schools, community centres, pavilions, parks, sporting fields and other civic amenities is critical to the formation of sustainable well-connected communities.

The purpose of this draft community facility provision strategy is to outline the preliminary concepts for proposed community facilities within the Caversham residential development. It details the facility types, expected uses, anticipated facility components and indicative cost estimates, forming a key element of the Community and Economic Development Plan (CEDP) for the estate. The intent is to guide the planning, development and funding of community facilities within the Caversham development.

2. Methodology and Community Facility Needs

2.1 Methodology

A number of different research methods were employed to identify needs for community facilities within the Caversham development. These include:

- Literature review;
- Demographic analysis;
- Review of existing community facilities and usage data;
- Review of community facility provision standards;
- Consultation with key City of Swan staff;
- Consultation with key stakeholders; and
- Analysis of research findings.

2.2 Community Facility Needs

An analysis of the research findings confirms the following community facilities will be required for the future Caversham community.

Public Built Facilities	Private Built Facilities	Public Open Space	Amenity
▶ 1 x Local multipurpose community centre ▶ 1 x Public primary school ▶ 4 x multi-marked outdoor sport courts	▶ 1 x Health and medical centre ▶ 1 x Child care centre ▶ 1 x local shopping centre.	▶ 1 x active sporting oval* ▶ Local passive parks* ▶ Shared-use of the proposed District Active Open Space in West Swan East	▶ Amenity for youth. ▶ Amenity for seniors. ▶ Interlinking walking and cycle paths. ▶ Broadband Internet Access.

* Will form part of the public open space allocation based on the provision of 10% gross subdivisible land area.

The provision of the abovementioned facility requirements will be the responsibility of a range of agencies including Caversham land developers, other land developers active within the urban growth corridor, state and local government and the private sector. The requirements for public built facilities, open spaces and amenity underpin the recommended facility provision strategy for the Caversham Local Structure Plan.

3. Community Facility Provision Strategy

The community facility provision strategy recommended for Caversham is based on the following principles:

- Creation of local community hubs: – where synergies exist, facilities should be co-located to create a focal point for community social and economic activity.
- Integration with existing facilities: – community facilities and services should aim to complement those already existing in the locality and avoid any duplication.
- Multipurpose and shared use facilities: – efficient facility design should maximize usage and minimise future management costs.
- Target local needs: – the facilities within Caversham should be local in nature and aim to meet identified needs for local services and activities.

Detailed below are the key elements of the strategy.

3.1 Local Multipurpose Community Centre

Co-located with the future primary school and active public open space, the Caversham Community Centre will be a key focal point for local residents, accommodating a broad range of community services and recreational activities. The building itself will combine elements of a multipurpose community centre with those of a junior sports pavilion to provide an efficient facility suitable for meetings, group activities, community education programs, social functions and community support services. The facility will be suitable for use by junior sporting clubs, not-for profit community support agencies, playgroups, youth clubs, seniors groups, and multicultural organisations.

Suggested facility design components for the local community centre include:

Internal Facility Component	Area (m^2)	Functionality	Design Details
Entrance Foyer	20	▸ Main entrance ▸ Community notice board ▸ Display area for local arts	▸ Vending machine.
Large Multipurpose Activity Room	120 + 25	▸ Club/ group functions ▸ Social/ fundraising activities ▸ Yoga/ Pilates ▸ Tae kwon do/ Tai chi ▸ Children's drama classes ▸ Youth events/ discos ▸ Seniors activities/ active ageing programs ▸ School activities and events	▸ Multipurpose flexible space ▸ Direct access to kitchen. ▸ Large store room for tables and chairs, portable staging and exercise mats.

Training Room	50 + 10	▶ Information presentations ▶ Community seminars ▶ Migrant education programs	▶ Multipurpose ▶ Secure store room for laptop and digital projection equipment.
Meeting/ Counselling Room	35	▶ Service clubs ▶ Community support group meetings ▶ Craft groups ▶ Women's/ mother's groups ▶ Outreach social services ▶ Outreach financial counselling	▶ Multipurpose ▶ Lockable storage cupboards for group equipment.
Playgroup Room/ Children's Activity Room	75 + 15 + 20	▶ Playgroups ▶ Before and after school care ▶ Children's holiday activities ▶ Parenting programs	▶ Direct access to enclosed outdoor play area. ▶ Internal store room for arts and craft equipment, games/ toys. ▶ External store for outdoor play equipment.
Kitchen/ Kiosk	25	▶ Multicultural cooking classes ▶ Tea/ Coffee facilities ▶ Food preparation and heating ▶ Serving area for functions	▶ Commercial kitchen ▶ Lockable storage cupboards for groups ▶ Internal and external servery
Toilets	30	▶ Male ▶ Female ▶ Disabled	▶ Internal access ▶ As per building standards.
Toilet/ Changerooms	130	▶ Male ▶ Female	▶ Universal design ▶ No showers required in change rooms. ▶ Ablutions to include accessible WC.
Cleaners Store	20	▶ Storage of cleaning equipment	
External Sports Equipment Store	30	▶ Storage of sporting equipment	
Total floor space	**605**		

Suggested external facility components for the local community centre include:

External Facility Component	Area (m^2)	Functionality	Design Details
Outdoor Play Area	100	▶ Play space for toddlers and primary aged children	▶ Direct access from Playgroup Room/ Children's Activity Room ▶ Enclosed area. ▶ Shaded play equipment. ▶ Grassed area.
Paved Courtyard	160	▶ Breakout space for functions/ social activities	▶ Direct access from Large Multipurpose Activity Room
Total external floor space	**260**		

The Caversham Community Centre will be designed and located to provide a multipurpose community centre with an identifiable image, a clear address/ entry off Patricia Road and a strong relationship with the neighbourhood precinct. Good pedestrian links and clear visual connections will integrate the community centre with the primary school, neighbourhood shopping centre, active open space and surrounding residential areas (see Appendix 1: Neighbourhood Centre Structure Plan). Other key design attributes of the community centre include:

- Located adjacent to the primary school site to enable shared usage.
- Multipurpose rooms ideal for a broad range of community uses.
- Direct access from the community centre onto the shared oval.
- Adequate storage throughout the building.

Once constructed, the centre will be owned by the City of Swan, which will be responsible for all centre management tasks including centre bookings, coordinating access, programming, cleaning, building maintenance and security. Ideally, centre bookings and programming should be managed through the Altone Place Office, with specific community development activities being an extension of those within the Altone Place Plan. This will enable the developers of Caversham to contribute to the activation of the Caversham Community Centre through sponsoring centre-based activities which complement those being delivered within the broader locality. Developer support would continue while the estate is being constructed, reducing as the estate nears completion to affect an exit strategy.

Potential also exists for the management model to incorporate a community management committee to enable the management of the centre to be 'locally driven'.

Agencies that have indicated an interest in using the centre include:

- Brockman House Inc – family support services and children's activities;
- Blue Sky Community Group – family support services and migrant education;
- Swan Districts Hospital – health promotion programs;
- Office of Crime Prevention – neighbourhood watch program; and
- Swan TAFE – training course to assist young women return to work, mentoring courses.

The Caversham Community Centre project has the potential to attract grant funding from the Department of Sport and Recreation (CSRFF) and Lotterywest. The balance of the capital funds required would be sourced through a collaborative funding arrangement between Caversham developers and the City of Swan. Construction of the community centre could be managed by the City of Swan or alternatively by the land developer (Western Corporate), however this would need to be determined at subdivision stage.

Prior to the development of community facility, interim arrangements may be entered into in order to provide spaces that can be used by community groups. Temporary arrangements may be established with local schools, shopping centres or the land sales office to make available space that can be used by community groups.

3.2 Shared Use Oval and Sports Courts

The public primary school site within the Caversham structure plan is 3.5 hectares in size and located immediately adjacent to a local active open space site. This has been done deliberately, the aim being to establish a shared school-community sporting oval on the open space. The site for the oval also offers opportunities to access additional space by covering a creek that dissects the site; a larger grassed area could be achieved if an increased playing area was required.

Once constructed, the school will be managed by the Department of Education and Training (DET) and is expected to cater for kindergarten through to Year 7. The development of the school is not included in DET's forward plans and it is envisaged that school aged children moving into the estate will initially attend either East Beechboro Primary School or Caversham Primary School, as both these school have capacity for increased enrolments.

The co-location of the primary school site with the active open space and the community centre maximises opportunities for the following shared use facilities.

3.2.1 Local Oval

The primary school will require use of a junior sports oval during school hours. The future need for a local sporting oval to accommodate junior sports programs and adult sports training is strongly supported by the research. Consequently, the preferred option for the provision of a local sports oval is to establish a junior sized shared-use oval on the active open space. Preliminary discussions with the DET confirms support for this approach and the establishment of a shared-use agreement between the City of Swan and the DET to share construction and maintenance costs on a 50/50 basis.

Depending on the rate of lot sales/ housing development, and the capacity of East Beechboro Primary School and Caversham Primary School to accommodate the increasing need for kindergarten, pre-primary and primary school services, it is unlikely that the primary school will be developed before 2017.

3.2.2 Outdoor Sports Courts

The DET would normally provide two outdoor sports courts within the primary school site. The research indicates a need for four multi-marked sport courts for community use. The preferred option is to develop a four court facility within the school site, but co-located with the community centre, which could be used by both the school and the community. The school would need exclusive use of 2 courts during school hours, while the community would have access to the remaining 2 courts during school hours and all 4 courts out of school hours.

A shared-use agreement between the City of Swan and the DET would be required to share construction and maintenance costs on a 50/50 basis.

Suggested facility design components for shared-use facilities with the primary school include:

Facility	Area (m^2)	Functionality	Design Details
Junior Oval	9912 (118 x 84)	▶ Local junior sports clubs – training and competition ▶ Local senior sports clubs – training only ▶ Casual community use	▶ Located on active POS vested in the City of Swan. ▶ Shared use facility with primary school.
4 Outdoor Sports Courts	3034	▶ Local sports club –training and competition ▶ Casual community use	▶ Located on primary school site adjacent to community centre. ▶ Shared use facility with primary school.

3.3 Childcare Centre Site

The anticipated number of young families in the future Caversham community supports the need for a site for a private childcare centre. An objective of the Local Structure Plan is to co-locate a private child care centre within the neighbourhood community centre adjoining the primary school. Where this is not possible it should be locate within four hundred meters of the centre. Whilst the proponents of the Caversham Local Structure Plan encourage the development of a private day care facility within the structure plan area, the construction of such a facility with be at the discretion of a private developer.

3.4 Local Parks

According to the City of Swan Play Place Strategy, the City does not support the provision of functional play spaces smaller than 3000m^2. Excluding public open space which has a drainage function, there are eight passive parks larger than 3000m^2 within the Caversham structure plan. These parks will provide passive green spaces within walking distance to residences for informal play and recreation. The functionality of each park will be slightly different from the other, providing a variety of options for different age groups and family structures. Park amenity and playground equipment will vary across each park to ensure provision for different age groups (toddlers under 3 years; juniors 3 – 5 years; intermediate 5 – 7 years; seniors 8 – 12 years; youth 13 – 17 years; and adults). In addition to a variety of play equipment, other park amenity will include shaded park furniture, BBQ's and picnic shelters, kick-about spaces, and recreation equipment for youth (i.e. skate tracks/ elements, 3- on-3 basketball court).

The proposed functionality and design for the public open space within the first stage (Cell 1) subdivision approval area is detailed below:

Facility	Area	Functionality	Design Details
Central Linear Park	2ha	▶ Central spine of POS integrating pedestrian cyclist connections linking Reid Hwy the to neighbourhood centre ▶ Passive recreation ▶ Drainage	▶ 'Living Stream' within natural landscaping ▶ BBQ/ picnic area ▶ Playground equipment ▶ Activity nodes ▶ Kickabout space ▶ Cycling and walking path
Northeast POS	2764m^2	▶ Local park	▶
Western POS adjacent high density	6346m^2	▶ Neighbourhood Park ▶ Dog walking	▶ BBQ/ Picnic area ▶ Park furniture ▶ Landscaping

The abovementioned local parks will initially be maintained by QUBE Property Group for a minimum of two years and then on a performance basis thereafter (up to five years). After which it will be vested in and maintained by the City of Swan.

Specific design concepts for other local parks will be developed prior to subdivision approval.

3.5 Walking and Cycle Paths

The provision of a network of dual use pathways (DUP's) and on-road cycling facilities within Caversham will be important to promote walking and cycling within the estate, and to connect the development with key destinations in the broader locality.

Constructed of 2.5m wide concrete, the DUP network within Caversham will provide access to all local community facilities within the estate (i.e. neighbourhood shopping centre, primary school, sporting oval and parks, community centre, health centre, retirement village, etc). The pedshed analysis produced for the structure plan indicates almost all future residents will be within a 10 minute walk to the primary school and neighbourhood centre.

The City of Swan has undertaken significant planning for the future provision of walking and cycle paths. The Altone Walk and Cycle Trails Plan Part Two (2009) indicates new shared paths along Patricia Street and Benara Road, providing opportunities for through connections to Beechboro, Lockridge, Whiteman Park, and Guildford. The Swan Valley Cycle Trail Pathways Extensions Stage 2 – Future Connections (2006) indicates an existing shared-use path on West Swan Road from Benara Road to George Street, with proposed future connections through to the new 'Albion' subdivision and district centre, Whiteman Park and Ellenbrook.

Importantly, new DUP's and on-road cycling facilities provided within Caversham will link with those existing and proposed shared use paths within adjacent areas to promote cycling as a viable local transport option for residents. The local structure plan assures coordination of this path network amongst the various landowners at Caversham.

3.6 Shared-use of District Active Open Space

The need for a District Active Open Space within the Urban Growth Corridor has been identified by the City of Swan and is incorporated within the West Swan East (WSE) structure plan area north of Reid Hwy. This facility is 14 hectares in size and will provide a multipurpose active sport facility for junior and senior formalised sporting activities, as well as passive recreation areas, all within a landscaped setting.

Residents of the Caversham estate will utilise this facility for participation in district level sporting competitions and recreation.

Facilities proposed for inclusion in this district active open space include:

- 1 x Junior Oval
- 2 x Senior Oval
- 4 x outdoor sports courts
- 2 x Cricket Practice Nets
- District Playground
- Passive Recreation Spaces
- District Pavilion

The District Active Open Space project has the potential to attract grant funding from the Department of Sport and Recreation (CSRFF). Traditionally, provision of district level facilities is the responsibility of state and local government, however, it is anticipated that the City of Swan will require developer contributions for this facility from all developers in the Urban Growth Corridor.

Once constructed, maintenance and coordination of usage of the facilities within the District Open Space will be the responsibility of the City.

3.7 Broadband Internet Access

The early provision of broadband internet within Caversham will ensure residents, people setting up home-based business, and others establishing small businesses in the estate have access to 'state of the art' electronic communications technology. Caversham developers are proposing to provide fibre optic cabling to all residences and commercial operators within its landholdings.

3.8 Commercial and Economic Facilities

Within Caversham, a number of retail and commercial facilities will be developed. These include:

- Neighbourhood Shopping Centre – small supermarket with a café and a variety of specialty shops.
- Retirement Village – Over 55's lifestyle village to be developed by Lester Group. Will include some recreation facilities for seniors which may be available for limited community use.
- Health and Medical Centre – Ideally located in close proximity to neighbourhood shopping centre. May include consulting rooms for a GP and other allied health professionals.
- Child Care Centre.

The zoning within the Caversham LSP allows for consideration of these uses. Subject to market forces, provision of the abovementioned commercial facilities will be developed by the private sector, meeting local service needs and providing opportunities for local employment.

4. Timing of Provision

Assuming a sales rate of 120 dwellings per year, the following table estimates population growth and the timing of provision for all local community facilities within Caversham. The trigger for the provision of community facilities would ultimately be population growth and market forces (lot sales). The trigger for construction of the community facilities, including the shared-use oval, will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to development of the proposed community facilities and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total Dwellings Settled Cell 1	120	120	120	78									
Total Dwellings Settled Cell 2			120	120	120	74							
Total Dwellings Settled Cell 3				80	80	45							
Total Dwellings Settled Cell 4		120	120	120	120	120	93						
Total Dwellings Settled Cell 5			120	120	120	35							
Cumulative Total Dwellings Settled	**120**	**360**	**840**	**1358**	**1798**	**2072**	**2165**						
Expected Population (ave 2.54ppl/ dwelling)	**305**	**915**	**2135**	**3450**	**4565**	**5260**	**5495**						
Local Community Facilities													
Local Parks													
Walking and Cycle Paths													
Broadband Internet Access													
Retirement Village													
Shared-use Oval													
Child Care Centre													
Neighbourhood Shopping Centre				.									
Local Community Centre													
Health and Medical Centre													
Primary School and Shared use Sports Courts													

5. Indicative Capital Cost Estimate

5.1 Local Public Community Facilities

The following table outlines indicative capital costs for all local public community facilities that will service the needs of the future Caversham community.

Local Facilities	No.	Rate	Elemental Cost (ex GST)	Fee & Contingency Allowance	Item Cost	Timeframe
Local Landscaped Parks	85,000m^2	$50	$4,250,000	$425,000	$4,675,000	2010 onwards
Walking and Cycle Paths (2.5m wide)	2,500m	$63	$157,500	$15,750	$173,250	2010 onwards
Broadband Internet Access	1,814 lots	$2,600		included	$4,716,400	2010 onwards
Shared Use Oval – earthworks, turf and irrigation	9,912m^2	$35	$346,920	$48,309	$395,229	2012
Shared Use Oval - Floodlighting	2 Poles	$25,000	$50,000	$5,000	$55,000	
Local Community Centre	605m^2	$2,600	$1,573,000	$314,600	$1,887,600	2013
Local Community Centre land	4,000m^2	$100			$400,000	
Shared-use Sports Courts – plexipave with fencing and lighting	4	$71,000	$284,000	$39,548	$323,548	2017
Gross Local Facility Project Costs (at current prices)					**$12,626,027**	

Funding of the abovementioned local facilities will involve partnerships with government funding programs, the WA Department of Education and Training, and the City of Swan.

5.2 Exclusions

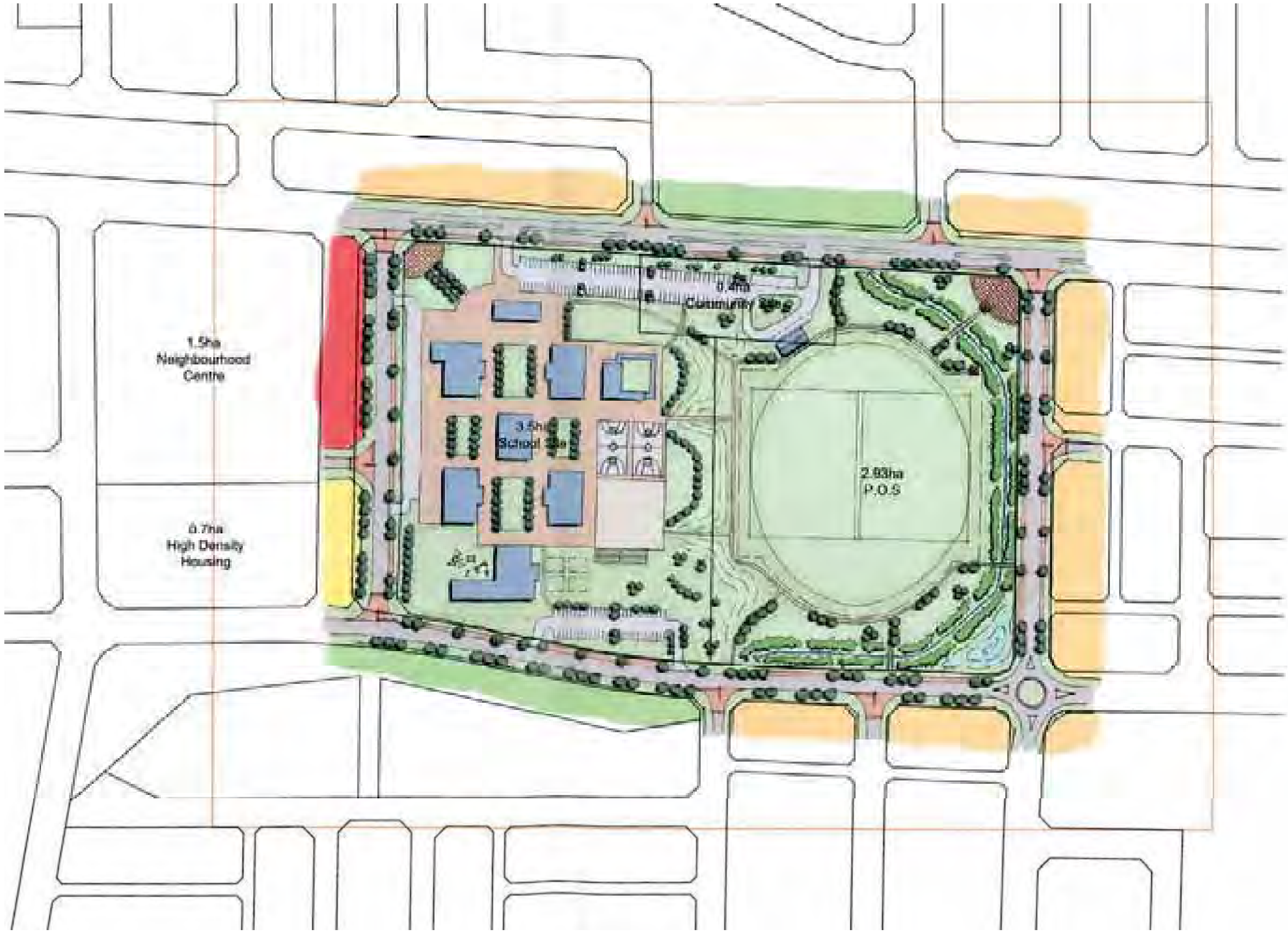
The abovementioned indicative costing excludes the following items:

- Parking;
- External services on site;
- External spaces within built facilities;
- Landscaping around built facilities;
- Loose furniture and equipment for built facilities; and
- Headworks and statutory charges.

5.3 Developer Contributions

Cost sharing arrangements and developer contributions for both local and district community facilities will be the subject of a developer contributions plan currently being prepared by the City of Swan.

6. Appendix 1: Caversham Neighbourhood Centre Structure Plan



Deputy Premier of Western Australia
Minister for Health; Indigenous Affairs

Our Ref: 25-01699

Mr Mark Hector, Director
Caversham Land Development Pty Ltd
c/- Cardno – Attention Mr Nicholas Dufty
Cardno (WA) Pty Ltd
PO Box 155
SUBIACO WA 6904

Dear Mr Hector

I refer to the section 18 notice ("the Notice"), dated 16 October 2008, submitted by the Caversham Land Development Pty Ltd ("the Landowner") to the Aboriginal Cultural Material Committee ("ACMC") pursuant to section 18(2) of the *Aboriginal Heritage Act 1972* ("AHA).

The Notice advised that you wish to use the land described in Part 4 of the Notice as Lot 213 Vol 1461 Folio 4 Plan 51713; Lot 214 Vol 1461 Folio 5 Plan 51713; Lot 94 Vol 1242 Folio 337 Plan 3551; Lot 123 Vol 1079 Folio 978 Plan 12246; Lot 88 Vol 2078 Folio 5 Plan 3551; Lot 2 Vol 502 Folio 51A Plan 41309; and Lot 89 Vol 1113 Folio 641 Plan 3551 ("the Land"), for the purpose described in Part 6 of the Notice as an urban development including all infrastructure, environmental remediation and landscaping ("the Purpose").

In accordance with my powers under section 18(3) of the AHA and following consideration of recommendations from the ACMC, I hereby grant consent to the use of the Land for the Purpose.

I am advised that based on current knowledge the Purpose will not impact upon any Aboriginal sites within the meaning of section 5 of the AHA ("Sites") on the Land.

Requests and Advice

The following information has been provided by the ACMC for the information and guidance of the Landowner (or authorised Agent) and does not constitute a condition of consent.

The ACMC requests that the Landowner (or authorised Agent) give due consideration to requests made by the Aboriginal people consulted about the Purpose regarding the protection of Aboriginal heritage and the recognition of Aboriginal culture and history. For example, recognition of Aboriginal heritage values, beliefs and prior occupation of the area may be conveyed through interpretive signage, street naming or murals.

In addition, the Landowner (or authorised Agent) should make all persons employed or engaged in respect of the Purpose aware of their obligations under the AHA. The Landowner (or authorised Agent) should insert into all and any relevant contracts, project plans, scopes of works, tenders and other similar documents, a requirement that such persons should examine relevant information on the Department of Indigenous Affairs ("DIA") website at:

- http://www.dia.wa.gov.au/Heritage--Culture/

Right of Review of Decision
Where the Landowner (or authorised Agent) is aggrieved by a decision of the Minister made under section 18(3) of the AHA, the Landowner may apply to the State Administrative Tribunal for a review of the decision. The Tribunal's website is www.sat.justice.wa.gov.au.

Other Matters
This consent can only be relied upon by the Landowner (or authorised Agent). Any subsequent owner of the land within the meaning of the AHA must make their own application under the AHA.

Copies of the AHA, the *Aboriginal Heritage Regulations 1974* and the *State Administrative Tribunal Act 2004* may be viewed and downloaded from the website of the State Law Publisher at www.slp.wa.gov.au.

If you have any queries in relation to your application, please contact Ms Sally McGann, DIA Senior Heritage Officer, on 9235 8138.

Yours sincerely

Dr Kim Hames MLA
DEPUTY PREMIER
MINISTER FOR INDIGENOUS AFFAIRS

0 5 JAN 2009

REPORT ON AN ETHNOGRAPHIC SURVEY OF

THE CAVERSHAM STRUCTURE PLAN AREA

Prepared by R. & E.O'Connor Pty. Ltd.
PO Box 815, Nedlands, WA 6909.
Email: rocej@iinet.net.au
Tel/Fax (08)93871415

For Koltasz Smith,
141 Burswood Road,
Burswood,
WA 6100.

January 2008.

The author has not been advised by the Aboriginal people who participated in the consultative process detailed in this report that any information given by them is to be treated as confidential.

The coordinates listed in this report are MGA Zone 50.

ABSTRACT

In November 2007, Koltasz Smith commissioned R. & E.O'Connor Pty. Ltd. to carry out an ethnographic survey of the Caversham Structure Plan Area, in order to identify if any Aboriginal heritage sites would be affected by proposed development there and, if so, to consult with relevant Aboriginal people in their regard and to prepare a report suitable for submission to the Aboriginal Cultural Material Committee in support of an application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* in respect of the Project Area, should such an application be necessary. This report documents the methodology, content and results of the ethnographic survey, which was carried out between December 2007 and January 2008.

The field survey involved representatives of the the Bropho family group in conjunction with the Swan Valley Circle of Elders; the Garlett family group; the Wilkes family group; the Headland/Corunna family group; the Ballaruk group and the Jacobs clan. Three of the Aboriginal groups gave unconditional approval for the project, on the grounds that provision had been made within the Structure Plan for protection of registered Aboriginal sites. Three of the groups attached conditions to their approvals, as follows:

- Moore's Camp and creekline to be protected (Bropho family group);
- Protect creek and (engage) monitors for initial ground disturbance (Headland/Corunna family group);
- No disturbance to creekline; protect Moore's Camp and (engage) monitors for initial earthmoving (Wilkes family group).

This report recommends that an application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* should be made in respect of the Project Area prior to commencement of ground disturbance there. The application should be accompanied by the required number of copies of this report and also of the archaeological report produced for the Project.

As the relevant Aboriginal people have been consulted in regard to the Project Area and have given approval for the Project to proceed, it is recommended that the Aboriginal Cultural Material Committee should make a recommendation to the Minister that consent should be given for it to proceed.

As the Structure Plan contains provision for protection of Moore's Camp (formerly Aboriginal site number 3746), Marshall's Paddock (Aboriginal site number 3744) and Little Creek (Aboriginal site number 22159), no specific recommendations are made in their regard.

This report recommends also that consideration should be given to the requests of the Aboriginal groups that Aboriginal monitors should be on site when initial ground disturbance is taking place. The role of the monitors is to keep a record for the group should Aboriginal cultural material be encountered in the course of ground disturbance. It is also advantageous to have monitors on hand if skeletal material is uncovered.

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1.0 INTRODUCTION

1.1 Background

In November 2007, Koltasz Smith commissioned R. & E.O'Connor Pty. Ltd. to carry out an ethnographic survey of the Caversham Structure Plan Area ("the Project Area"), in order to identify if any Aboriginal heritage sites would be affected by proposed development there and, if so, to consult with relevant Aboriginal people in their regard and to prepare a report suitable for submission to the Aboriginal Cultural Material Committee ("ACMC") in support of an application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* ("AHA") in respect of the Project Area, should such an application be necessary. This report documents the methodology, content and results of the ethnographic survey, which was carried out between December 2007 and January 2008.

1.2 Research Brief

The Project location is shown in Figure One. Figure Two is a Preliminary Concept Structure Plan. It is bounded to the north by the Reid Highway; to the east by existing lots fronting West Swan Road; to the south by Benara Road; and to the west by existing housing in Carignan Avenue and Alsace Avenue. Arthur Street runs through its central-east sector in a roughly north-south direction; Patricia Street runs through its north-central sector in a roughly east-west direction. In respect of the

Project Area, as thus defined, the research brief required the following tasks to be carried out:

(i) identify any Aboriginal sites as determined by the *Aboriginal Heritage Act*; and

(ii) ascertain whether or not work on the Project will disturb any such site;

(iii) ascertain whether the Project area is covered by any native title applications.

The research brief also requires that the findings of the survey are to be reported in a format suitable to enable the Aboriginal Cultural Material Committee of the Department of Indigenous Affairs to:

(i) determine whether there is an Aboriginal site within the survey area, and

(ii) evaluate the importance and significance of any such site.

2.0 SOCIAL AND HISTORICAL BACKGROUND.

2.1 Anthropological Considerations

The Aboriginal political geography of Southwestern Australia has been described in O'Connor (1984), O'Connor, *et al.,* (1985) and O'Connor and Quartermaine (1986 and 1987). The following summarised points are relevant to the present exercise.

2.1.1 Southwestern Aborigines were a distinct sociocultural group in pre-contact times.

2.1.2 Dialectal variation occurred within a single southwestern language family.

2.1.3 A regional system of land tenure, based on either kinship or dialectal units existed.

2.1.4 As contemporary accounts of this system are internally inconsistent and sometimes contradictory, it is now impossible to reconstruct the pre-contact political geography of the region.

2.1.5 Territorial separateness disappeared soon after European settlement, due to population movements, deaths and the development of fringe camps (and later settlements and "missions").

2.1.6 The development of a widely-scattered population of people of mixed-ethnic background, who live in the southwest of this State, see themselves as sharing a common identity and refer to themselves as "Nyungars", occurred during the nineteenth century.

2.1.7 Continuity with the traditional past, knowledge of regional mythology and knowledge of areas of religious significance were passed to the present senior adult generation of Nyungars by a pivotal generation of culture transmitters.

2.1.8 There is now a determination among the present senior adult generation to protect remaining areas of significance from development.

2.2 Significance

As with other parts of the Southwest, significance is attributed by Aboriginal people to areas in the survey region on the basis of former or current domestic usage, or on the basis of relevance to traditional ritual or mythology. Broadly speaking, this distinction can be viewed as a series of dichotomies between historical and mythological, human and supernatural, or mundane and sacred areas. Thus, one area may be viewed as significant from a historical/human/mundane viewpoint, and another from a mythological/sacred viewpoint.

In addition to the above, a substantial number of Aboriginal sites are mentioned in Hammond (1933), Moore (1885), Bates (numerous dates) and other historical sources. Any sites not known to contemporary Aborigines cannot reasonably be classified as "sites of significance to living Aborigines". However, rediscovery or realisation of the existence of such sites could lead to an attribution of significance. Thus, the neat compartmentalisation resulting from European academic disciplines may not fit absolutely the Aboriginal models; any archaeological or historical site in the survey region could also be potentially significant to Aboriginal people.

In the course of a previous survey in the Mandurah area, however, a further aspect of significance, which the present author terms "generalised significance" was encountered. This has been touched upon in O'Connor and Quartermaine (1989), but not considered there in detail. The Aboriginal elders from the Mandurah area referred to the undeniable fact that the region's wetlands and rivers were Aboriginal food and water resources, access tracks and campsites. They also pointed out that those areas were spiritual repositories, not in the sense of the ubiquitous Waugal myth, which has been previously recorded in relation to the Murray and Serpentine Rivers, but in a more general sense which draws on the fundamentals of Aboriginal philosophico-religious belief. In this belief system all living creatures, including humans, share a common spiritual essence and therefore, by extension, every living being represents a part of the wider spiritual universe. The region's wetlands, as breeding grounds for numerous living creatures, are therefore repositories of this spiritual essence realised generationally by individuals.

The above concept is clearly a development from the commonly held notion that significance is only attributable specifically. However, if Section Five of the *Aboriginal Heritage Act* is carefully considered, it is clear that it would be difficult to argue that areas to which this generalised significance is attributed are not Aboriginal sites within the meaning of the Act, as they are clearly being described by the Aboriginal people concerned as "sacred" places "of importance and special significance to persons of Aboriginal descent". Nonetheless, the author has been notified by the Department of Indigenous Affairs that the Aboriginal Cultural Material Committee has received legal advice that an attribution of generalised significance by Aboriginal people is insufficient to meet the requirements of Section 5 (b) of the Act. There is therefore a potential dissonance between “Aboriginal sites”, as defined by Aboriginal people, and “Aboriginal sites”, as defined by the Act.

2.3 Native Title Matters

In September 2006, a judgement was made by Wilcox J in the Federal Court of Australia that Aboriginal native title exists over the Perth Metropolitan Area and that it is held by a defined group of people, including those who have been involved in the Aboriginal consultations detailed below. The relevant section of His Honour's judgement is as follows.

The formal orders that I make are as follows.

In relation to the Perth Metropolitan part of the Single Noongar claim (Part of WAD 6006 of 2003), I order that:

1. The question which was directed, by an order entered on 6 April 2005, to be decided separately from any other question (as amended up to and including 21 December 2005), be answered as follows:

As to para (i):

But for any question of extinguishment of native title by inconsistent legislative or executive acts carried out pursuant to the authority of the legislature under Divisions 2, 2A, 2B or Part 2 of the Native Title Act 1993 (Cth) or under the Titles (Validation) and Native Title (Effect of Past Acts) Act 1995 (WA), native title exists in relation to the whole of the land and waters in the area of the separate proceeding, other than off-shore islands and land and waters below low-water mark;

As to para (ii):

The persons who hold the common or group rights and interests comprising the native title in the said land and waters (hereafter 'the area') are the Noongar people, as identified in Schedule A of the application for determination filed on 10 September 2003 in matter WAD 6006 of 2003;

As to para (iii):

Without purporting to specify the final terms of a formal Determination of Native Title, the said native title rights and interests are the rights to occupy, use and enjoy the area in the following way:

(a) to access and live on the area;
(b) to conserve and use the natural resources of the area for the benefit of the native title holders;
(c) to maintain and protect sites, within the area that are significant to the native title holders and other Aboriginal people;
(d) to carry out economic activities on the area, such as hunting, fishing and food-gathering;
(e) to conserve, use and enjoy the natural resources of the area, for social, cultural, religious, spiritual, customary and traditional purposes;
(f) to control access to, and use of, the area by those Aboriginal people who seek access or use in accordance with traditional law and custom;

(g) to use the area for the purpose of teaching, and passing on knowledge, about it, and the traditional laws and customs pertaining to it;
(h) to use the area for the purpose of learning about it and the traditional laws and customs pertaining to it.

The above determination is in favour of the group representing the area known as Region Six, Single Noongar Claim, as notified to the Court on 10 September 2003. That group, which includes a large listing of Perth Noongar families, is administered by a Working Party and represented by the South West Aboriginal Land and Sea Council. It numbers amongst its members the Bropho family group, the Wilkes family group, the Headland/Corunna family group and the Garlett family group, as well as persons more usually associated with the Independent Metropolitan Environmental Group. It should be noted that, apart from rights which the said Noongar people may have under the *Aboriginal Heritage Act, 1972*, the native title holders now enjoy, as a native title right, *the right to maintain and protect sites within the area that are significant to the native title holders and other Aboriginal people.*

The Ballaruk/Bodney Application for Determination of Native Title (Number WC95/86) was struck out by order of Wilcox J on 25 August 2003. The strike-out motion had been brought by the South West Aboriginal Land and Sea Council acting on behalf of Mr Robert Bropho, Mr Albert Corunna, Mr Richard Wilkes, Mr Greg Garlett, Mr William Warrell and others, who pleaded that Mr Bodney's application failed to satisfy the requirements of Section 61 of the *Native Title Act.* Acting without legal advice, and appearing on his own behalf, Mr Bodney appealed to the Full Bench of the Federal Court of Australia. The matter was heard before Spender, Branson and Stone JJ on 24 August 2004. Their Honours found in favour of Mr Bodney and the orders of Wilcox J were set aside. The Ballaruk Application for Determination of

Native Title was therefore again listed on the maps of native title claims produced by the National Native Title Tribunal. It was not, however, registered, as it had failed to satisfy the requirements of Section 190A of the *Native Title Act.* Unsurprisingly, given the result of the strike-out motion of August 2003, Wilcox J did not find that the Bodney family shares in the native title now enjoyed by the group discussed above. The question of the Ballaruk group's right to participate in Aboriginal heritage surveys in the area in which they have been found not to hold native title therefore needs addressing (it should also be noted that Mr Bodney has again appealed His Honour's judgement to the Full Bench of the Federal Court of Australia). This question was raised in Parliament on 13 August 2003, following the findings of Nicholson J in the matter of *Daniel et al v the State of Western Australia* in 2003 and was answered by the Hon. Minister representing the Hon. Minister for Indigenous Affairs as follows.

Hon. John Fischer to the Minister representing the Hon. Minister for Aboriginal Affairs: Is the Minister aware of findings in the matter of Daniel v the State of Western Australia 2003 FCA 666 *by Nicholson J and published in the Draft Determination in which Nicholson J states that the Second Applicants – being Yaburara and Mardudhunera – do not hold any native title rights and interests in the determination area? ... If this is the case, why are they being paid from the public purse as heritage consultants prior to developments in an area over which Nicholson J determined they have no claim?*

Hon Minister representing the Hon. Minister for Aboriginal Affairs in reply: Consultations under the Aboriginal Heritage Act 1972 *are separate and distinct from matters concerning the federal* Native Title Act 1993. *A finding that a group does not hold native title in no way suggests that that group does not have traditional* *associations with an area. It means that that group was unable to meet the onerous legal requirements necessary to establish native title. Indigenous people employed as consultants for heritage surveys are those with a known or claimed association with the development area.*

Accordingly, notwithstanding the findings of Wilcox J (and the pending appeal against those findings) it would appear that the Ballaruk group should continue to be consulted in regard to Aboriginal heritage matters in the Perth area.

In addition to the above two native title claimant groups, the Jacobs Clan has been associated with the Swan Valley and Perth Metropolitan region for several generations and its elders retain a high level of cultural knowledge relevant to that area. It is therefore normal procedure for members of that clan to be involved in Aboriginal heritage surveys in the area in which the Project is located.

3.0 THE SURVEY

3.1 Methodology

The survey included four separate stages, as follows:

(i) examination of existing ethnographic database;

(ii) consultation with relevant Aboriginal organisations and individuals;

(iii) inspection of designated survey area by Aboriginal spokespersons;

(iv) report preparation.

The field methodology adopted, with the approval of the Aboriginal people, was that of a *Site Identification Survey,* described in the *Aboriginal Heritage Procedures Manual (2002)* as follows.

Ethnographic research involves the identification and recording of Aboriginal sites, as defined under the Aboriginal Heritage Act, through interviews and field inspections with Aboriginal Consultants. This process has been termed a "site identification survey"
During the ethnographic research process, the Aboriginal Consultants are asked about their associations with the area under consideration and whether they know of the existence of any places that might be considered Aboriginal sites.
If such places are identified, the Aboriginal Consultants are asked to provide details of their nature and extent. Although the ethnographer may record detailed cultural information about the place(s), this will not necessarily be communicated to the proponent, as it may be deemed highly culturally sensitive by the Aboriginal Consultants.

Aboriginal Liaison Consultant T.Hart liaised with the Senior Field Officer at the South West Aboriginal Land and Sea Council, in order to ensure that the representatives of the Single Noongar native title holders involved in the survey were authorised by the council to participate.

3.2 Desk Top Study of Ethnographic Database

A search of the Aboriginal Site Register for the polygon described by the following co-ordinate sets was carried out: 403750E 6474250N; 403250E 6472750N; 401500E 6472750E; 401500E 6474500N. The Register contains entries for ten Aboriginal sites within this polygon, of which five are relevant to the Project, as follows (grid coordinates for sites are given here where the information is listed as "reliable" in the Aboriginal Site File at the Department of Indigenous Affairs; information listed as "unreliable" is not included in this report, as it has the potential to be misleading).

1. Site Number 3744. "Marshall's Paddock", a burial site. This site is listed as "closed access" in the Register. However, as it was originally recorded by the author, access is available to him. Details of the site, as recorded in 1985, are as follows. *To the west of the Arthur Street/Patricia Street junction a narrow laneway to the south leads into Marshall's paddock. A traditional Aboriginal burial took place in this paddock, near the spring where the late Mr Marshall built his house. A prominent mulberry tree marks the approximate location of this burial. The exact position of the grave could not be pinpointed, but a circle of twenty meters diameter, with the mulberry tree as centre, would enclose this burial site. The researchers interviewed Mr Joe Barfarich, the present owner of the paddock, who had a crop of melons ripening there at the time of the survey. He had no knowledge of the burial site. Mr Marshall, an*

elderly man whose father had bought and built on the paddock in question, was also interviewed – again without success. As the paddock has been heavily ploughed for many seasons, it is likely that the human remains interred there have been scattered. This site has been taken into consideration in preparation of the Structure Plan.

2. Site Number 3746. "West Swan Road Camp (Moore's Camp)", a camping site. Originally recorded by the present author in 1985 on the verbal evidence of a number of Aboriginal people, but not then inspected to obtain a precise location, this site was then described as follows. *This camping area is in the bushland on the western side of West Swan Road, between Coast Road, Arthur Road and Patricia Street.* The map supplied by the "Lockridge Camp Aboriginal Group" (the group formerly led by Mr Robert Bropho) to the Department of Indigenous Affairs locates this camp on the northeastern side of the junction of Arthur and Patricia Streets, which seems unlikely, as this is a formerly ploughed paddock, currently used for grazing livestock (see Appendix Five). The map from the Site Registration Form locates Moore's camp further to the northeast, in the bushland that still remains to the immediate south of Reid Highway. This would appear to be a more likely location. The Aboriginal Cultural Material Committee has resolved that Moore's Camp is not a place to which the Act applies and it is therefore listed on the Register only as "stored data", to which the provisions of the State's Aboriginal heritage legislation do not apply. However, the Aboriginal people continue to consider it to be an area of significance. In fact, Mr Bropho has recently written to Main Roads, Western Australia, expressing concern that any future expansion of Reid Highway to the south could threaten the site.

This is therefore a situation such as that referred to in 2.2 above, where the Aboriginal people consider an area or place to be a site of significance to them, but the Aboriginal Cultural Material Committee does not consider that it falls within the meaning of Section 5 of the Act (see Appendix Two). In such a situation, Aboriginal people aggrieved by a resolution of the Western Australian Aboriginal Cultural Material Committee have the option of making an application pursuant to Section 9 or Section 10 of the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act* in respect of any "significant Aboriginal area", as defined by that legislation. As this consideration may be relevant to the Project, Moore's Camp site has been taken into consideration in preparation of the Structure Plan.

3. Site Number 3840. "Bennett Brook Camp Area", a "plant resource, camp, hunting place and water source" site. This site is also listed as "closed access" in the Register. However, as it was originally recorded by the author, the information is available to him. Details of the site, as recorded in 1985, are as follows. *This Aboriginal site complex has Benara Road as its southern boundary, Patricia Street extension as its northern boundary, Bennett Street as its eastern boundary and Lord Street as a notional western boundary. It is no longer possible to establish the western limit of this camping area; in the 1930s to 1960s, Aboriginal camps spread across Lord Street into the area now occupied by a modern housing estate. Burials were also reported to have taken place, both between Benara Road and Widgee Road extension and in the vicinity of the new housing estate. Their exact location, however, is not nowadays known…Between Benara Road and Widgee Road extension was an occasional camping area during the period of habitation. Between Patricia*

Street and Widgee Road extensions was densely populated. Evidence of this usage still exists: camp fire ashes, refuse and the remains of temporary shelters are readily visible through the area. This site, as recorded, is therefore outside the Project area. However, the map supplied to the Department of Indigenous Affairs by the Lockridge Camp Aboriginal Group appears to show it extending marginally into the Project area in the vicinity of Patricia Street (see Appendix Five).

4. Site Number 3997. "Bennett Brook Benara Road 1", an artefact scatter site located at 401689E 6472649N. This listing is now classified as "stored data" only, as the Aboriginal Cultural Material Committee determined by Resolution 99069 of 8 June 1999 that it is not a place to which the Act applies. The site was originally three artefact scatters in the vicinity of the Bennett Street/Benara Road junction. The ACMC Resolution is based on the fact that the scatters were test-pitted, collected in part and then destroyed by development.
5. Site Number 22159. "Little Creek/One Hundred Year Creek", a "mythological and camping" site. This site registration refers only to the section of the ephemeral waterway flowing through Perth Holiday Park on Benara Road. This anomalous situation has arisen because the Aboriginal groups named the waterway as a site in the course of a consultative process pertaining to a proposal to expand the Holiday Park. However, a note in the file states that the entire waterway is a significant Aboriginal site on the basis of its association with a Waugal myth and because it was formerly utilised as a camping area by Nyungars. Because of the general paucity of corroborative information, the site has been entered only on the Interim Register. However, the fact that it is

claimed as a mythological site by the Nyungars is of relevance to the Project. Maps of the waterway extracted from the Aboriginal Site File at the Department of Indigenous Affairs are included in this report as Appendix Four. The main arm of the creek appears to rise to the immediate south of Coast Road to the west of Arthur Street. From here it flows roughly south to pass under Reid Highway near the western end of Victoria Road. In places here, also, it appears that the creek may have been straightened in the past, with the result that it is a man-made drain at those points, rather than a natural waterway. The waterway then continues roughly south and then turns west and southwest to the south of Patricia Street, turning again to the west to the south of Widgee Road, where it is met by a tributary draining from the housing estate where Marshall's Pool was originally located. This site has also been taken into consideration in preparation of the Structure Plan.

3.3 The Field Survey – Justification for Consultation

In accordance with the discussion in 2.3 above, representatives of the two relevant native title groups were invited to attend the consultative meetings at the Project site. The Ballaruk group is a single entity; the Perth Metropolitan section of the Single Noongar Claim is made up of four separate family groups, as follows:

- The Bropho family group in conjunction with the Swan Valley Circle of Elders;
- The Garlett family group;
- The Wilkes family group;

- The Headland/Corunna family group.

As noted above, representatives of these Single Noongar sub-groups who attended were identified with the assistance of the South West Aboriginal Land and Sea Council. There have been changes to the configurations of these sub-groups, arising from decisions made by the Working Party which administers the claim. The participants invited to attend the consultative meetings were chosen in accordance with the current instructions of that Working Party. In addition to the native title groups, as discussed in 2.3 above, members of the Jacobs clan were also invited to attend the consultative meetings.

Apart from the formal representatives of the two relevant native title groups noted above and the independent group, three other groups have occasionally been consulted in regard to proposed developments in the general region in which the Project is located, as follows:

- The Colbung family,
- The Independent Environmental Group, and
- The Warrell family.

These groups were not involved in the consultative process for the following reasons:

- Mr Ken Colbung, elder of the Colbung family is a Registered Applicant on the Southwest Boojarah native title application, which is centered upon the Busselton area. As such, Mr Colbung has sworn an affidavit to the effect that the Busselton area is his traditional country. Busselton is a considerable distance to the south of Midland.
- The Independent Environmental Group is normally included by the author in ethnographic surveys of the Central Business District and the Swan River

from there to Fremantle, as they have shown in the past independent knowledge of heritage sites in those areas.

- Ms. J.Mogridge/Warrell is a Registered Applicant on the Yued native title application, which is centered upon the town of Moora. As such, Ms. Mogridge has sworn an affidavit to the effect that the Moora area is her traditional country. Moora is a considerable distance from Midland.

3.4 The Field Survey Results

In general, all of the parties consulted claimed to have both the authority to speak for the Caversham area and also to have traditional knowledge of that area. It is the author's opinion that all do have authorisation from their respective family groups to represent them at consultative meetings such as that herein reported. All parties, in the author's opinion, also appear to have detailed knowledge of material pertaining to Aboriginal sites in the survey area. The data reported in this document can therefore be taken as accurate and it is unlikely that additional information pertaining to Aboriginal heritage sites in the Project Area could be gleaned by the inclusion of other persons in the consultative process. This is particularly so in the case of lands surrounding Bennett Brook and Reid Highway, as thoroughgoing Aboriginal heritage surveys have been carried out there on numerous occasions since the nineteen-eighties.

The on-site meetings with the representatives of the groups, as listed below, took place on the following days.

- 23 December 2007: Garlett family group as members of the Perth Metropolitan Area native title holders, represented by Mr Greg Garlett, Mr Daniel Garlett, Ms. Kylie Garlett and Ms. Sherma Ugle. Following inspection of the Project Area and discussions, the group gave unconditional approval, on the understanding that the Structure Plan affords protection to the registered Aboriginal sites there.
- 23 December 2007: Wilkes family group as members of the Perth Metropolitan Area native title holders, represented by Mr Richard Wilkes, Mrs Olive Wilkes, Ms. Linley Wilkes and Ms. Larle Wilkes. This group gave approval for the Project, subject to the following three conditions: (1) no disturbance to creek line; (2) protect Moore's Camp; (3) monitors fro initial earthmoving.
- 24 December 2007: Bropho family group and Swan valley Circle of Elders as members of the Perth Metropolitan Area native title holders, represented by Mr Robert Bropho, Mr Barry Parfitt, Ms Mena Bropho and Ms. Bella Bropho. This group gave approval for the Project, subject to the following condition: Moore's Camp and creekline to be protected.
- 24 December 2007: Bodney family group as members of the Ballaruk native title claimant group (subject to Appeal), represented by Mr Corrie Bodney, Mrs Violet Mippy, Ms. Janet Bodney and Ms. Christine Bodney. Following inspection of the Project Area and discussions, the group gave unconditional approval, on the understanding that the Structure Plan affords protection to the registered Aboriginal sites there.
- 2 January 2008: Headland family group, as members of the Perth Metropolitan Area native title holders, represented by Mr Stan Headland, Ms. Marion

Collard, Ms. Thelmay McIntosh and Mr Glen Gillespie. This group also approved the Project, subject to the following conditions: protect creek and (engage) monitors for initial ground disturbance.

- 13 January 2008: Jacobs clan, represented by Rev. Cedric Jacobs and Ms. Kezia Jacobs-Smith. Following inspection of the Project Area and discussions, the group gave unconditional approval, on the understanding that the Structure Plan affords protection to registered Aboriginal sites there.

3.5 Potential Disturbance of Aboriginal Sites

It was noted in 3.2 above that Moore's Camp (formerly registered Aboriginal site number 3746) is now listed as "stored data" in the Register of Aboriginal Sites and is therefore no longer covered by the provisions of the AHA. It is, however, the author's understanding that the developers intend to retain undisturbed the remnant bushland which formerly contained this camp. Similarly, the developer intends to retain undisturbed the location of registered Aboriginal site number 3744 ("Marshall's Paddock").

The developer also proposes to retain "Little Creek" (registered Aboriginal site number 22159) as Public Open Space within the Project (see Figure One). However, it is likely that reshaping, rehabilitation and revegetation of the creek will need to take place. In the author's opinion, such activity would constitute a breach of Section 17 of the AHA, if prior Ministerial consent pursuant to Section 18 is not obtained.

If the map supplied to the Department of Indigenous Affairs by the Lockridge Camp Aboriginal Group is correct where it appears to show registered Aboriginal site number 3840 ("Bennett Brook Camp Area") extending marginally into the Project area in the vicinity of Patricia Street (see Appendix Five), then any activities as described in Section 17 of the AHA would be a breach of that Act if prior Ministerial consent pursuant to Section 18 is not obtained.

4.0 CONCLUSIONS AND RECOMMENDATIONS

In November 2007, Koltasz Smith commissioned R. & E.O'Connor Pty. Ltd. to carry out an ethnographic survey of the Caversham Structure Plan Area, in order to identify if any Aboriginal heritage sites would be affected by proposed development there and, if so, to consult with relevant Aboriginal people in their regard and to prepare a report suitable for submission to the Aboriginal Cultural Material Committee in support of an application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* in respect of the Project Area, should such an application be necessary. This report documents the methodology, content and results of the ethnographic survey, which was carried out between December 2007 and January 2008.

The field survey involved representatives of the the Bropho family group in conjunction with the Swan Valley Circle of Elders; the Garlett family group; the Wilkes family group; the Headland/Corunna family group; the Ballaruk group and the Jacobs clan. Three of the Aboriginal groups gave unconditional approval for the project, on the grounds that provision had been made within the Structure Plan for protection of registered Aboriginal sites. Three of the groups attached conditions to their approvals, as follows:

- Moore's Camp and creekline to be protected (Bropho family group);
- Protect creek and (engage) monitors for initial ground disturbance (Headland/Corunna family group);
- No disturbance to creekline; protect Moore's Camp and (engage) monitors for initial earthmoving (Wilkes family group).

This report recommends that an application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* should be made in respect of the Project Area prior to commencement of ground disturbance there. The application should be accompanied by the required number of copies of this report and also of the archaeological report produced for the Project.

As the relevant Aboriginal people have been consulted in regard to the Project Area and have given approval for the Project to proceed, it is recommended that the Aboriginal Cultural Material Committee should make a recommendation to the Minister that consent should be given for it to proceed.

As the Structure Plan contains provision for protection of Moore's Camp (formerly Aboriginal site number 3746), Marshall's Paddock (Aboriginal site number 3744) and Little Creek (Aboriginal site number 22159), no specific recommendations are made in their regard.

This report recommends also that consideration should be given to the requests of the Aboriginal groups that Aboriginal monitors should be on site when initial ground disturbance is taking place. The role of the monitors is to keep a record for the group should Aboriginal cultural material be encountered in the course of ground disturbance. It is also advantageous to have monitors on hand if skeletal material is uncovered.

REFERENCES

Bates, D.

1944 *The Passing of the Aborigines*. London: John Murray

Bates, D.

1992 (ed. P.Bridge) *Aboriginal Perth.* Perth: Hesperian Press.

Brown,S.

1983 Aboriginal Sites in the Perth Area. Unpublished Report to Main Roads Department.

Hammond, J.

1933 *Winjan's People.* Perth: Imperial Publishing.

Moore, G.

1885 *Diary of Ten Tears Eventful Life as an Early Settler in Western Australia.* Facsimile Edition, U.W.A. Press.

O'Connor, R.

1984 Report on the Ethnographic Survey of the Proposed Power Station Site, Collie, Southwestern Australia. Prepared for SECWA.

O'Connor, R., C.Bodney and L.Little

1985 Report on the Survey for Aboriginal Areas of Significance in the Perth Metropolitan and Murray River Regions. Prepared for Australian

Heritage Commission.

O'Connor, R. and G.Quartermaine.

1986 Aboriginal Site Survey - Mandurah to Pinjarra. Prepared for Main Roads Department.

O'Connor, R. and G.Quartermaine.

1987 Report on the Survey for Aboriginal Sites in the Cooljarloo Mineral Sands Project.

O'Connor, R., C.Bodney and G.Quartermaine.

1989. Report on an Investigation into Aboriginal Significance of Wetlands and Rivers in the Perth-Bunbury Region. Water Resources Council.

Wall. R.

1976. Notes on Aboriginal Reserves around Perth. Unpublished Mss.

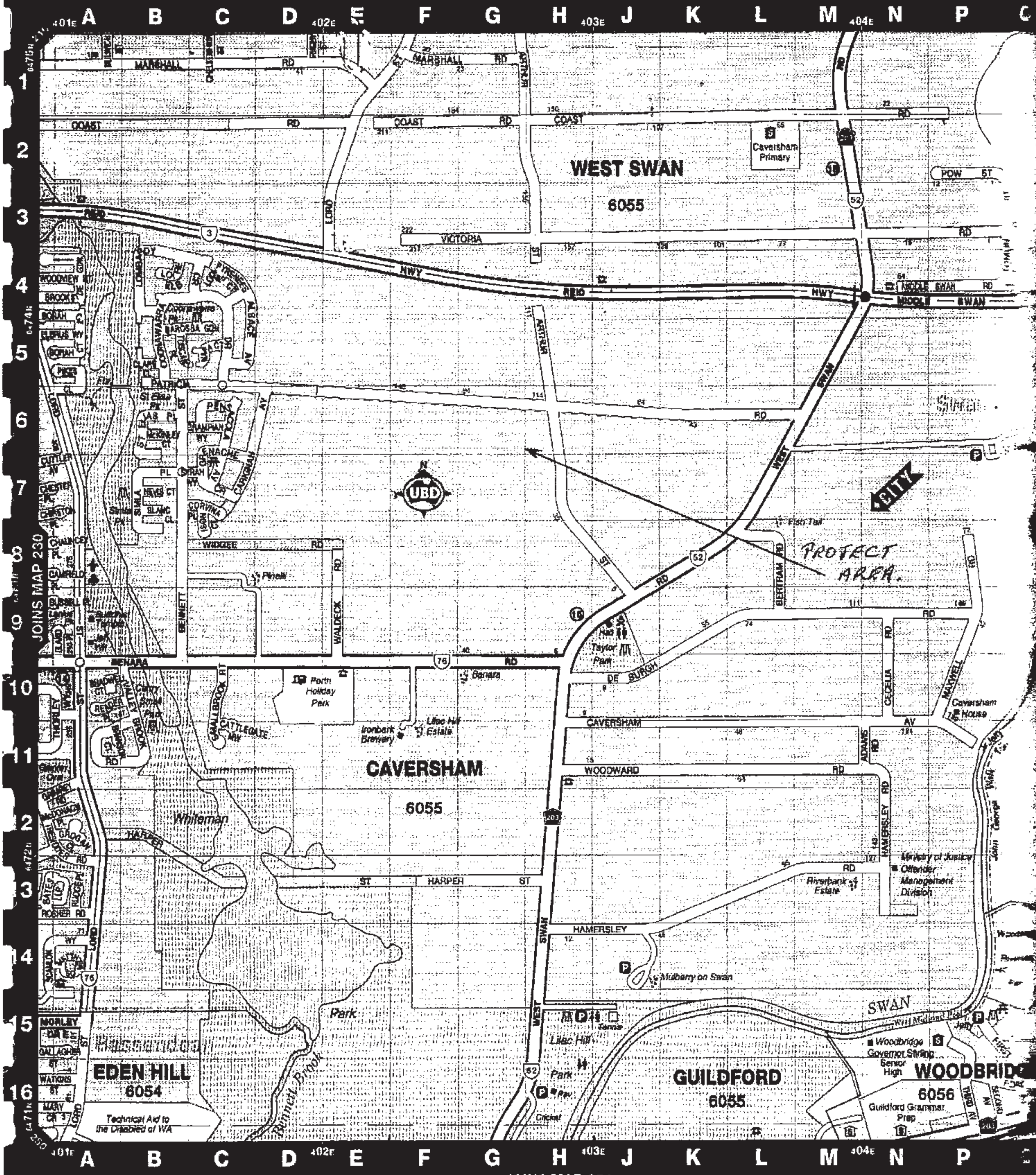
Figure One:

Location of the Project Area

REAL ESTATE Plus

11 The Midland Crescent, Midland 6056

PH: 9274 5000



SCALE 1:19 000

Metres 500 1000 1km

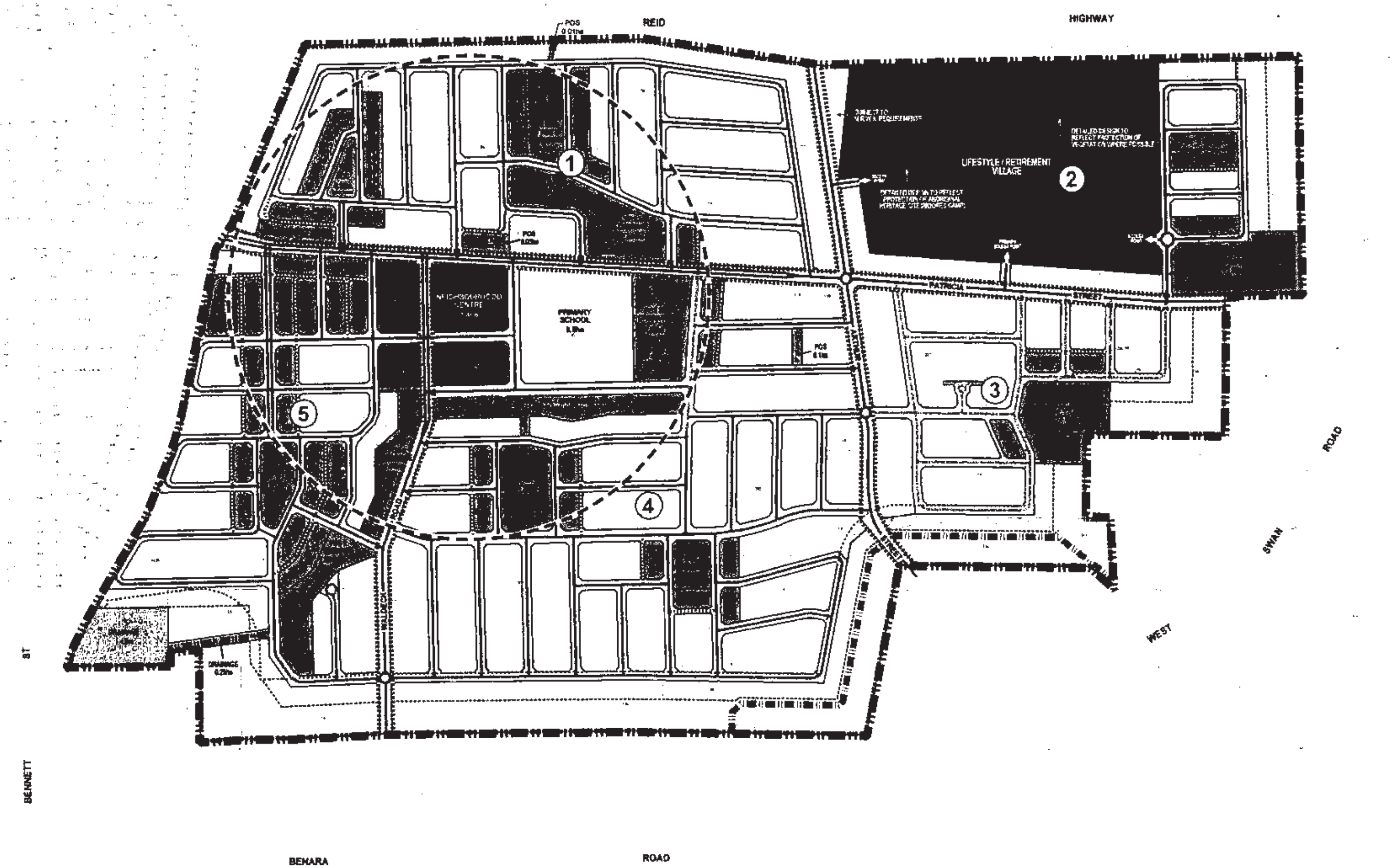
FREEWAY
PROPOSED FREEWAY
HIGHWAY or MAIN ROUTE
ALTERNATE ROUTE
TRAFFICABLE ROAD
PROPOSED ROAD
PARK, RESERVE, OVAL
SCHOOL, HOSPITAL
MISCELLANEOUS AREA
MALL, PLAZA
SWAMP
AMBULANCE STATION
BARBECUE
BOAT RAMP
BOWLING CLUB/GREEN
CAMPING AREA
CARAVAN PARK
CAR PARK
COLLEGE - PRIVATE
COLLEGE - PUBLIC
CYCLEWAY
DISTANCE FROM GPO
EMERGENCY TELEPHONE

PRIMARY RECTANGLE PERTH BG34

Figure Two:

The Structure Plan

CAVERSHAM STRUCTURE PLAN



LEGEND

- CAVERSHAM STRUCTURE PLAN AREA
- 400m WALKABLE CATCHMENT
- CELL BOUNDARY / NUMBER
- 18 METRE MULTIPLE USE CORRIDOR (DRAINAGE CHANNEL)
- DRAINAGE EASEMENT
- RESIDENTIAL R20
- RESIDENTIAL R30
- RESIDENTIAL R60
- RETIREMENT VILLAGE R25/R50
- NEIGHBOURHOOD CENTRE
- TRANSITION LOT
- PUBLIC OPEN SPACE / DRAINAGE
- PRIVATE OPEN SPACE
- PRIMARY SCHOOL
- DRAINAGE
- 100 METRE BUFFER TO RURAL LAND
- TRANSITION LOT BUFFER

0 200 400m

CAVERSHAM MAIN LANDOWNERS GROUP : CLIENT
1:7,500 @A3 : SCALE
17 NOVEMBER 2006 : DATE
dw-2965-5015a-struc plan : PLAN No
: REVISION
K.M. : PLANNER
M.H. : DRAWN

Base data supplied by DPI

Projection MGA50

Areas and dimensions shown are subject to final survey calculations. All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

CELL 1

TOTAL CELL AREA	32 36ha
DEDUCTIONS: none	
NET CELL AREA	32.36
10% POS & DRAINAGE REQUIRED=	3.24
POS & DRAINAGE SUPPLIED=	3.34 (10%)
LOT YIELD	
RESIDENTIAL R30	88 lots
RESIDENTIAL R20	316 lots
TOTAL	404 lots

CELL 2

TOTAL CELL AREA	28.96ha
DEDUCTIONS:	
ROAD WIDENING	0.49
TRANSITION BUFFER & PIPELINE EASEMENT	1.49
NET CELL AREA	26.98
10% POS & DRAINAGE REQUIRED=	2.70
POS & DRAINAGE SUPPLIED=	2.70 (10%)
LOT YIELD	
RESIDENTIAL R30	20 lots
RESIDENTIAL R20	86 lots
TRANSITION	7 lots
RETIREMENT VILLAGE	300-350 D.U.s
TOTAL	87 lots

CELL 3

TOTAL CELL AREA	21.20ha
DEDUCTIONS:	
TRANSITION BUFFER	4.16
NET CELL AREA	17.04
10% POS & DRAINAGE REQUIRED=	1.70
POS & DRAINAGE SUPPLIED=	1.71
LOT YIELD	
RESIDENTIAL R30	15 lots
RESIDENTIAL R20	158 lots
TRANSITION	20 lots
TOTAL	193 lots

CELL 4

TOTAL CELL AREA	58.19ha
DEDUCTIONS:	
PRIMARY SCHOOL	3.5
TRANSITION BUFFER	5.81
NEIGHBOURHOOD CENTRE	1.4
NET CELL AREA	50.98
10% POS & DRAINAGE REQUIRED=	5.10
POS & DRAINAGE SUPPLIED=	5.10 (10%)
LOT YIELD	
RESIDENTIAL R30	79 lots
RESIDENTIAL R20	430 lots
RESIDENTIAL R60	35 D.U.'s
TRANSITION	32 lots
TOTAL	541 lots

CELL 5

TOTAL CELL AREA	30.94ha
DEDUCTIONS:	
TRANSITION BUFFER	3.35
RELOCATED DRAINAGE SITE	1.66
NET CELL AREA	25.93
10% POS & DRAINAGE REQUIRED=	2.59
POS & DRAINAGE SUPPLIED=	3.03 (11%)
LOT YIELD	
RESIDENTIAL R30	126 lots
RESIDENTIAL R20	139 lots
RESIDENTIAL R60	77 D.U.'s
TRANSITION	18 lots
TOTAL	283 lots

FIGURE 15

koltasz smith
TOWN PLANNING · PROJECT MANAGMENT
URBAN DESIGN · DEVELOPMENT CONSULTING

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Appendix One:

Notes on the *Aboriginal Heritage Act, 1972*

APPENDIX 1

OBLIGATIONS RELATING TO SITES UNDER THE ABORIGINAL HERITAGE ACT, 1972

Report of Findings

"15. Any person who has knowledge of the existence of anything in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual of ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any other place or thing to which this Act applies or to which this Act might reasonably be suspected to apply shall report its existence to the Registrar, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Registrar."

Excavation of Aboriginal Sites

"16. (1) Subject to Section 18, the right to excavate or to remove any thing from an Aboriginal site is reserved to the Registrar.

(2) The Registrar, on the advice of the Committee, may authorise the entry upon and excavating of an Aboriginal site and the examination or removal of any thing on or under the site in such manner and subject to such conditions as the Committee may advise."

Offences Relating to Aboriginal Sites

"17. A person who-

(a) Excavates, destroys, damages, conceals or in any way alters any Aboriginal site; or

(b) In any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site,

commits an offence unless he is acting with the authorisation of the Registrar under Section 16 or the consent of the Minister under Section 18."

Consent to Certain Uses

"18. (1) For the purposes of this section, the expression "the owner of any land" includes a lessee from the Crown, and the holder of any mining tenement or mining privilege, or of any right or privilege under the Petroleum Act, 1967, in relation to the land.

(2) Where the owner of any land gives to the Trustees notice in writing that he requires to use the land for a purpose which, unless the Minister gives his consent in this Section, would be likely to result in a breach of Section 17 in respect of any Aboriginal site that might be on the land, the Committee shall, as soon as they are reasonably able, form an opinion as to whether there is any Aboriginal site on the land, evaluate the importance and significance of any such site, and submit the notice to the Minister together with their recommendations in writing as to whether or not the Minister should consent to the use of the land for that purpose, and, where applicable, the extent to which and the conditions upon which his consent should be given.

(3) When the Committee submit a notice to the Minister under subsection (2) of this section he shall consider their recommendation and having regard to the general interest of the community shall either -

(a) Consent to the use of the land the subject of the notice, or a specified part of the land, for the purpose required, subject to such conditions, if any, as he may specify; or

(b) Wholly decline to consent to the use of the land the subject of the notice for the purpose required,

and shall forthwith inform the owner in writing of his decision.

(4) Where the owner of any land has given to the Committee notice pursuant to the subsection (2) of this section and the Committee have not submitted it with their recommendation to the Minister in accordance with that subsection the Minister may require the Committee to do so within a specified time, or may require the Trustees to take such other action as the Minister considers necessary in order to expedite the matter, and the Committee shall comply with any such requirement.

(5) Where the owner of any land is aggrieved by a decision of the Minister made under subsection (3) of this section he may, within the time and in the manner prescribed by the rules of court, appeal from the decision of the Minister to the Supreme Court which may hear and determine an appeal.

(6) In determining an appeal under subsection (5) of this section the Judge hearing the appeal may confirm or vary the decision of the Minister against which the appeal has been made or quash the decision of the Minister, and may make such order as to the costs of the appeal as he sees fit.

(7) Where the owner of the any land gives notice to the Committee under subsection (2) of this section, the Committee may if they are satisfied that it is practicable to do so, direct the removal of any object to which this Act applies from the land to a place of safe custody.

(8) Where consent has been given under this section to a person to use any land for a particular purpose nothing done by or on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitute an offence against the Act."

Appendix Two:

Notes on the Recognition of Aboriginal Sites

APPENDIX 2

Notes on the Recognition of Aboriginal Sites

There are various types of Aboriginal Sites, and these notes have been prepared as a guide to the recognition of those types likely to be located in the survey area.

An Aboriginal Site is defined in the Aboriginal Heritage Act, 1972, in Section 5 as:

"(a) Any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made for or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

(b) Any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

(c) Any place which, in the opinion of the Committee is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the state;

(d) Any place where objects to this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed."

Habitation Sites

These are commonly found throughout Western Australia and usually contain evidence of tool-making, seed grinding and other food processing, cooking, painting, engraving or numerous other activities. The archaeological evidence for some of these activities is discussed in details under the appropriate heading below.

Habitation sites are usually found near an existing or former water source such as a gnamma hole, rock pool, spring or soak. They are generally in the open, but they sometimes occur in shallow rock shelters or caves. It is particularly important that none of these sites be disturbed as the stratified deposits which may be found at such sites can yield valuable information about the inhabitants when excavated by archaeologists.

Seed Grinding

Polished or smoothed areas are sometimes noticed on/near horizontal rock surfaces. The smooth areas are usually 25cm wide and 40 or 50cm long. They are the result of seed grinding by the Aboriginal women and indicate aspects of past economy.

Habitation Structures

Aboriginal people sheltered in simple ephemeral structures, generally made of branches and sometimes of grass. These sites are rarely preserved for more than one occupation period. Occasionally rocks were pushed aside or used to stabilise other building materials. When these rocks patterns are located they provide evidence for former habitation sites.

Middens

When a localised source of shellfish and other foods has been exploited from a favoured camping place, the accumulated ashes, hearth stones, shells, bones and other refuse can form mounds at times several metres high and many metres in diameter. Occasionally these refuse mounds or middens contain stone, shell or bone tools. These are most common near the coast, but examples on inland lake and river banks are not unknown.

Stone Artefact Factory Sites

Pieces of rock from which artefacts could be made were often carried to camp sites or other places for final production. Such sites are usually easily recognisable because the manufacturing process produces quantities of flakes and waste material which are clearly out of context when compared with the surrounding rocks. All rocks found on the sandy coastal plain , for example, must have been transported by human agencies. These sites are widely distributed throughout the State.

Quarries

When outcrops of rock suitable for the manufacture of stone tools were quarried by the Aborigines, evidence of the flaking and chipping of the source material can usually be seen in situ and nearby. Ochre and other mineral pigments used in painting rock surfaces, artefacts and in body decoration are mined from naturally occurring seams, bands and other deposits. This activity can sometimes be recognised by the presence of wooden digging sticks or the marks made by these implements.

Marked Trees

Occasionally trees are located that have designs in the bark which have been incised by Aborigines. Toeholds, to assist the climber, were sometimes cut into the bark and sapwood of trees in the hollow limbs of which possums and other arboreal animals sheltered. Some tree trunks bear scars where section of bark or wood have been removed and which would have been used to make dishes, shield, spearthrowers and other wooden artefacts. In some parts of the state wooden platforms were built in trees to accommodate a corpse during complex rituals following death.

Burials

In the north of the state, it was formerly the custom to place the bones of the dead on a ledge in a cave after certain rituals were completed. The bones were wrapped in sheets of bark and the skull placed beside this. In other parts of Western Australia the dead were buried, the burial position varying according to the customs of the particular area and time. Natural erosion, or mechanical earthmoving equipment occasionally exposes these burial sites.

Stone Structures

If one or more stone are found partly buried or wedged into a position which is not likely to be the result of natural forces, then it is probable that the place is an Aboriginal site and that possibly there are other important sites nearby. There are several different types of stone arrangements ranging simple cairns or piles of stones to more elaborate designs.

Low weirs which detain fish when tides fall are found in coastal areas. Some rivers contain similar structures that trap fish against the current. It seems likely that low stone slab structures in the south west jarrah forests were built to provide suitable environments in which to trap some small animals. Low walls or pits were sometimes made to provide a hide or shelter for a hunter.

Elongated rock fragments are occasionally erected as a sign or warning that a special area is being approached. Heaps or alignments of stones may be naturalistic or symbolic representations of animals, people or mythological figures.

Paintings

These usually occur in rock shelters, caves or other sheltered situations which offer a certain degree of protection from the weather. The best known examples in Western Australia occur in the Kimberley region but paintings are also found through most of the states. One of several coloured ochres as well as other coloured pigments may have been used at a site. Stencilling was a common painting technique used throughout the state. The negative image of an object was created by spraying pigment over the object which was held against the wall.

Engravings

This term described designs which have been carved, pecked or pounded into a rock surface. They form the predominant art form of the Pilbara region but are known to occur in the Kimberleys in the north to about Toodyay in the south. Most engravings occur in the open, but some are situated in rock shelters.

Caches

It was the custom to hide ceremonial objects in niches and other secluded places. The removal of objects from these places, or photography of the places or objects or any other interference with these places is not permitted.

Ceremonial Grounds

At some sites the ground has been modified in some way by the removal of surface pebbles, or the modelling of the soil, or the digging of pits and trenches. In other places there is not noticeable alteration of the ground surface and Aborigines familiar with the site must be consulted concerning its location.

Mythological Sites

Most sites already described have a place in Aboriginal mythology. In addition there are many Aboriginal sites with no man-made features which enable them to be recognised. They are often natural features in the landscape linked to the Aboriginal Account of the formation of the world during the creative "Dreaming" period in the distant past. Many such sites are located at focal points in the creative journeys of mythological spirit beings of the Dreaming. Such sites can only be identified by the Aboriginal people who are familiar with the associated traditions.

Appendix Three:

Signed Statements

Date 24-12-07

The proposed Caversham project has been

discussed by elders of the Bropho

group and has been:

~~Approved~~

Approved subject to the following conditions

~~Not approved for the following reasons~~

Moore's Camp and creekline to be protected.

Signed:

Robert Bropho

Barry Parfitt

Mena Bropho

Bella Bropho.

Date 24-12-07

The proposed Caversham project has been discussed by elders of the Ballaruk group and has been:

Approved

Approved subject ~~to the following~~ conditions

Not approved for the ~~following reasons~~

Signed:

Date 2-1-08

The proposed Caversham project has been inspected by elders of the Nundland group and has been:

~~Approved~~

Approved subject to the following conditions ✓

~~Not approved for the following reasons~~

Protect creek.

Monitors for initial ground disturbance.

Signed: [illegible]

[illegible]

Thelma McIntosh

Glenn Gillespie

Date 13/1/08.

The proposed Caversham project has been

discussed by elders of the JACOBS

group and has been:

Approved ✓

Approved ~~subject to the following conditions~~

Not ~~approved for the following reasons~~

Signed:

CEDRIC JACOBS

KEZIA JACOBS-SMITH

Ksmith

23-12-07

Date. [illegible] ....

The following members of the ...... GARLETT ....

group

have received the sum of $400 per day as reimbursement of expenses for attending a meeting to discuss the proposed ......CAVERSHAM .... PROJECT .... project. And has Been Approved

Name	Signature
GREG GARLETT	[signature]
DANIEL GARLETT	[signature]
KYLIE GARLETT	[signature]
Sherma [illegible]	[signature]

23-12-07

Date..

The proposed CAVE Scam .... project has been

discussed by elders of the Wilkes ....

group and has been:

~~Approved~~

Approved subject to the following conditions ✓

~~Not approved for the following reasons~~

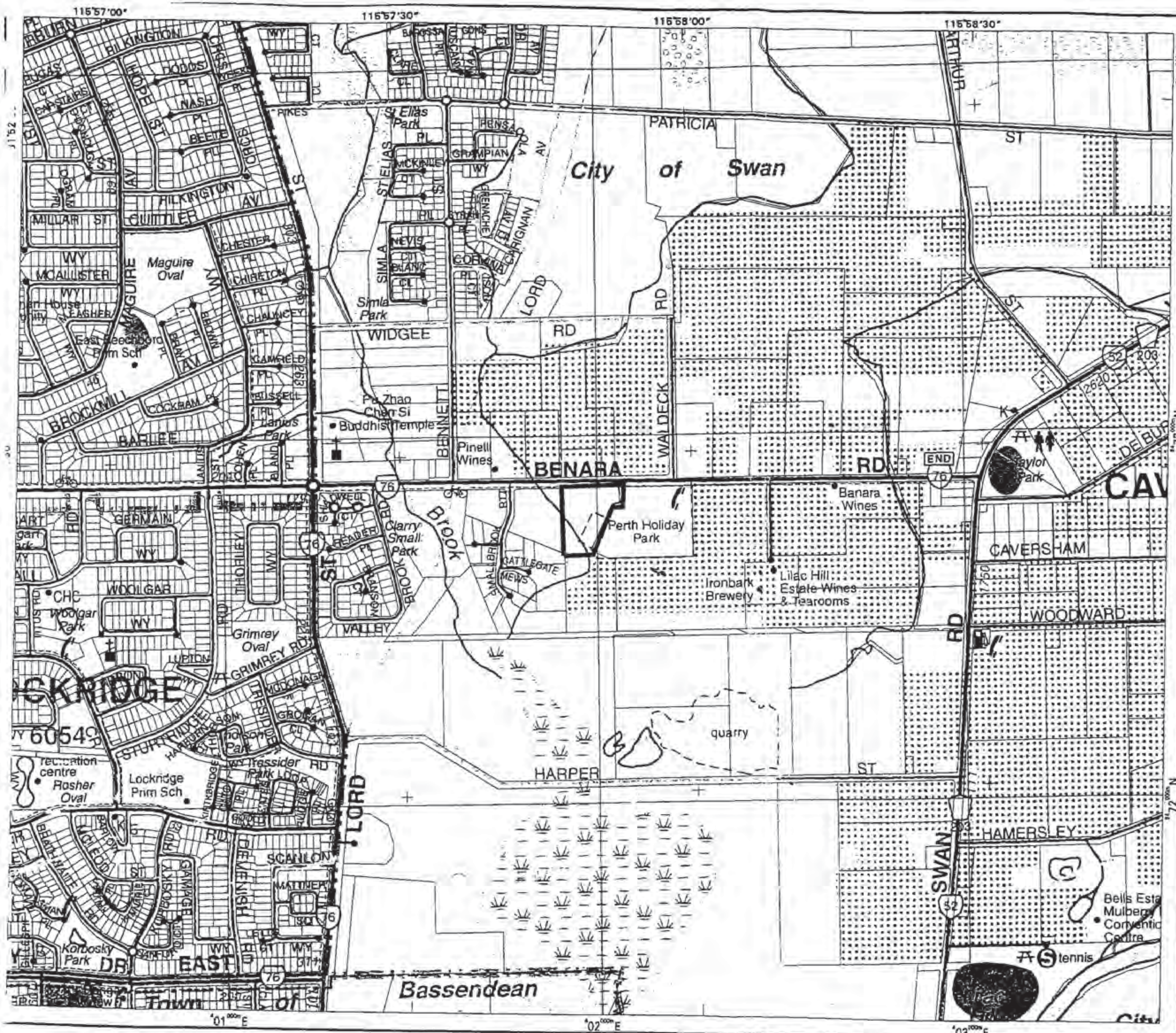
RICHARD WILKES
OLIVE WILKES Per R Wilkes
LANKEY WILKES
LARLE WILKES

(1) No disturbance to creek line.
(2) Protect Moore's Camp.
(3) Monitors for initial earthmoving

Signed:

Appendix Four:

Maps of Aboriginal Site Number 22159



Site No: 22159

Capture Method: Map

Source date: 15/07/2005

Reliability: Reliable

Circle Radius: N/A

DIA INTERNAL USE ONLY

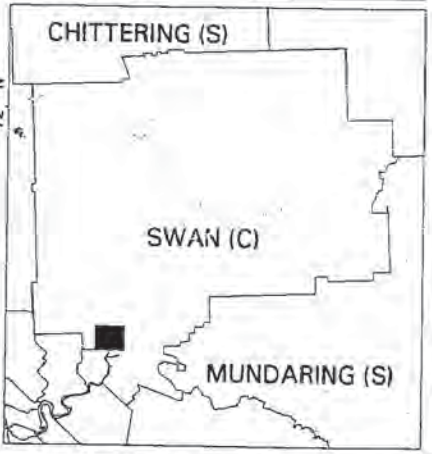
Captured By:................................

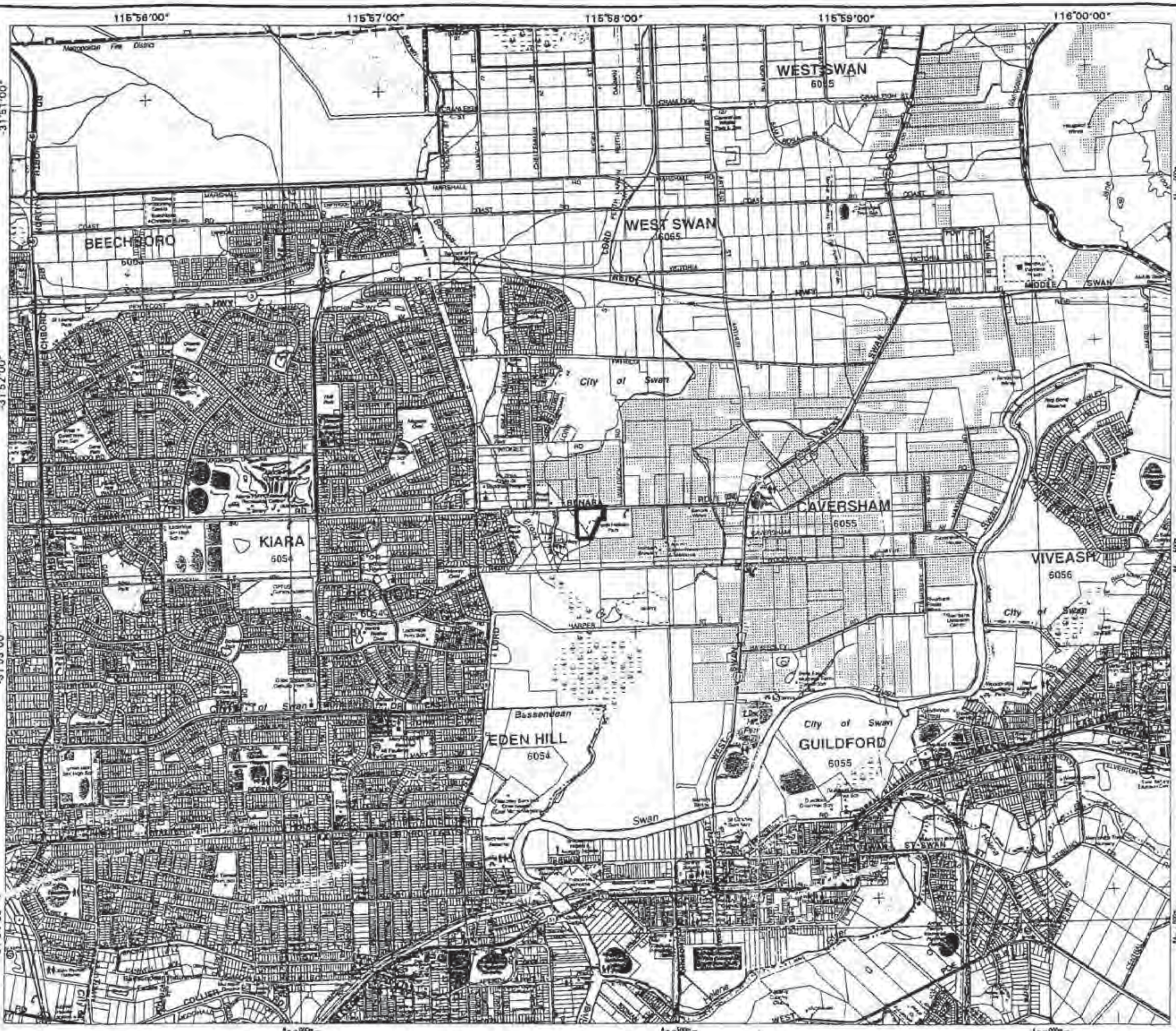
QA By:..

0 ——— 250 m

Scale 1:10000

Date: 04 Aug 05





Site No: 22159

Capture Method: Map

Source date: 15/07/2005

Reliability: Reliable

Circle Radius: N/A

DIA INTERNAL USE ONLY

Captured By:..............................

QA By:..............................

0 500 m

Scale 1:25000

Date: 04 Aug 05

CHITTERING (S)

SWAN (C)

MUNDARING (S)

Appendix Five:

Swan Valley Fringedwellers Group Map of Former Aboriginal Camps

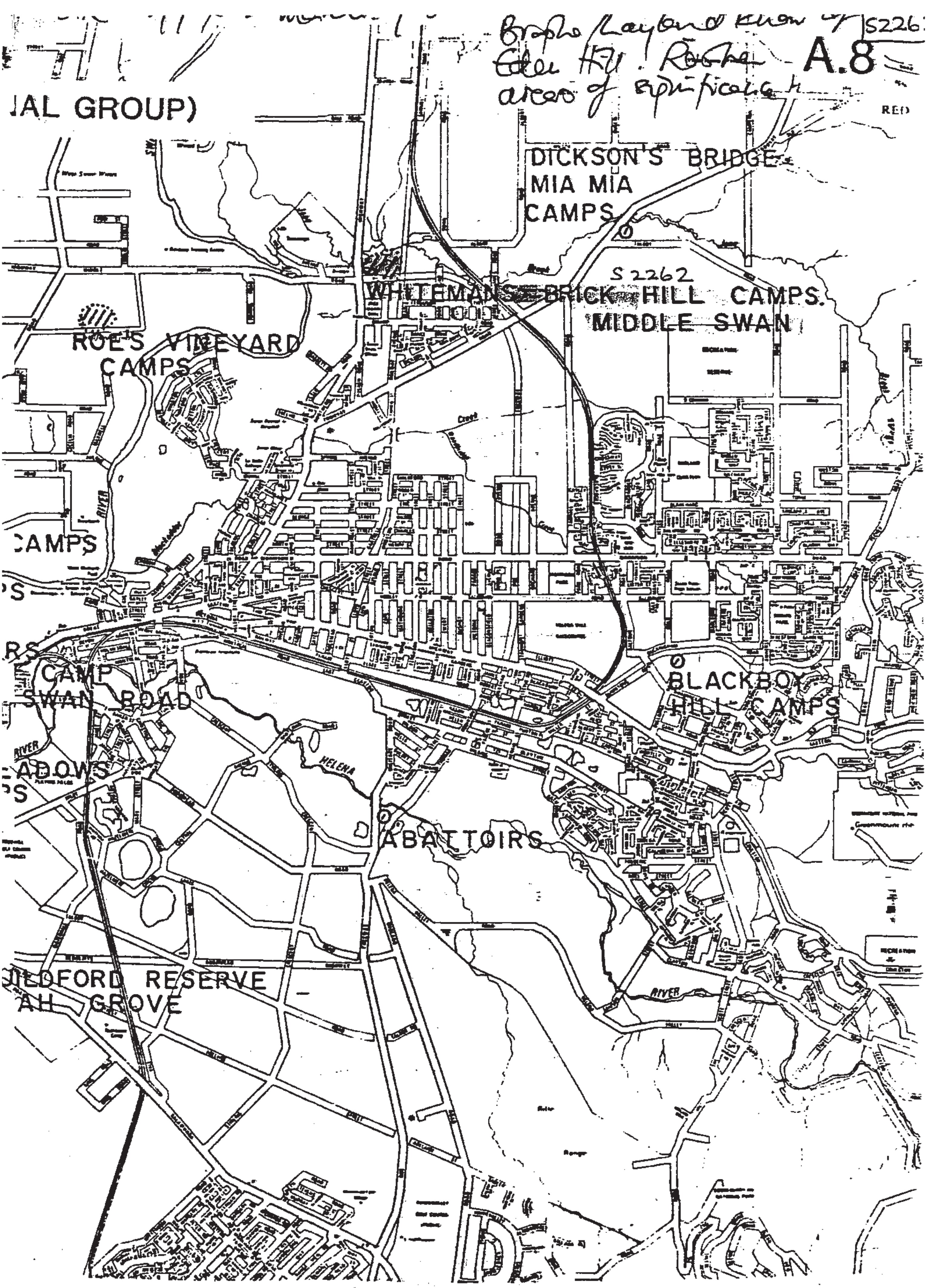
P. Barnes 28.11.83

ABORIGINAL CAMPS

(MAP PROVIDED BY LOCKRIDGE CAMP ABORIG

Reserve, ↑

THIS MAP IS REPRODUCED BY PERMI



SION OF THE SURVEYOR GENERAL, DEPT. OF LANDS AND SURVEY.

QUARTERMAINE
CONSULTANTS

REPORT ON A PRELIMINARY ARCHAEOLOGICAL INVESTIGATION FOR ABORIGINAL SITES CAVERSHAM STRUCTURE PLAN

Prepared for Koltasz Smith

By Quartermaine Consultants

November 2005

REPORT ON A PRELIMINARY ARCHAEOLOGICAL

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CAVERSHAM STRUCTURE PLAN

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November 2005

REPORT ON A PRELIMINARY ARCHAEOLOGICAL

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CAVERSHAM STRUCTURE PLAN

Prepared for Koltasz Smith

By Gary Quartermaine

ABSTRACT

A preliminary archaeological investigation ("desktop study") for Aboriginal heritage significance of the Caversham Structure Plan Project Area, in the northern metropolitan area, was commissioned by Koltasz Smith. It was conducted to so that the proponents can comply with the provisions of the W.A. *Aboriginal Heritage Act*, 1972.

The archaeological investigation involved the assembly of data from previous work in the region, including information from the Heritage and Culture Division, Department of Indigenous Affairs (DIA) Aboriginal site register and files, previous survey reports and other relevant documents, maps and environmental information. No registered archaeological sites were located within the designated project area.

Those areas most likely to contain archaeological sites are lake, swamp and water course margins, and sand hills. There is an area or relatively undisturbed vegetation in the north-east quadrant marked on the project area plan. This area may have some potential to contain archaeological material.

Although no registered archaeological sites are within the project area, it is recommended that an archaeological investigation of areas with archaeological site potential, as well as other relatively undisturbed areas, be undertaken prior to development.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background to Investigation

A preliminary archaeological investigation ("desktop study") for Aboriginal heritage significance of the Caversham Structure Plan Project Area, in the northern metropolitan area, was commissioned by Koltasz Smith and executed in November, 2005.

The archaeological investigation was carried out by Quartermaine Consultants. The work was undertaken by Gary Quartermaine, BA Honours (Anthropology and Archaeology), who has conducted numerous Aboriginal heritage investigations throughout the state. This was undertaken in conjunction with the ethnographic component of the investigation, reported upon separately, which was conducted by R & E O'Connor Pty Ltd.

The objective was to conduct an investigation to facilitate planning of the proposed development. The archaeological investigation involved the assembly of data from previous work in the region, including information from the Heritage and Culture Division, Department of Indigenous Affairs (DIA) Aboriginal site register and files, previous survey reports and other relevant documents, maps and environmental information.

1.2 Location

The Caversham Structure Plan Project Area is located in the northern metropolitan area approximately 15 kilometres north-east of the Perth CBD (see Figures 1 and 2 for location). Maximum dimensions are 1.7 kilometres EW by 1.1 kilometres NS. The project area is bounded by Reid Highway in the north, Lord Street in the west, Benara Road in the south, and West Swan Road in the east.

2.0 ARCHAEOLOGICAL CONTEXT

2.1 Introduction

The principal aim of archaeologists is to describe and explain past ways of life with reference to material culture. The general focus of Australian Aboriginal archaeological research has been to describe and explain the history of the occupation of the continent, examining cultural change and adaptations to develop explanatory models to describe how and why the occupation of the Australian continent proceeded.

2.2 Site Definitions

Aboriginal material culture is based, to a large extent, on non-durable materials; such as wood, bark, fibre and skins; that have a limited life in the archaeological record. Stone tools, conversely, remain as often the only evidence of prehistoric activity. Bone; either as a tool, as refuse, or as a burial; falls somewhere between these extremes. Lofgren (1975:7) describes spears, spear-throwers and clubs for men, and digging sticks, wooden carrying dishes and grindstones for women, as the basic implements of Aboriginal life.

Therefore, stone artefact sites reflect only one aspect of Aboriginal material culture which utilised a wide range of materials from the natural environment.

For scientific purposes, an archaeological site is defined as "any place containing traces of past human activity" (Fagan, 1980:7). This is manifested in a number of different site components which may occur singularly or with one or more of the others to form an archaeological site. The most common of these are surface artefact scatters, quarries, art sites, stone arrangements, rock shelters with evidence of occupation, grinding patches, shell middens, burials and marked trees.

The above definition of archaeological sites is a scientific definition. However, registered Aboriginal sites may not meet the scientific criteria on all occasions. The assessment as to whether such sites are covered by the provisions of the W.A. *Aboriginal Heritage Act*, 1972, Section 5, is made for the Minister for Indigenous Affairs by the Aboriginal Cultural Material Committee. Such assessment is usually undertaken as part of a Section 18 application for site disturbance.

An Aboriginal archaeological site is mentioned in the WA *Aboriginal Heritage Act*, 1972, in Section 5 (c), which reads:

“Any place which, in the opinion of the Committee is, or was, associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the state.”

In order to address the state legislation and in the absence of any guidance from DIA despite several enquiries over the past twenty years, an artefact scatter is recorded as a site by this consultant if it contains a concentration of artefacts in contextual association, three or more with a density of at least $1/100m^2$. Areas of solitary artefacts, called Isolated Finds, are presently recorded but not registered as Aboriginal sites. This was not always the case in the past and some previously registered sites contain only a solitary artefact, in keeping with the broad scientific definition.

2.3 Previous Archaeological Research

The earliest evidence for prehistoric occupation of the South-West of Australia is dated at 38,000 years ago, for a stratified site at Upper Swan, located 25 kilometres northeast of Perth. The investigation of an archaeological site at Upper Swan yielded radio-metrically dated material in association with Aboriginal artefacts in a stratified deposit. This site, DIA ID 4299 (S00999), on the northern river terrace of the Swan River, gave a date of 38,000 years ago for Aboriginal occupation (Pearce and Barbetti, 1981).

Schwede (1983a) has obtained a date of 29,000 years ago for stratified material from alluvial deposits at a site, DIA ID 3967 (S01453), on the Helena River, in Hazelmere.

As well, a number of Holocene sites have yielded data on possible cultural/environmental changes during, and after, the recent transgression of the sea, for the metropolitan region (see Clarke and Dortch, 1977; Hallam, 1974; and Pearce, 1978).

Excavations at these and other sites in the south-west have recorded a flaked stone industry with few formal tool types since early occupation. Distinctive microlithic tools appear in such assemblages from approximately 6,000 years ago (Dortch, 1977).

Prehistoric stone tool industries in the South-West have been classified into earlier and later phases (Dortch, 1977). The early phase industries have only been documented from a few well-dated sites. They include small thick flake scrapers, bipolar cores, notched-denticulated pieces, flakes from discoidal cores, and single and multi-platform cores.

These artefacts have been manufactured from a range of lithic materials, including a distinctive Eocene fossiliferous chert. It appears that access to this chert was lost after the last marine transgression (Dortch, 1977; and Glover, 1975).

Later phase stone industries, generally found in archaeological contexts dating from 4,000 years ago, include the addition of geometric microliths, backed blades, and a variety of adze flakes, which are part of the Australian "small tool tradition" (Dortch, 1977; and Mulvaney, 1975).

As part of a regional survey of the Metropolitan area, Hallam (1986:5) concludes that the majority of sites lie around the lakes and swamps of the Swan Coastal Plain, and that site numbers double in the last few hundred years. Four phases of occupation are suggested for the Coastal Plain. These are:

a. Early - low number of sites centred towards coast. Artefacts include steep scrapers on flakes and scrapers made from an Eocene fossiliferous chert. This phase was up to 5000 years ago.

b. Middle - from 5000 - 500 years ago. Showed a contraction of occupation to sites near permanent water. Artefacts were made on quartz and green chert and included backed blades, adzes, scrapers and flakes.

c. Late - from 500 years ago. Concentration of sites on the Coastal Plain. Fabricators (bipolar cores) were introduced and a large percentage of assemblages were made up of quartz flakes, chips and debitage.

d. Final - post European contact and settlement. Use of introduced materials, such as glass, pottery and clay pipes, for the manufacture of artefacts (Hallam, 1971, 1973, 1974, 1977 and 1986).

Schede questions Hallam’s Early and Late phase assemblages based on her studies of quartz artefacts in the metropolitan area (Schwede, 1991:243-244). Schwede concludes that the Early Phase covers sites between 4,600 and 40,000 years ago based on the absence of backed blades and the results of the analysis of debitage from sites older than 4,600 BP rather than the presence of fossiliferous chert. Schwede also concludes that quartz rich assemblages are common to all phases not just the Late Phase (Schwede, 1991:243-244).m However, the Hallam model remains the most comprehensive study of archaeological sites in the metropolitan area and provides a useful basis to categorise archaeological sites.

Information from a survey of the Swan Coastal Plain to the foothills of the Darling Range and centred on the Swan River gives a picture of Aboriginal prehistoric occupation concentrated on the area immediately west of the foothills (Hallam, 1987). This information includes the results of two east-west transects across this region. The results show that the majority of recorded archaeological sites are located in the Bassendean Dunes and Pinjarra Plain landforms, around the rivers, lakes and swamps. There is little evidence of usage of coastal areas, only starting in the eastern part of the Spearwood Dunes zone (Hallam, 1987:20-23).

Hallam (1986) concludes that Aborigines congregated around the estuaries and lagoons of the coastal plain in the summer and dispersed, in small groups, in winter through a wider hinterland which included the area of the Darling Scarp and Plateau.

Anderson (1984) has proposed a land-use model for prehistoric exploitation of the Swan Coastal Plain, and its hinterland, based on regional research into the relative proportions of variously sized surface artefact scatters and their associated artefact densities. This model suggests that, due to the variation in resources available in the three different environmental zones investigated, there was more intensive use of the coastal plain than either the adjacent forest or open woodland plateau.

The seasonal movement of Aboriginal groups relates to the exploitation of the various resources available in the different environmental situations. Hallam (1986) concludes that Aborigines congregated around the estuaries and lagoons of the coastal plain in the summer and dispersed, in small groups, in winter through a wider hinterland which included the area of the Darling Scarp and Plateau.

On the coastal plain, recorded sites are mostly located in disturbed areas, either from natural processes or humanly affected. Because of the nature of the coastal plain, it is postulated that sites may be present but covered by sand and vegetation and only discovered when they are exposed. The rivers, lakes and estuaries in the area would have provided fresh water and a terrestrial resource base for the Aboriginal people camping in this region.

Commercial surveys and academic research have shown that the most common sites in the South West Region are artefact scatters, burial sites, quarries, and scarred trees. Stone arrangements associated with ceremonial sites are also known. It is evident that larger occupation sites are associated with fresh water sources. The preceding data provides a basis for predicting the occurrence of sites, assuming resources as the principal factor in site location. This predictive model of site location can be used to discover sites. The site types which can be expected to occur with the vicinity of the survey area are:

1) Camp sites - small scatters, including brief or sporadic occupation, may occur at task specific sites or ephemeral water sources. Generally these small sites are interpreted as representing ephemeral “dinnertime” camps or task specific sites associated with the daily foraging activities of prehistoric groups. Large sites with high artefact densities commonly occur on the margins of permanent or semi-permanent water sources. These sites typically represent campsite locations that were repeatedly occupied, sometimes for prolonged periods.

2) Burial Sites - Usually located with ethnographic information or due to surface disturbance, and virtually impossible to detect without excavation;

3) Scarred Trees - Resulting from bark removal for carrying bowls, shields and spear throwers; such sites are probably under represented owing to the lack of preservation: trees die and decay.

3.0 METHODS

3.1 Obligations under the Act

The Western Australian *Aboriginal Heritage Act*, 1972, makes provision...

"... for the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purpose incidental thereto."

The Act defines the obligations of the community relating to sites (see Appendices 1 and 2).

An archaeological investigation is aimed at identifying the effects of proposed disturbance of the physical environment on historic and pre-historic Aboriginal sites.

In recognition of the significance of this area to living Aboriginal people, an investigation of Aboriginal interests was conducted and reported upon separately.

3.2 Investigation Methodology

The research involved familiarisation with DIA Aboriginal Site Register and site files, previous survey reports and other relevant literature, plus maps and environmental information for the areas under investigation.

The tasks undertaken were as follows:-

1. To document any registered Aboriginal sites located in the project area and assess their significance;

2. To map those sites on appropriate scale;

3. To check survey reports and other relevant literature covering sites and surveys in the project area.

4.0 RESULTS

4.1 Archival Research

The W.A. Aboriginal Heritage Act, 1972 (as amended), is administered by the Department of Indigenous Affairs' Division of Heritage and Culture. The DIA maintains a Register in the form of a computerised data base of reported Aboriginal sites. Each registered Aboriginal site is designated by a numerical site id, site type (e.g. engravings, ceremonial, artefacts, etc), site name and its position is recorded by the Map Grid of Australia 1994 (MGA94) coordinates related to the Geocentric Datum of Australia 1994 (GDA94), as well as Longitude and Latitude.

Although the grid references are given in MGA94/GDA94 coordinates, many of these sites were recorded in the period when imperial grid references were used. Since their recording, the grid references have been changed to the metric system on AGD66 then to AGD84 and finally to GDA94. Given that there was likely to be some errors in any imperial recordings, as they were given a grid reference within a one square mile coordinate, the transfer to the present system may have resulted in further errors in site location coordinates. Field verification is, therefore, required to determine the correct site location for any sites near the project area if there is insufficient information in the individual sites files to establish the actual location of the site.

As a result of research at Heritage and Culture Division, it was established that eighteen Aboriginal sites have been registered at the DIA within two kilometres of the designated project area (Schwede, 1983b, 1984a, 1984b; Pickering, 1984; O'Connor, et al, 1985; Hallam, 1986; O'Connor and Quartermaine, 1987a, 1987b; Strawbridge, 1988; O'Connor, et al, 1989; McDonald, 1990; Quartermaine, 1988a, 1988b, 1988c, 1997, 2000a, 2000b, 2001; Lanske, 1995; Sauman, 2001; Hames, 2003).

Of the Aboriginal sites, six are registered as archaeological sites. These are listed in Table 1. They are all artefact scatters with mainly quartz material while some contain fossiliferous chert chips, flakes scrapers and cores. Except for DIA ID 3879, the sites are registered as stored data only which usually means they have been subject to a Section 18 application for disturbance and are no longer extant.

TABLE 1: Registered Archaeological Sites

DIA Site ID	DIA Site No.	Status *	Grid Ref.	Site type	Site name
3227	S00441	S	401399.6471979	Artefacts	Bennett Br: Stephenson's
3521	S02502	S	401489.6474149	Artefacts	Bennett Br: Bennett St
3879	S01940	P	401439.6472799	Artefacts	Bennett Br: Benara Rd 2
3907	S01819	S	400989.6474149	Artefacts	Lot 1068
3992	S01426	S	401389.6472499	Artefacts	Bennett Br: Grimrey Road
3997	S01431	S	401689.6472649	Artefacts	Bennett Br: Benara Rd 1

* P = Permanent register, S = Stored data

The closest registered sites to the project area are DIA IDs 3879 and 3997. These are both located on the south side of Benara Road near Bennett Brook.

4.2 Previous Archaeological Surveys

Several archaeological investigations have been conducted in the vicinity of the subject land (Schwede, 1983b, 1984a, 1984b; Pickering, 1984; O'Connor and Quartermaine, 1987a, 1987b; Strawbridge, 1988; McDonald, 1990; Quartermaine, 1988a, 1988b, 1988c, 1997, 2000a, 2000b, 2001; Lanske, 1995; Sauman, 2001; Hames, 2003).

Archaeological survey work has been completed for the original Dampier to Bunbury Natural Gas Pipeline (Pickering, 1984; Schwede, 1983b, 1984a) and the recent duplication corridor (Hames, 2003; Sauman, 2001). No archaeological sites were located near the subject land as a result of these investigations.

Schwede (1984b) undertook excavations at two archaeological sites near Bennett Brook on the south side of Benara Road prior to the pipeline installation. DIA ID 3879 is recorded as a surface artefact scatter of 40 pieces with no stratified material. This site is located in an area that has been quarried and re-filled so the provenance of the artefacts is dubious. DIA ID 3997 was originally recorded as three separate concentrations containing 15 artefacts over an area measuring 250 x 400 metres along firebreaks. Two test-pits were excavated at the site and artefacts were recorded to 100cm below surface level. However, lupin seeds were also found to this depth, so the artefacts may be of recent age. Analysis of results revealed that quartz was used for 95% of artefacts, and 95% were less than one centimetre maximum dimensions while none were more than four centimetres in length, the assemblage was consistent through the arbitrary spit levels (Schwede, 1984b).

Another of these investigations involved the Reid Highway corridor for the Proposed Northern Perimeter Highway Route and covered the northern margin of the area of the subject land (O'Connor and Quartermaine, 1987a). No archaeological sites were located near the subject land.

Following survey work of the Reid Highway alignment (O'Connor and Quartermaine, 1987a; McDonald Hales, 1990), a Section 18 application for the Bennett Brook and Swan River crossings was granted to MRWA. The conditions included monitoring of ground disturbance in the Swan River area by an archaeologist.

An archaeological survey for the Balga to Wundowie Powerline Route followed Marshall Road to the north of the subject land (O'Connor and Quartermaine, 1987b). No archaeological sites were located in this section of the route corridor.

Archaeological surveys of a housing development and a proposed quarry site to the south of Benara Road and east of Lord Street failed to locate any new archaeological sites (Quartermaine, 1988a, 1988b). An archaeological monitoring programme at the housing development failed to uncover any archaeological material (Quartermaine, 2000a).

An archaeological survey for a housing development immediately west of the subject land, east of Lord Street and south of Reid Highway, located one archaeological site near Bennett Brook, DIA ID 3521 (Quartermaine, 1988c). This site has been subsequently destroyed and is listed as stored data only.

An archaeological survey of proposed road works for the Reid Highway and Lord Street extensions found no archaeological sites near the subject land (Lanske, 1995). Other road works surveys have been for the Hepburn Avenue extension to Reid Highway (Quartermaine, 2000b) and the Whiteman Park Access Road from Beechboro Road (Quartermaine, 2001).

An archaeological survey of the Beechboro Land Scheme Area was undertaken (Quartermaine, 1997). This is located immediately north-west of the subject land, to the north of Reid Highway and between Beechboro Road and Lord Street. No archaeological sites were located within the survey area.

None of the above reports resulted in archaeological sites being recorded within the subject land.

Previously recorded sites in the area reflect a distribution that indicates where site survey work has been undertaken as well as the fact that development over the past 175 years has obscured many archaeological sites. The locations of numerous sites are on the margins of rivers, lakes and swamps. Site density for various parts of the south-west, based on the results of archaeological surveys, points to an average site density of about two sites per square kilometre overall with large variations according to location and environment.

Most sites in the coastal plain have been recorded on the Bassendean Dunes landform and along the rivers and lakes with few sites on the Quindalup and Spearwood Dunes landforms. The subject land is within the Bassendean Dunes landform.

5.0 CONCLUSIONS

5.1 Discussion

A preliminary archaeological investigation ("desktop study") for Aboriginal heritage significance of the Caversham Structure Plan Project Area, in the northern metropolitan area, was commissioned by Koltasz Smith.

The Caversham Structure Plan Project Area is located in the northern metropolitan area approximately 15 kilometres north-east of the Perth CBD. Maximum dimensions are 1.7 kilometres EW by 1.1 kilometres NS. The project area is bounded by Reid Highway in the north, Lord Street in the west, Benara Road in the south, and West Swan Road in the east.

The archaeological investigation involved the assembly of data from previous work in the region, including information from the Heritage and Culture Division, Department of Indigenous Affairs (DIA) Aboriginal site register and files, previous survey reports and other relevant documents, maps and environmental information.

As a result of research at Heritage and Culture Division, it was established that eighteen Aboriginal sites have been registered at the DIA within two kilometres of the designated project area.

Of the Aboriginal sites, six are registered as archaeological sites. They are all artefact scatters with mainly quartz material while some contain fossiliferous chert chips, flakes scrapers and cores. Except for DIA ID 3879, the sites are registered as stored data only which usually means they have been subject to a Section 18 application for disturbance and are no longer extant.

The project area has few areas of relatively undisturbed land that could provide a more accurate reflection of the archaeological signature of this part of the coastal plain. Visibility and obtrusiveness of archaeological material may be factors affecting the discovery of archaeological sites due to surface vegetation and a build up of a layer of organic material and covering by sand since traditional Aboriginal usage ceased in the nineteenth century, as well as disturbance from vegetation clearance and agricultural activities.

Those areas most likely to contain archaeological sites are lake, swamp and water course margins, and sand hills. There is an area or relatively undisturbed vegetation in the north-east quadrant marked on the project area plan (Figure 2). This area may have some potential to contain archaeological material.

5.2 Recommendations

The recommendations which follow are based on previous field observations and investigations of previously recorded sites in area.

1. It is recommended that care be taken in those areas with the most potential to contain archaeological material. These are lake, swamp and water course margins, and sand hills. No registered archaeological sites are within the project area. However, it is recommended that an archaeological investigation of areas with archaeological site potential, as well as other relatively undisturbed areas, be undertaken prior to development.

2. If any Aboriginal material is uncovered as a result of any development involving disturbance to the environment, it should be reported to the relevant authorities.

3. Should any archaeological sites be affected by future development, permission for use of the relevant land, under Section 18 of the W.A. *Aboriginal Heritage Act*, 1972, must be obtained before any disturbance occurs. This can be done by written application to the Registrar of Aboriginal Sites for the consent by the Minister for Indigenous Affairs to use the land containing the site under the above Section.

4. It is pointed out that human interference to Aboriginal sites is an offence, unless authorised under the Act, as outlined in Section 17 of the W.A. *Aboriginal Heritage Act*, 1972. Therefore, it is recommended that the Proponent take adequate measures to inform any project personnel of this requirement.

6.0 REFERENCES

Anderson, J. (1984) Between Plateau and Plain. Occasional Papers in Prehistory, No. 4. A.N.U., Canberra.

Clarke, J. and Dortch, C.E. (1977) "A 10,000 year BP radio carbon date for archaeological finds in a soil of the Spearwood Dune system, Mosman Park, W.A." Search, 8:36-38.

Dortch, C.E. (1977) "Early and late stone industrial phases in Western Australia" in Wright, R.V.S. (ed.) Stone Tools as Cultural Markers. A.I.A.S. Canberra. pp. 104 - 132.

Fagan, B. (1980) People of the Earth. Little, Brown and Company, Boston.

Glover, J E. (1975) "The petrology and probable stratigraphic significance of Aboriginal Artefacts from part of south-west Australia". Journal of the Royal Society of Western Australia, 58:75-85.

Hallam, S.J. (1971) Roof Markings in the "Orchestra Shell" Cave Wanneroo, near Perth, Western Australia.

Hallam, S.J. (1973) Ecology and demography in southwestern Australia. Journal of the Royal Society of Western Australia, 56:46-48.

Hallam, S.J. (1974) "Excavations at the Orchestra Shell Cave, Wanneroo, Western Australia". Archaeology and Physical Anthropology in Oceania, 9: 66 - 84.

Hallam, S.J. (1977) Population and Resource Usage of the Western Littoral. Paper presented to ANZAAS, Melbourne.

Hallam S.J. (1986) Prehistoric Aboriginal Populations on the Swan Coastal Plain, Western Australia. Final Report on the project : Australian Research Grants Scheme.

Hallam, S.J. (1987) Coastal does not equal Littoral. Australian Archaeology, 25:10-29.

Hames Consultancy Group. (2003) Management report of Aboriginal Heritage aspects of the Dampier to Bunbury Natural Gas Pipeline corridor through the Perth Metropolitan Area. Unpublished report.

Lanske, D. (1995) Report on an Archaeological and Ethnographic Heritage Survey of the Reid Highway / Lord street Extensions, Ellenbrook. Unpublished report.

Lofgren, M. E. (1975) Patterns of Life. Western Australian Museum Information Series No. 6.

McDonald Hales and Associates. 1990. An Aboriginal Sites Survey at the Bennett Brook and Swan River Crossings of the Proposed Reid Highway. Prepared for MRD.

Mulvaney, D.J. (1975) The Prehistory of Australia. Penguin, Melbourne.

O'Connor, R., Bodney, C. and Little, L. (1985) Preliminary Report on the Survey for Aboriginal Areas of Significance in the Perth Metropolitan and Murray River Regions. Prepared for the Centre for prehistory, U.W.A.

O’Connor, R. and Quartermaine, G. (1987a) Report on the Survey for Aboriginal Heritage Significance of the Proposed Powerline Route, Balga to Wundowie 132kV. Report to SECWA.

O’Connor, R. and Quartermaine, G. (1987b) Report on the Survey for Aboriginal Sites in the Vicinity of the Proposed Northern Perimeter Highway Route, Perth Metropolitan Area. Report to MRD, Perth.

O'Connor, R. Quartermaine, G. and Bodney, C. (1989) Report on an Investigation into Aboriginal Significance of Wetlands and Rivers in the Perth - Bunbury Region. Published by the Western Australian Water Resources Council.

Pearce, R.H. (1978) "A dated sequence from Walyunga. Western Australia." Journal of the Royal Society of Western Australia, 61: 1 - 10.

Pearce, R.H. & M. Barbetti. (1981) "A 38,000 year old archaeological site at Upper Swan, Western Australia". Archaeology in Oceania, 16: 173-178.

Pickering, M. (1984) An Archaeological Survey of the Dampier to Perth Natural Gas Pipeline Route. Section 5: Muchea to Wagerup. Report to S.E.C., Perth.

Quartermaine, G. (1988a) Report of a Survey for Aboriginal Archaeological Sites at a Proposed Housing Development, Caversham. Report to H.C. Small.

Quartermaine, G. (1988b) Report on a Survey for Archaeological Sites at the Proposed Quarry Site near Bennett Brook, Caversham. Report to K.A. Adam & Associates.

Quartermaine, G. (1988c) Report on a Survey for Archaeological Sites at the Proposed Bennett Brook Development. Report to CMS Urban Consultants.

Quartermaine, G. (1997) Report on an Archaeological Survey for Aboriginal Sites, Beechboro Land Scheme. Prepared for BSD Consultants.

Quartermaine, G. (2000a) Report on an Archaeological Monitoring Programme, Lot 13, Short Street, Caversham. Prepared for Roger Small.

Quartermaine, G. (2000b) Report on an Archaeological Investigation of Aboriginal and Heritage Sites, Hepburn Avenue Extension. Prepared for the City of Swan.

Quartermaine, G. (2001) Report on an Archaeological Investigation for Aboriginal Sites, Proposed Whiteman Park Access Road. Prepared for Argenta Management Group Pty Ltd.

Sauman, D. (2001) Site Avoidance Survey under the Aboriginal Heritage Act (1972) of proposed deviations to the extended Dampier to Bunbury Natural Gas Pipeline Corridor. Unpublished report.

Schwede, M.L. (1983a) An Archaeological Investigation of the Helena River Site. Report to M.R.D., Perth.

Schwede, M.L. (1983b) An Archaeological survey for Aboriginal Sites along Gas Pipeline Laterals in the East Perth Metropolitan Area. Prepared for SECWA.

Schwede, M.L. (1984a) Archaeological Investigations along Gas Pipeline Laterals in the Perth Metropolitan Area – 1983 to 1984. Prepared for SECWA.

Schwede, M.L. (1984b) A Report on Archaeological Excavations on Bennett Brook Sites S1431 and S1940. Report to Dames and Moore.

Schwede, M.L. (1991) Quartz, the multifaceted stone. Unpublished PhD thesis, University of WA.

Strawbridge, L. (1988) Aboriginal Sites in the Perth Metroploitan Area : A Management Scheme. Prepared for the Centre for Prehistory, U.W.A.

Figure 1: Location Plan

Figure 2: Caversham Structure Plan Project Area

APPENDIX 1

OBLIGATIONS RELATING TO SITES UNDER THE ABORIGINAL HERITAGE ACT, 1972

Report of Findings

"15. Any person who has knowledge of the existence of anything in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual of ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any other place or thing to which this Act applies or to which this Act might reasonably be suspected to apply shall report its existence to the Registrar, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Registrar."

Excavation of Aboriginal Sites

"16. (1) Subject to Section 18, the right to excavate or to remove any thing from an Aboriginal site is reserved to the Registrar.

(2) The Registrar, on the advice of the Committee, may authorise the entry upon and excavating of an Aboriginal site and the examination or removal of any thing on or under the site in such manner and subject to such conditions as the Committee may advise."

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"17. A person who-

(a) Excavates, destroys, damages, conceals or in any way alters any Aboriginal site; or

(b) In any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site,

commits an offence unless he is acting with the authorisation of the Registrar under Section 16 or the consent of the Minister under Section 18."

Consent to Certain Uses

"18. (1) For the purposes of this section, the expression "the owner of any land" includes a lessee from the Crown, and the holder of any mining tenement or mining privilege, or of any right or privilege under the Petroleum Act, 1967, in relation to the land.

(2) Where the owner of any land gives to the Trustees notice in writing that he requires to use the land for a purpose which, unless the Minister gives his consent in this Section, would be likely to result in a breach of Section 17 in respect of any Aboriginal site that might be on the land, the Committee shall, as soon as they are reasonably able, form an opinion as to whether there is any Aboriginal site on the land, evaluate the importance and significance of any such site, and submit the notice to the Minister together with their recommendations in writing as to whether or not the Minister should consent to the use of the land for that purpose, and, where applicable, the extent to which and the conditions upon which his consent should be given.

(3) When the Committee submit a notice to the Minister under subsection (2) of this section he shall consider their recommendation and having regard to the general interest of the community shall either -

(a) Consent to the use of the land the subject of the notice, or a specified part of the land, for the purpose required, subject to such conditions, if any, as he may specify; or

(b) Wholly decline to consent to the use of the land the subject of the notice for the purpose required,

and shall forthwith inform the owner in writing of his decision.

(4) Where the owner of any land has given to the Committee notice pursuant to the subsection (2) of this section and the Committee have not submitted it with their recommendation to the Minister in accordance with that subsection the Minister may require the Committee to do so within a specified time, or may require the Trustees to take such other action as the Minister considers necessary in order to expedite the matter, and the Committee shall comply with any such requirement.

(5) Where the owner of any land is aggrieved by a decision of the Minister made under subsection (3) of this section he may, within the time and in the manner prescribed by the rules of court, appeal from the decision of the Minister to the Supreme Court which may hear and determine an appeal.

(6) In determining an appeal under subsection (5) of this section the Judge hearing the appeal may confirm or vary the decision of the Minister against which the appeal has been made or quash the decision of the Minister, and may make such order as to the costs of the appeal as he sees fit.

(7) Where the owner of the any land gives notice to the Committee under subsection (2) of this section, the Committee may if they are satisfied that it is practicable to do so, direct the removal of any object to which this Act applies from the land to a place of safe custody.

(8) Where consent has been given under this section to a person to use any land for a particular purpose nothing done by or on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitute an offence against the Act."

APPENDIX 2

Notes on the Recognition of Aboriginal Sites

There are various types of Aboriginal Sites, and these notes have been prepared as a guide to the recognition of those types likely to be located in the survey area.

An Aboriginal Site is defined in the Aboriginal Heritage Act, 1972, in Section 5 as:

"(a) Any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made for or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

(b) Any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

(c) Any place which, in the opinion of the Committee is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the state;

(d) Any place where objects to this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed."

Habitation Sites

These are commonly found throughout Western Australia and usually contain evidence of tool-making, seed grinding and other food processing, cooking, painting, engraving or numerous other activities. The archaeological evidence for some of these activities is discussed in details under the appropriate heading below.

Habitation sites are usually found near an existing or former water source such as a gnamma hole, rock pool, spring or soak. They are generally in the open, but they sometimes occur in shallow rock shelters or caves. It is particularly important that none of these sites be disturbed as the stratified deposits which may be found at such sites can yield valuable information about the inhabitants when excavated by archaeologists.

Seed Grinding

Polished or smoothed areas are sometimes noticed on/near horizontal rock surfaces. The smooth areas are usually 25cm wide and 40 or 50cm long. They are the result of seed grinding by the Aboriginal women and indicate aspects of past economy.

Habitation Structures

Aboriginal people sheltered in simple ephemeral structures, generally made of branches and sometimes of grass. These sites are rarely preserved for more than one occupation period. Occasionally rocks were pushed aside or used to stabilise other building materials. When these rocks patterns are located they provide evidence for former habitation sites.

Middens

When a localised source of shellfish and other foods has been exploited from a favoured camping place, the accumulated ashes, hearth stones, shells, bones and other refuse can form mounds at times several metres high and many metres in diameter. Occasionally these refuse mounds or middens contain stone, shell or bone tools. These are most common near the coast, but examples on inland lake and river banks are not unknown.

Stone Artefact Factory Sites

Pieces of rock from which artefacts could be made were often carried to camp sites or other places for final production. Such sites are usually easily recognisable because the manufacturing process produces quantities of flakes and waste material which are clearly out of context when compared with the surrounding rocks. All rocks found on the sandy coastal plain , for example, must have been transported by human agencies. These sites are widely distributed throughout the State.

Quarries

When outcrops of rock suitable for the manufacture of stone tools were quarried by the Aborigines, evidence of the flaking and chipping of the source material can usually be seen in situ and nearby. Ochre and other mineral pigments used in painting rock surfaces, artefacts and in body decoration are mined from naturally occurring seams, bands and other deposits. This activity can sometimes be recognised by the presence of wooden digging sticks or the marks made by these implements.

Marked Trees

Occasionally trees are located that have designs in the bark which have been incised by Aborigines. Toeholds, to assist the climber, were sometimes cut into the bark and sapwood of trees in the hollow limbs of which possums and other arboreal animals sheltered. Some tree trunks bear scars where section of bark or wood have been removed and which would have been used to make dishes, shield, spearthrowers and other wooden artefacts. In some parts of the state wooden platforms were built in trees to accommodate a corpse during complex rituals following death.

Burials

In the north of the state, it was formerly the custom to place the bones of the dead on a ledge in a cave after certain rituals were completed. The bones were wrapped in sheets of bark and the skull placed beside this. In other parts of Western Australia the dead were buried, the burial position varying according to the customs of the particular area and time. Natural erosion, or mechanical earthmoving equipment occasionally exposes these burial sites.

Stone Structures

If one or more stone are found partly buried or wedged into a position which is not likely to be the result of natural forces, then it is probable that the place is an Aboriginal site and that possibly there are other important sites nearby. There are several different types of stone arrangements ranging simple cairns or piles of stones to more elaborate designs.

Low weirs which detain fish when tides fall are found in coastal areas. Some rivers contain similar structures that trap fish against the current. It seems likely that low stone slab structures in the south west jarrah forests were built to provide suitable environments in which to trap some small animals. Low walls or pits were sometimes made to provide a hide or shelter for a hunter.

Elongated rock fragments are occasionally erected as a sign or warning that a special area is being approached. Heaps or alignments of stones may be naturalistic or symbolic representations of animals, people or mythological figures.

Paintings

These usually occur in rock shelters, caves or other sheltered situations which offer a certain degree of protection from the weather. The best known examples in Western Australia occur in the Kimberley region but paintings are also found through most of the states. One of several coloured ochres as well as other coloured pigments may have been used at a site. Stencilling was a common painting technique used throughout the state. The negative image of an object was created by spraying pigment over the object which was held against the wall.

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APPENDIX 3

SITE REGISTER LIST

Figure 1: Location Plan

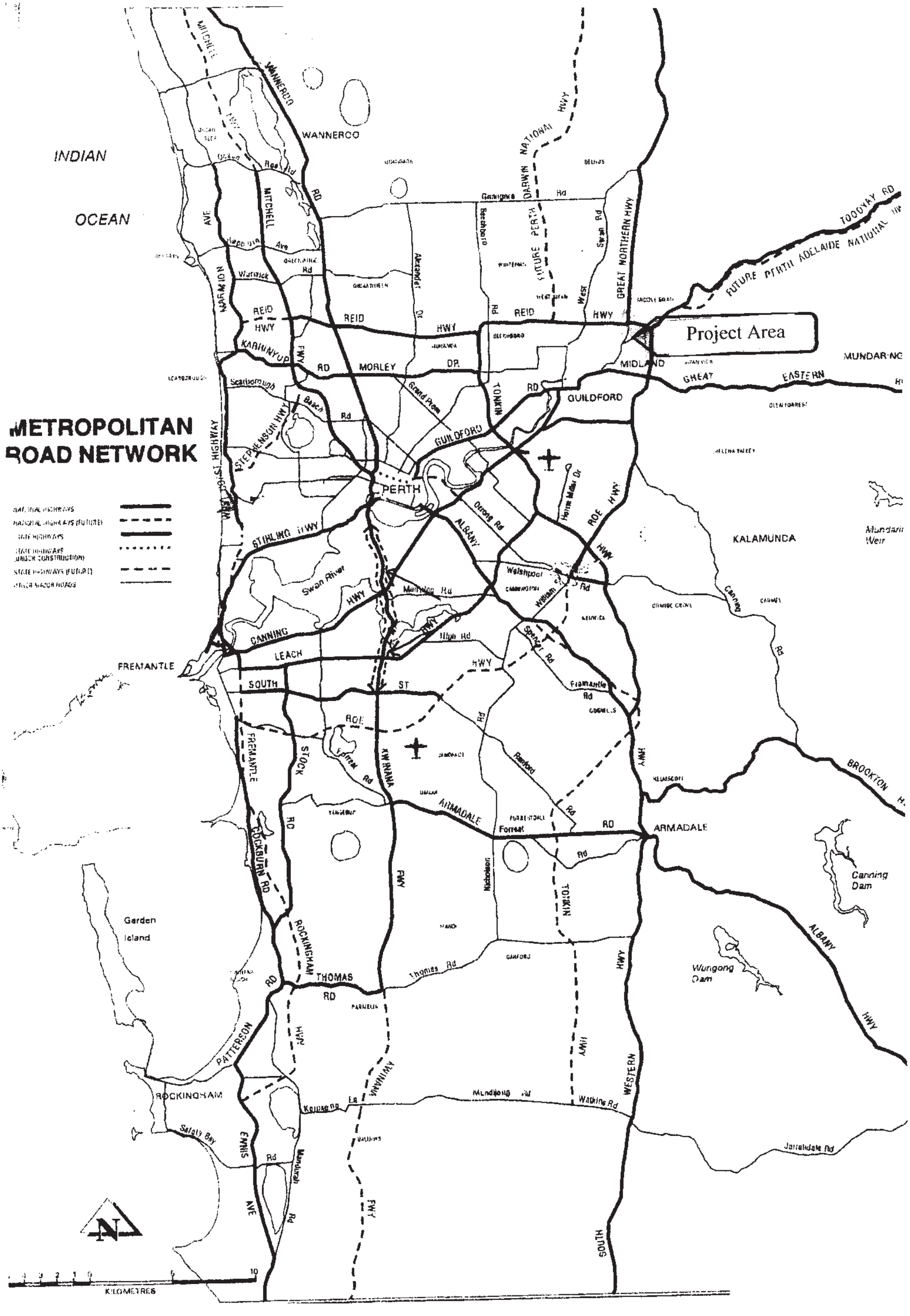
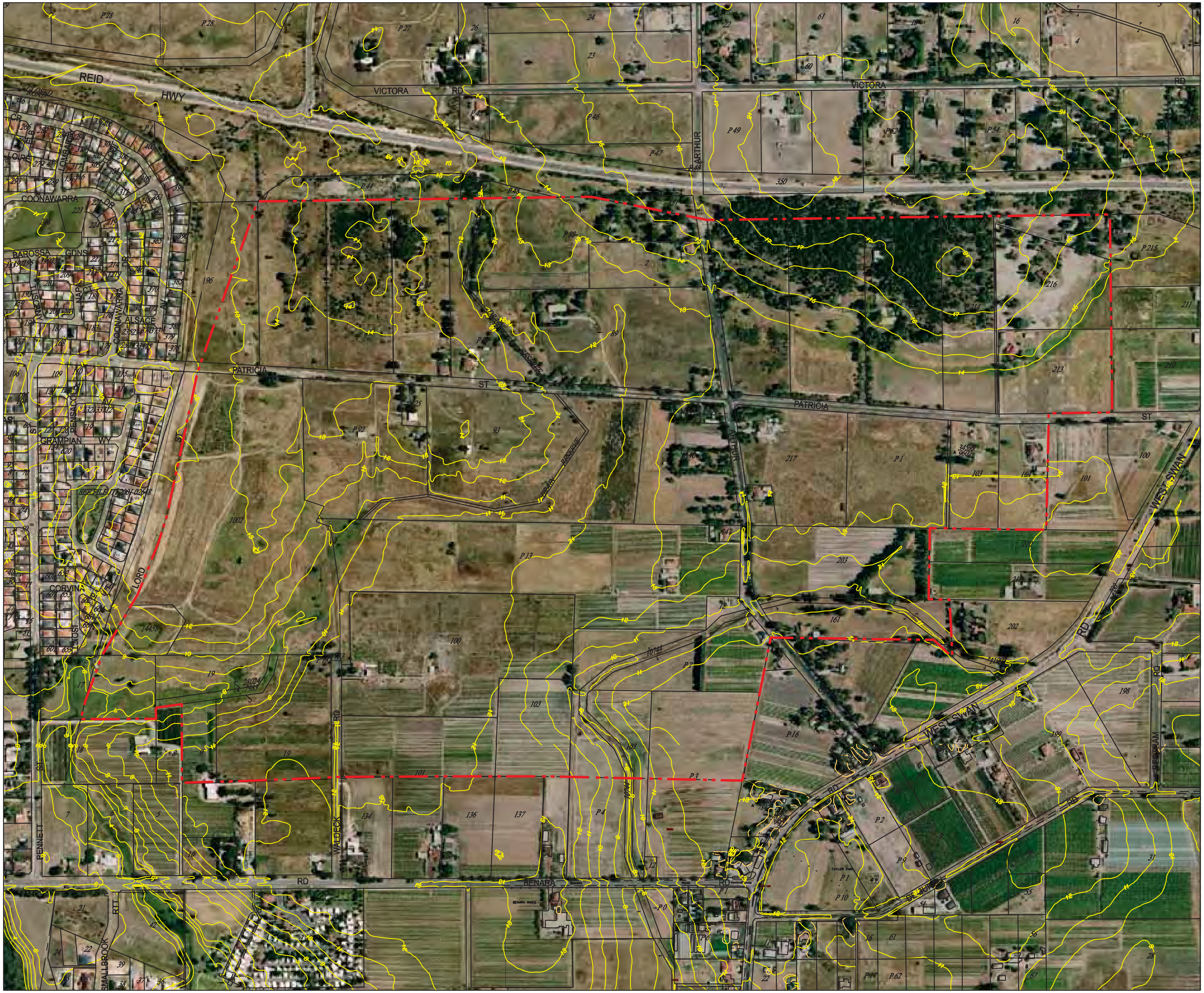


Figure 1 : Locality Plan

Figure 2: Caversham Structure Plan Project Area



CAVERSHAM STRUCTURE PLAN

AERIAL PLAN

L E G E N D

Subject Land

0 175 350m

MAIN LANDOWNER GROUP CAVERSHAM STRUCTURE PLAN	:	CLIENT
1:7,000	:	SCALE
21 OCTOBER 2005	:	DATE
2965-1-001	:	PLAN No
	:	REVISION
R. DIXON	:	PLANNER
N. PLEITER	:	DRAWN

Base data supplied by Department of Land Information Aerial Photography dated January 2002, accuracy +/- 4m, Projection MGA50

Areas and dimensions shown are subject to final survey calculations. All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

FIGURE 4

koltasz smith

TOWN PLANNERS · URBAN DESIGNERS
DEVELOPMENT CONSULTANTS · PROJECT MANAGERS

PERTH Tel. (08) 9486 2222 Email: perth@ksap.com.au

APPENDIX 1

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APPENDIX 3

SITE REGISTER LIST

Department of Indigenous Affairs
Government of Western Australia

REGISTER OF ABORIGINAL SITES

RPGSR
Reference No: 213165

Search Criteria

MGA Coordinates (Zone 50)
Easting: 401000 Northing: 6472000
Easting: 401000 Northing: 6474500
Easting: 405000 Northing: 6474500
Easting: 405000 Northing: 6472000

Disclaimer

Aboriginal sites exist that are not recorded on the Sites Register, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

Legend

Restriction	Status	Access
N No Restriction	I Interim Register	C Closed
M Male Access Only	P Permanent Register	O Open
F Female Access Only	S Stored Data	V Vulnerable

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting / Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Reliable – The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.
Unreliable – The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3227	S	O	N	BENNETT BROOK: STEPHENSON'S	Artefacts / Scatter			-31.8837 S / 115.9575 E, 401399mE 6471979mN Zone 50 [Reliable]	S00441
3489	P	C	N	BENNETT BROOK: LORD ST. 1	Ceremonial, Skeletal material/Burial			-31.8819 S / 115.9581 E, 401461mE 6472177mN Zone 50 [Reliable]	S02663
3521	S	O	N	BENNETT BROOK: BENNETT ST	Artefacts / Scatter			-31.8642 S / 115.9586 E, 401489mE 6474149mN Zone 50 [Reliable]	S02502
3536	P	O	N	SWAN RIVER	Mythological		*Registered Informant names available from DIA.	-31.9974 S / 116.6503 E, 466969mE 6459800mN Zone 50 [Reliable]	S02548

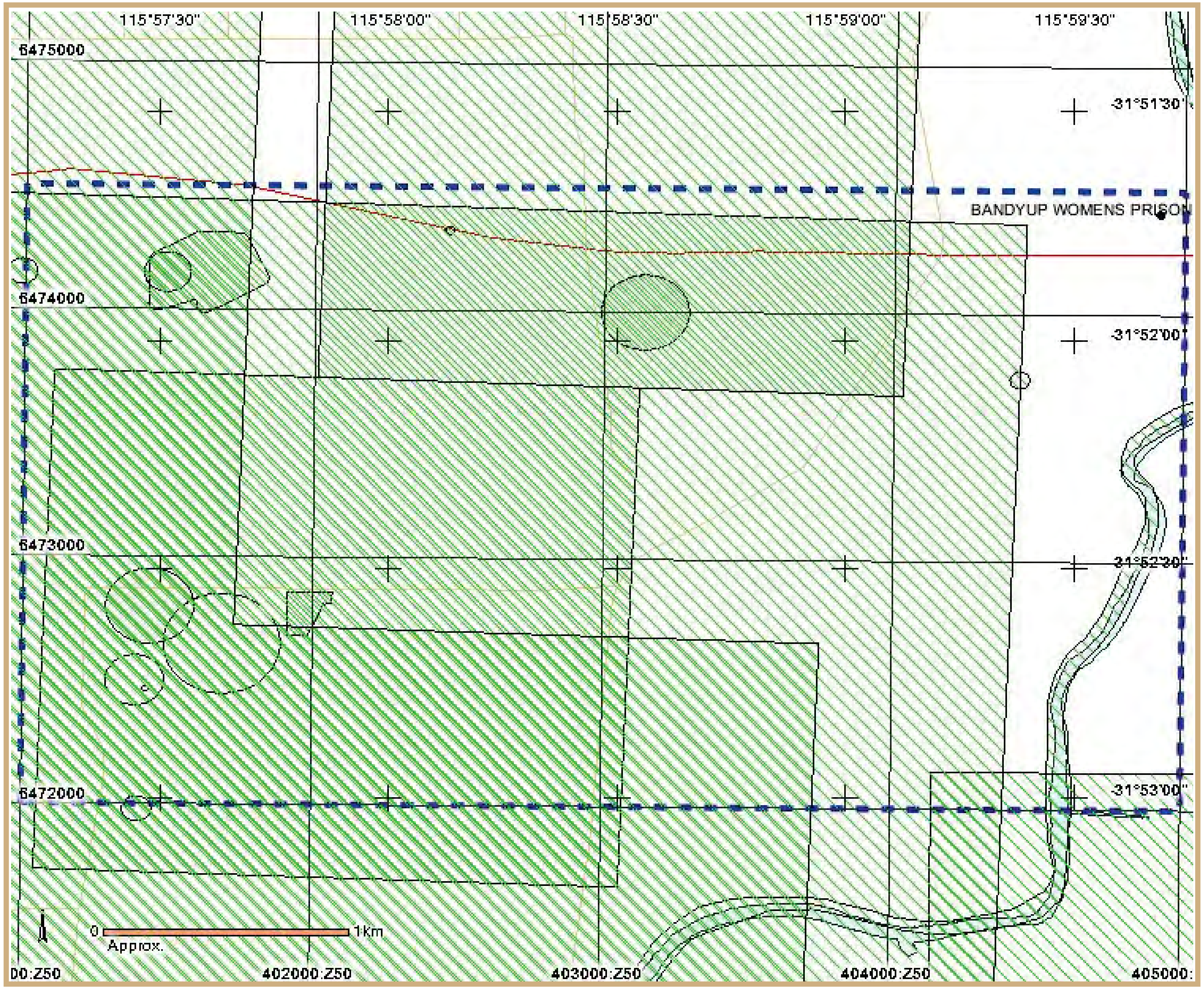
Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3611	I	O	N	ROES VINEYARD.		Camp	*Registered Informant names available from DIA.	-31.8681 S / 115.9897 E, 404433mE 6473735mN Zone 50 [Unreliable]	S02348
3692	P	C	N	BENNETT BROOK: in toto	Mythological		*Registered Informant names available from DIA.	-31.8587 S / 115.9432 E, 400020mE 6474744mN Zone 50 [Reliable]	S02254
3744	P	C	N	MARSHALLS PADDOCK	Skeletal material/Burial		*Registered Informant names available from DIA.	-31.8685 S / 115.9641 E, 402010mE 6473676mN Zone 50 [Unreliable]	S02194
3746	S	O	N	WEST SWAN ROAD CAMP (Moore's Camp)		Camp	*Registered Informant names available from DIA.	-31.8656 S / 115.976 E, 403139mE 6473999mN Zone 50 [Unreliable]	S02196
3795	I	O	N	WOODBRIDGE SHOWGROUND?.		Camp		-31.887 S / 115.9917 E, 404639mE 6471649mN Zone 50 [Unreliable]	S02134
3840	P	C	N	BENNETT BROOK: CAMP AREA.	Ceremonial, Mythological, Skeletal material/Burial, Man-Made Structure, Fish Trap, Artefacts / Scatter, Historical	Plant Resource, Camp, Hunting Place, Water Source	*Registered Informant names available from DIA.	-31.8819 S / 115.9581 E, 401461mE 6472177mN Zone 50 [Unreliable]	S01997
3879	P	O	N	BENNETT BROOK: BENARA RD 2	Artefacts / Scatter			-31.8763 S / 115.958 E, 401439mE 6472799mN Zone 50 [Reliable]	S01940

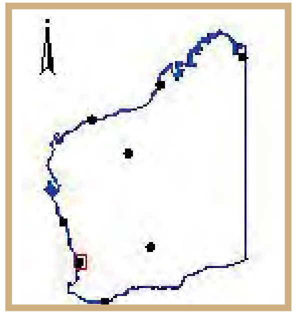
Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3907	S	O	N	LOT 1068	Artefacts / Scatter			-31.8641 S / 115.9533 E, 400989mE 6474149mN Zone 50 [Reliable]	S01819
3992	S	O	N	BENNETT BROOK: GRIMREY ROAD	Artefacts / Scatter			-31.879 S / 115.9574 E, 401389mE 6472499mN Zone 50 [Reliable]	S01426
3997	S	O	N	BENNETT BROOK: BENARA RD 1	Artefacts / Scatter			-31.8777 S / 115.9606 E, 401689mE 6472649mN Zone 50 [Reliable]	S01431
20030	I	O	N	Ancient Well		Water Source	*Registered Informant names available from DIA.	-31.8627 S / 115.9689 E, 402462mE 6474324mN Zone 50 [Reliable]	
21432	S	O	N	Marshall Pool Wetlands		Camp, Water Source	*Registered Informant names available from DIA.	-31.8642 S / 115.9601 E, 401632mE 6474148mN Zone 50 [Reliable]	
22134	I	O	N	Isolated Find Caversham	Artefacts / Scatter			-31.8793 S / 115.9578 E, 401425mE 6472466mN Zone 50 [Unreliable]	
22159	I	O	N	Little Creek / One Hundred Year Creek	Mythological	Camp	*Registered Informant names available from DIA.	-31.8766 S / 115.9638 E, 401988mE 6472770mN Zone 50 [Reliable]	

Department of Indigenous Affairs
Government of Western Australia

REGISTER OF ABORIGINAL SITES
SITE SEARCH MAP

WALIS





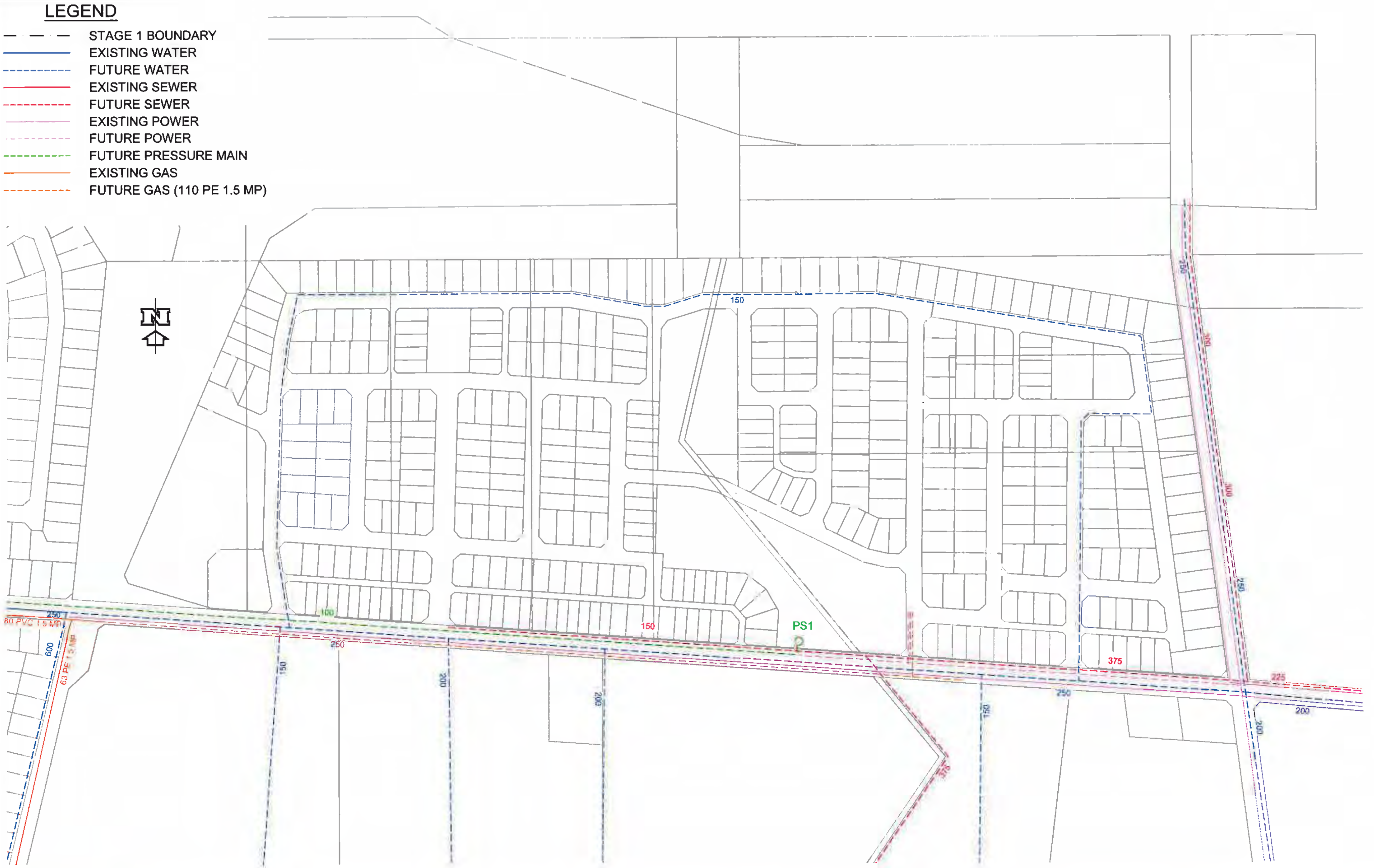
Legend

- Selected Site
- Town
- Map Area
- Search Area

18 Aboriginal Heritage Sites found in Polygon

MGA Coordinates (Zone 50)
Easting: 401000 Northing: 6472000
Easting: 401000 Northing: 6474500
Easting: 405000 Northing: 6474500
Easting: 405000 Northing: 6472000

1069-F001-0001.dwg



SUB REGIONAL PLAN
FOR THE SWAN URBAN GROWTH CORRIDOR

FIGURE: 1.1
REVISION: A

BROOKLEIGH ESTATE UWMP

QUBE CAVERSHAM DEVELOPMENT PTY LTD

SCALE: NTS
CO-ORDS: NA
DRWN: TS
CHKD: CL

EMERSON STEWART

Cad File: W:\Infrastructure\Infrastructure_Projects\1069_Caversham Subdivision - QUBE (ex 108067I)\08_CaddGis\Drawings\SERVICING FIGS\1069-F001-0001.dwg
Plotted By: brett.worley Plot Date: 09/09/09 - 10:22

EMERSON
IMPLEMENTEURS
STEWART

Nathan James
Qube Caversham Development Pty Ltd
168 Stirling Highway
NEDLANDS WA 6009

8 June 2009

Dear Nathan

CAVERSHAM NORTH - BROOKLEIGH ESTATE SERVICING REPORT

Further to your request Emerson Stewart provides the following general information regarding servicing the subdivision of Brookleigh Estate in Caversham North.

This report is prepared in support of the Early Land Release for Brookleigh Estate in Caversham North. It sets out the major infrastructure requirements for the estate. This includes:

- Sewer
- Water supply
- Stormwater Management
- Power
- Gas
- Communications

Sewer

The Water Corporation sewer planning indicates that a Regional Pump Station (Type 180) is required at Bennett Street and 5.5km of pressure main to Hollett Road to service the Swan Urban Growth Corridor.

However for the initial stages of 500 lots which include the Early Release for Brookleigh Estate, the following infrastructure will be required:

1. Temporary developer funded Type 40 pump station situated in the POS north of Patricia Street
2. Developer funded 1100m pressure main along Patricia Street to Bennett Street
3. 500m of DN375 gravity sewer along Patricia Street from the pump station to Arthur Street

Water supply

The Water Corporation water planning indicates that a prefunded DN600 Water Distribution Main from Altone Road is required to service the Swan Urban Growth Corridor. The DN600 water main will run from Altone Road, along Benara Road, Bennett Road and then northerly along Corvina Place, Carignan Avenue to Particia Street.

A DN250 reticulated water main is also required from the DN600 Water Distribution Main, along Patricia Street to Arthur Street to service Brookleigh Estate.

Stormwater Management

- All lots to install soakwells for the on-site retention and disposal of stormwater.
- 1 year 1 hour ARI flows will be retained and infiltrated in the bioretention areas which will be located adjacent to the Caversham North Central drain.
- The 5 year ARI flows are to be conveyed predominantly by a conventional pipe network along the road reserves. 5 year ARI flows will generally follow the same flow paths as the 100 year ARI events.
- The peak 5 year ARI flow rate through the 1200 x 450 mm box culvert crossing Patricia Street will be restricted to 0.37 m^3/s, in accordance to the DWMP predevelopment modelling (DoW 2009).
- The peak 100 year ARI flow rate through the 1200 x 450 mm box culvert crossing Patricia Street will be restricted to 1.21 m^3/s, in accordance to the DWMP predevelopment modelling (Dow 2009).
- Flood levels within the Brookleigh Estate will return to minimum levels within 24-48 hrs after the peak 5 year or 100 year ARI storm event.

Power

There are existing 22kV HV aerial power lines along Patricia Street and Arthur Street which is capable to service Brookleigh Estate.

According to Western Power the whole of Brookleigh Estate can be serviced by connecting into the 22kV line at the corner of Arthur Street and Patricia Street by a HV cable and a switchgear.

Gas

Currently there is a 110 PE medium pressure gas main at the corner of Carrignan Avenue and Patricia Street.

Westnet Energy have indicated the existing 110 PE MP gas main is capable to service the whole Brookleigh Estate. A developer funded extension of the gas main (about 800m) is required along Patricia Street.

Communications

There are existing telecommunication cables along Arthur Street and Patricia Street as well as Optic Fibre cables along Arthur Street. These existing cables are able to service Brookleigh Estate.

Testra and a few other service providers are able to service the estate with Fibre To The Home (FTTH) service. The funding for the provision of FTTH service will be provided by the developer.

If you have any queries or would like further information, please do not hesitate to contact the undersigned.

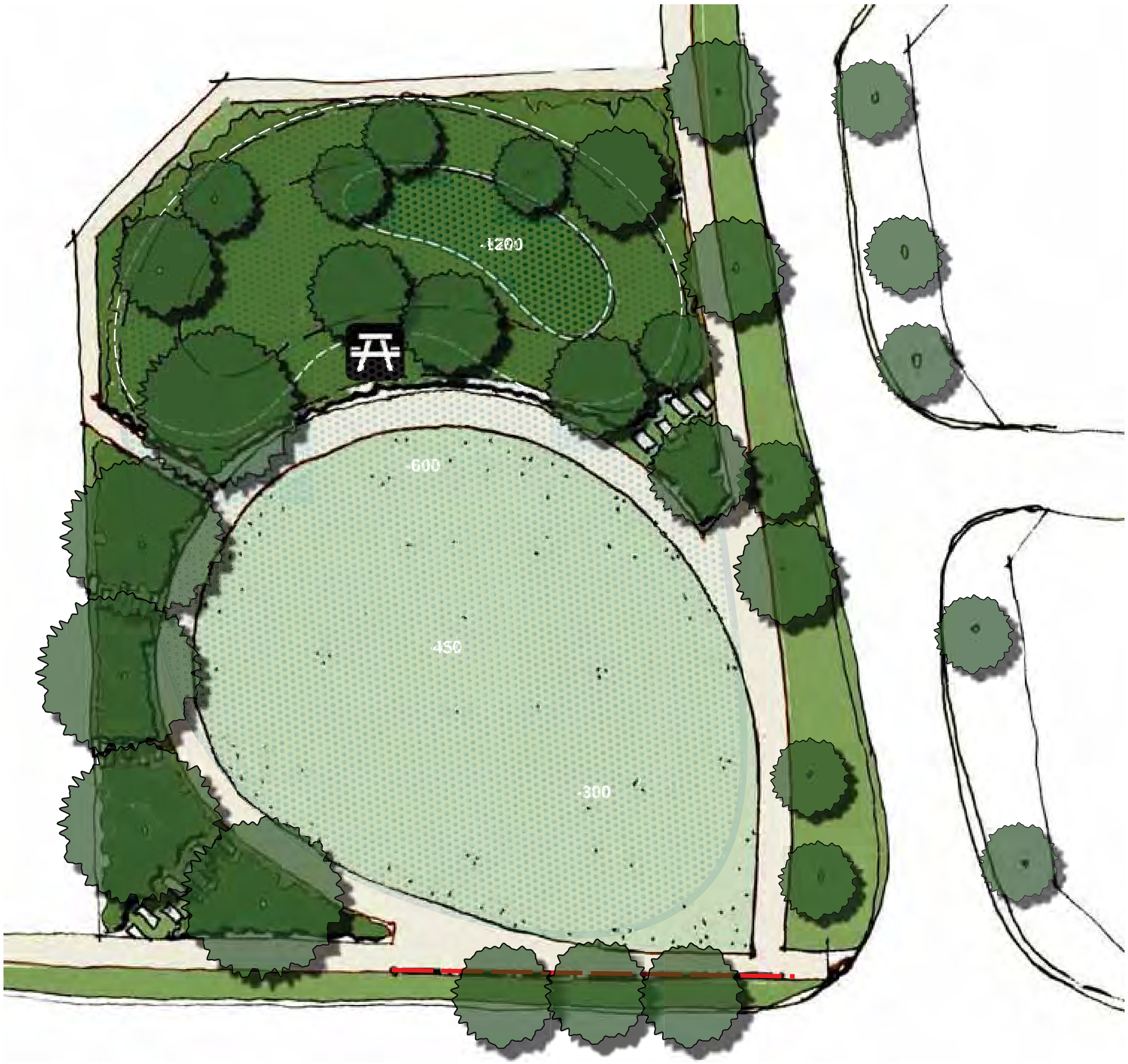
Yours sincerely

Onn Chan

PRINCIPAL ENGINEER

EMERSON STEWART

resources I infrastructure I energy
EMERSON STEWART PTY LTD
OLD SWAN BREWERY 110/171 MOUNTS BAY ROAD PERTH WESTERN AUSTRALIA 6000
T + 61 8 9424 9555 F +61 8 9485 1339 E MAIL@EMERSONSTEWART.COM ACN 115 673 231



LEGEND

- drainage sump (1:5 banks max)
- existing trees to be retained
- existing trees to be removed
- proposed trees
- concrete paving
- mass planting
- turf
- sand pit & play equipment
- stabilised gravel maintenance access
- water course
- decking
- feature screen

rev A
SK 22
SEPT 2009

Caversham North Land Development

Pocket Park South-west Concept

QUBE PROPERTY GROUP PTY LTD
Not to Scale. (This Plan is Diagrammatic Only)
Project No. 1911-07

ecoscape

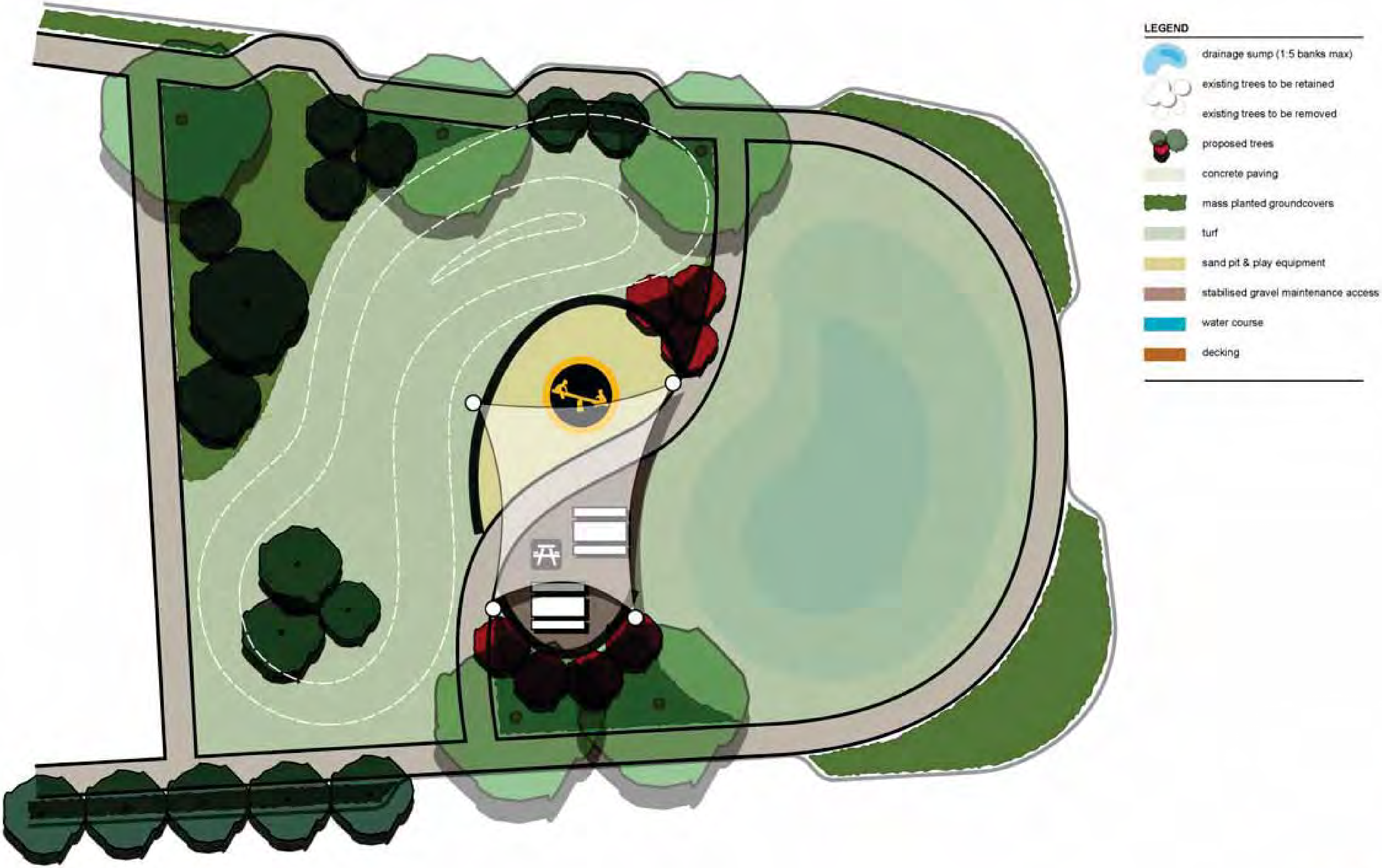
rev B
SK 21
NOV 2009

Caversham North Land Development

Stage 1A POS Concept

QUBE PROPERTY GROUP PTY LTD
Not to Scale.
Project No. 1911-07

ecoscape



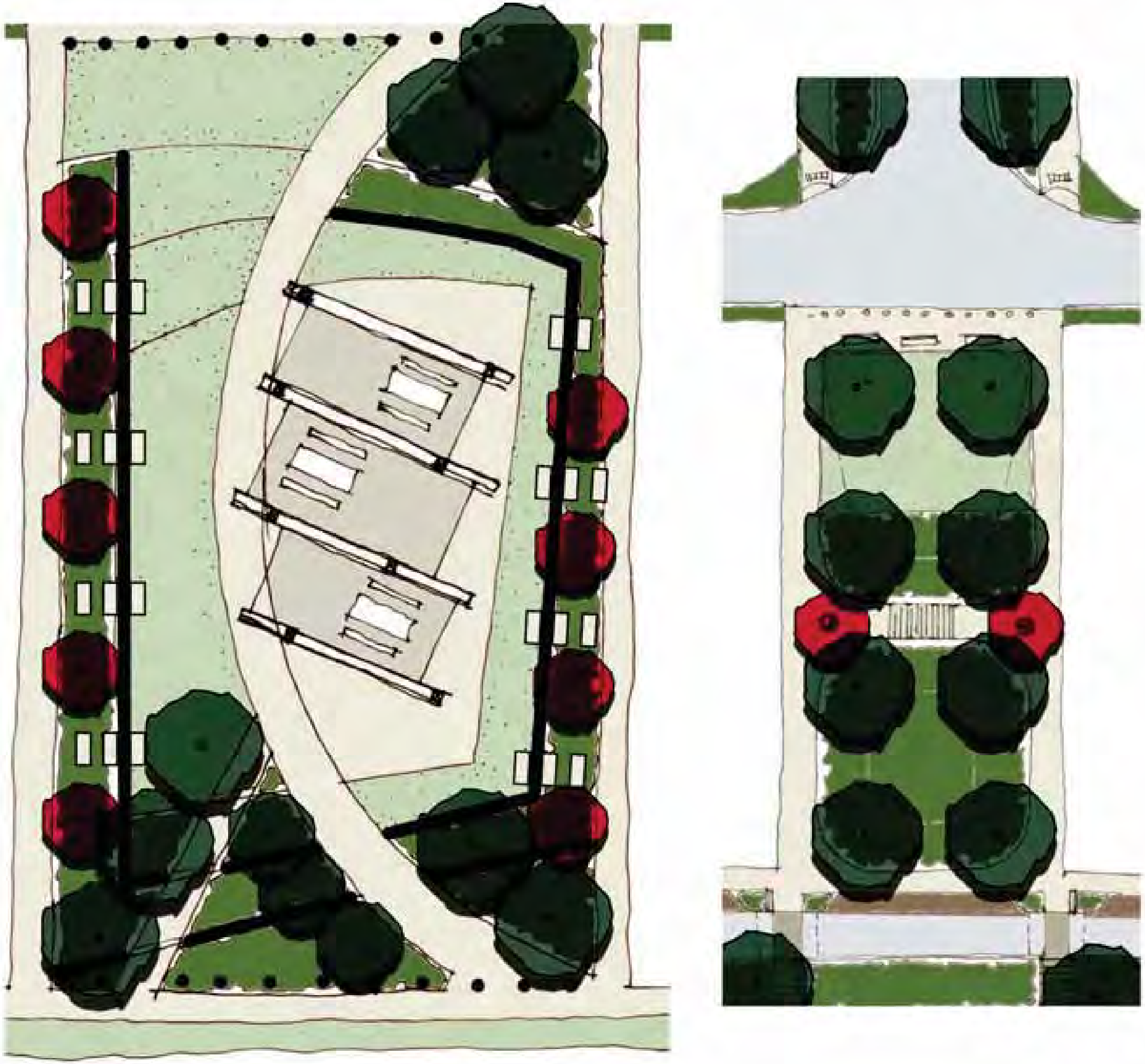
rev B
SK 19
NOV 2009

Caversham North Land Development

Neighbourhood Park Concept

QUBE PROPERTY GROUP PTY LTD
Not to Scale
Project No. 1911-07

ecoscape



LEGEND

- drainage sump (1:5 banks max)
- existing trees to be retained
- existing trees to be removed
- proposed trees
- concrete paving
- mass planting
- turf
- sand pit & play equipment
- stabilised gravel maintenance access
- water course
- decking
- feature timber screen

rev A
SK 20
SEPT 2009

Caversham North Land Development

Formal Park & PAW Concepts

QUBE PROPERTY GROUP PTY LTD
Not to Scale.
Project No. 1911-07

ecoscape

Caversham LSP Transport Statement

T08003

Prepared for Qube Property Group

February 2010

Brisbane Office
Level 11 Green Square Nth Tower
515 St Paul's Terrace
Locked Bag 4006 Fortitude Valley
Queensland 4006 Australia
Tel: (07) 3310 2401
Fax: (07) 3369 9722

Gold Coast Office
Level 2 Emerald Lakes Town Centre
1/3321 Central Place, Carrara
PO Box 391, Nerang
Queensland 4211 Australia
Tel: (07) 5502 1585
Fax: (07) 5502 1586

Sydney Office
910 Pacific Highway, Gordon
New South Wales 2072 Australia
Tel: (02) 9496 7700
Fax: (02) 9499 3902

Perth Office
2 Bagot Road, Subiaco
Western Australia 6008 Australia
PO Box 155 Subiaco WA 690
Tel: (08) 9273 3815
Fax: (08) 9388 3831

Caversham North Local Structure Plan Revised Transport Assessment

Prepared for QUBE Property Pty Ltd

February 2010

CONTENTS **PAGE NUMBER**

TABLES:

FIGURES:

APPENDICES:

Document Control T08003_100204_report_Revised Transport Assessment					
Version	**Date**	**Author**		**Reviewer**	
		Name	**Initials**	**Name**	**Initials**
4	February 2009	Jacob Martin		Ray Cook	

1.0 INTRODUCTION

Cardno Eppell Olsen has been commissioned by QUBE Property Group Pty Ltd to undertake an updated Revised Transport Assessment for the Caversham North Local Structure Plan, consistent with the requirements of both the City of Swan and the Western Australian Planning Commission. A Local Structure Plan (LSP) has been developed to guide the development of the Caversham North area, which is located in the north-west quadrant of the overall Caversham Structure Plan area, and is bounded by Lord Street to the west, Reid Highway to the north, Arthur Street to the east and Patricia Street and Western Corporate lands to the immediate south. Figure 1.1 shows the location of the proposed Caversham North Local Structure Plan cell with respect to the internal local and primary boundary road network and in the context of the overall Caversham Structure Plan area.

This revised report has been prepared following consultation with the City of Swan on 18 November 2009.

Figure 1.1 ***Caversham North Local Structure Plan - Location***

The proposed updated concept plan for the Caversham North Local Structure Plan area and overall Caversham Structure Plan area have been attached in Appendix A.

This Revised Transport Assessment is intended to supersede the Transport Review, prepared by Cardno and issued in December 2008, which outlined the results of a preliminary traffic assessment associated with the proposed road reservation and future function of Patricia Street in the context of a full build-out scenario within the LSP, based upon the previous concept plan. This assessment is also intended to inform the detailed traffic assessment for the overall Caversham Structure Plan Area, currently being undertaken by Transcore. The updated Caversham Structure Plan Traffic Report will address the wider impacts associated with overall structure plan-generated traffic upon the primary and secondary boundary road networks, in addition to outlining the specific triggers associated with the Lord Street and Arthur Street extension and a Developer Contributions Framework for the constituent land developers for these infrastructure upgrades.

The detailed Transport Assessment has been based upon subsequent discussions with City of Swan staff and other landowners within the overall Caversham Structure Plan cell. The following assumptions have been discussed and confirmed with the City of Swan as part of the updated assessment:

- *Stage 1: Interim Build-Out Scenario* - Development of the eastern half of the Caversham North Local Structure Plan cell (approximately 200 residential lots, as part of the Early Release Subdivision process) plus approximately 100 residential lots within the adjacent Western Corporate lands to the south; and
- *Stage 2: Ultimate Build-Out Scenario* – Complete build-out of the balance of the Caversham North Local Structure Plan cell plus build-out of the south-western, south-eastern and north-eastern quadrants within the overall Caversham Structure Plan area.

In order to fully assess the movement network impacts associated with both Stage 1 and Stage 2 development scenarios, the following road infrastructure scenarios have been considered as part of the transport assessment:

- *Scenarios 1a and 1b:* Existing boundary road network with and without completion of Patricia Street link west to Bennett Street, under Stage 1;
- *Scenario 2*: Lord Street extension, south of Reid Highway, linking Reid Highway with Benara Road plus direct access to Lord Street via Patricia Street at the western end of the Caversham North Local Structure Plan area, under Stage 2;
- *Scenario 3*: Arthur Street flyover connection across Reid Highway to connect Caversham Structure Plan and West Swan Structure Plan urban cells, under Stage 2; and
- *Scenario 4:* Coincident construction of both Lord Street extension and Arthur Street flyover, under Stage 2.

As part of this assessment, the following key tasks have been undertaken:

- Update of December 2008 Transport Review in order to accommodate the City of Swan's specific technical requirements, including updating the localised traffic assessment to reflect up-to-date local road traffic volumes. Including the undertaking of detailed intersection surveys at the intersections of Patricia Street/Bennett Street and Benara Road/Bennett Street;
- Review of the revised Caversham North Local Structure Plan with regard to internal road connections, traffic control measures and Local Area Traffic Management measures;
- Update of trip generation and distribution assumptions under both Stage 1 and Stage 2 developments scenarios, in the context of modification to proposed development scenarios on the Western Corporate lands to the south, minor changes to the proposed level and staging of development within the Caversham North Structure Plan Early Release Subdivision and changes to future boundary road network to include both the Arthur Street flyover and the extension of Lord Street. These updated assumptions will be consistent with the most recent traffic assessments undertaken by Transcore for the adjacent West Swan Structure Plan area and for the overall Caversham Structure Plan Area;
- Detailed internal and external Intersection assessment using SIDRA for both Stage 1 and Stage 2 development scenarios;
- Discussion of infrastructure development triggers for both Arthur Street and Lord Street extensions;
- Review of pedestrian and cycling infrastructure requirements associated with the Caversham North Local Structure Plan area, with a focus on linking into existing infrastructure, and reflecting the requirements of 'Safe Routes to Schools' guidelines in the context of the proposed primary school to be located south of Patricia Street;
- Review of proposed internal local road reservations and road hierarchies and preparation of relevant cross-sections, including justification for the proposed Patricia Street road reservation;
- Review of public transport requirements for both Stage 1 and Stage 2 development scenarios, to be consistent with overall Caversham Structure Plan Traffic Assessment, prepared by Transcore; and
- Preparation of a detailed report outlining the results of the transport assessment, suitable for submission to the City of Swan, Main Roads Western Australia (if required) and the WPAC which is consistent with the WAPC *Transport Assessment Guidelines for Structure Plans - Volume 2*.

2.0 REVIEW OF CAVERSHAM STRUCTURE PLAN TRANSPORT ASSESSMENT

The original transport assessment for the overall Caversham Structure Plan area was prepared by Sinclair Knight Merz (SKM) in 2006 on behalf of the Caversham Main Landowners Group. In late 2006, Transcore was retained by the Caversham Main Landowners Group to review this assessment following SKM's appointment to undertake work for the City of Swan in relation to the *Swan Urban Growth Corridor Management Strategy.*

The key findings from the Transcore review of the 2006 SKM study have been summarised as follows:

- Based upon *Liveable Neighbourhoods - Edition 3 Guidelines* (Department for Planning and Infrastructure, 2004), it was recommended that Patricia Street be classified as a *Neighbourhood Connector A* road. The recommended road reservation for Patricia Street in the vicinity of the Caversham North lands was 20 metres;
- While the SKM report recommended a 23 metre road reservation for Patricia Street, land uses abutting Patricia Street are now sufficiently refined in terms of access to and from the Caversham North Local Structure Plan lands as well as the general spatial location of non-residential uses abutting the south side of Patricia Street on the Western Corporate lands (i.e. POS, school, retail centre, etc.) that a 20 metre road reservation was deemed to be adequate;
- Proposed traffic control for the Patricia Street / Arthur Street intersection consists of Stop Control on the Arthur Street minor approaches to the intersection with Patricia Street. However, if construction of the Arthur Street flyover over Reid Highway is justified in the future, this interim level of traffic control may need to be upgraded to either a traffic signal or roundabout;
- Traffic modelling for the primary roads within the structure plan was undertaken as part of this updated transport assessment for the Caversham North Structure Plan. For the purpose of this modelling exercise, the overall Caversham Structure Plan area was divided up into 5 zones, with the modelling undertaken using data from the Main Roads Western Australia (MRWA) Regional Operations model;
- Specific details relating to the proposed community and neighbourhood centre uses were not documented and / or were not included as part of the modelling exercise undertaken by SKM;
- Discussions with strategic planners at both MRWA and DPI for the area indicated that the Arthur Street flyover was not required from a strategic perspective and was also unlikely to be constructed in the short-term; and
- If the flyover was not constructed in the short-term, Arthur Street south of Reid Highway could be downgraded from a District Distributor road to a Neighbourhood Connector.

The 2006 Caversham Structure Plan Transcore review has been attached in Appendix B.

Cardno met with the City of Swan in October 2008 to identify key issues which needed to be addressed in updated transport assessment for the Caversham North Local Structure Plan area and it was noted that while the Arthur Street connection may not be required from a regional perspective, it would likely be required to accommodate local traffic and inter-urban cell public transport services in the future. The Patricia Street cross-section has also since been amended in accordance with the City of Swan's requirements and was approved in principle in late 2008 by the City's Engineering Department. This cross-section and road function has been outlined in Section 6.5 of this report.

3.0 EXISTING SITUATION AND PROPOSED DEVELOPMENT

3.1 Existing Land Uses

The existing land uses operating in the proposed Caversham North cell consist primarily of rural residential housing, pastureland and vacant land. Adjacent land uses include a residential development to the west of the proposed Lord Street extension and additional rural residential and pastureland to the north, east and south. An aerial image of the existing site is shown in Figure 3.1.

Figure 3.1 Aerial View of Caversham North Local Structure Plan Cell

3.2 Road Network and Traffic Volumes

The existing boundary road network immediately adjacent to the Caversham North Local Structure Plan consists of Arthur Street to the east, Patricia Street to the south and Reid Highway to the north. Other major boundary roads serving the overall area include West Swan Road to the east, Benara Road to the south and Bennett Street to the west.

Arthur Street extends north from West Swan Road to Harrow Road, but is discontinuous on both sides of Reid Highway where it currently terminates in cul-de-sac on both the north and south sides. Arthur Street currently has an unmarked rural road cross-section, with an 8 m seal.

Patricia Street extends west from West Swan Road and terminates at a cul-de-sac near the proposed western boundary of the Caversham Structure Plan area immediately east of the Lord Street extension road reservation. Patricia Street currently has an unmarked rural cross-section, with approximately a 6m seal.

The intersection of Arthur Street and Patricia Street is unsignalised and is controlled by Give Way control. Both of these roads provide direct access to existing rural properties in the area.

Existing daily traffic volumes (AADT) for the major roads in the vicinity of the site have been collected by Transcore as part of the updated assessment for the overall Caversham Structure Plan and confirmed by Cardno with MRWA and the City of Swan and include the following:

- Reid Highway west of West Swan Road 26,650vpd (2007)
- West Swan Road north of Benara Road 11,100vpd (2001)
- Benara Road west of West Swan Road 8,600vpd (2004)

In addition, a series of detailed traffic movement surveys were undertaken on Thursday 4 September 2009 at the intersections of Patricia Street/Bennett Street and Benara Road/Bennett Street to establish the existing levels of local background traffic during the PM roadway peak period (4:30pm-6:00pm). The results of these surveys are discussed in Section 4.0 of this report.

3.3 Proposed Caversham North Local Structure Plan

The Caversham North Local Structure Plan cell consists of a proposed residential precinct to consist of approximately 400 residential lots within the north-western quadrant of the overall Caversham Structure Plan area, and bounded by Arthur Street to the east and Patricia Street to the south. Approximately 50 percent of these lots are proposed in the context of an Early Release Subdivision and are located mainly within the eastern half of the local structure plan area.

Proposed residential development within the Caversham North Structure Plan area are proposed to consist of primarily R15 to R30 low density residential housing with a small proportion of R50 group housing to be located proposed at the south-west corner, near the intersection of Patricia Street and the Lord Street extension. The proposed breakdown of residential is outlined as follows:

- R15-R30 Residential 393 lots @ 19.74ha
- R50 Residential 55 du @ 0.99ha

Other land uses, including commercial, retail and service uses as well as a primary school use are proposed to be located within other cells of the overall Caversham Structure Plan area. This includes a Neighbourhood Centre and Primary School to be located directly to the south of Patricia Street within the Western Corporate lands. The resultant impacts of internal trip generation associated with staged development within the Western Corporate lands have been accounted for in the analysis of both the Stage 1 and Stage 2 development scenarios

Appendix A contains the proposed development plan fro the Caversham North Local Structure Plan cell, including the Early Release Subdivision, and the most recent overall Caversham Structure Plan.

3.4 Development Staging

The Caversham North Local Structure Plan is proposed to be developed over several stages, as outlined in Section 1 of this report. In Stage 1, development of approximately 200 dwelling units within the eastern half of the cell is proposed, with full connection of Patricia Street to both Arthur Street and Bennett Street. It has also been assumed that as part of the Stage 1 development scenario of the overall structure plan build-out that approximately 100 residential lots will be constructed within the Western Corporate lands immediately to the south of the Caversham North Structure Plan area.

Stage 2 will consist of the build-out of the remaining proposed uses within the overall Caversham Structure Plan area, including the balance of residential lots within the Caversham North Local Structure Plan area, and the balance of residential, retail and commercial uses within the north-east, south-east and south-west quadrants.

3.5 Road Network Staging

Following negotiations with the City of Swan, the upgrade of roads and intersections will be conducted as follows:

- Patricia Street will be initially upgraded from Arthur Street west to Road E, as designated in this report, to accommodate traffic associated with construction and Stage 1 residential demand for the Early Release Area.
- At the commencement of development outside the Early Release Area (106 lots) Patricia Street is to be upgraded to a rural standard from the intersection of Patricia Street and Arthur Street through to West Swan Road, with a carriageway width of 7.4 metres. This upgrade can only be viewed as an interim solution, for which an offset would only be appropriate under the proposed Development Contribution Plan if the extant works are able to form part of the final road treatment. The trigger for upgrading Patricia St to urban standard, between Arthur St and West Swan Road, will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the ultimate Patricia Street upgrade and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

- The intersections of West Swan Road with Arthur Street and Patricia Street will (including lighting to the Australian standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the Early Release Area. The trigger for construction of the ultimate arrangement at these intersections will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the West Swan Road/Arthur Street and West Swan Road/Patricia Street intersections and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
- Completion of Patricia St west of Arthur Street to connect to the roundabout intersection with Bennett Street will be constructed before or at subdivision clearance of deposited plan that generates the 250th lot (unit of equivalent demand). This will be constructed to a boulevard treatment as shown in Figure 6.1 to the western boundary of the Caversham DCA. Landowners will be required to contribute to the Patricia Street extension and its intersection treatment proposed with Lord Street to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
- Although the Caversham North Structure Plan area contributes to the need for Lord Street between the Reid Highway and Benara Road, the development itself is not of sufficient size to warrant construction. The trigger for construction will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the Lord Street extension and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

4.0 TRAFFIC OPERATIONS ASSESSMENT

4.1 Traffic Modelling Assumptions

As part of the undertaking of a brief Transport Review undertaken in December 2008 to address the future road reservation and cross-section requirements for Patricia Street in the context of development within the Caversham North Structure Plan cell, a desktop modelling exercise was undertaken to forecast anticipated daily traffic volumes on Patricia Street and peak hour turning volumes at all intersections along this road, between Lord Street and Arthur Street. An outline of the modelling approach which has been used as a basis for the updated Transport Assessment is discussed briefly below:

- The SKM Zones were disaggregated into 16 more detailed zones in order to allow for a more accurate traffic forecast for Patricia Street in the future. Internal to external traffic generation and distribution was then estimated for these new zones, both on a daily basis and for the AM and PM peak hour periods;
- An estimation of school and neighbourhood centre generated traffic, within the cell south of Patricia Street, was undertaken using information contained within the Transcore *Caversham Structure Plan Traffic Study* (November 2008). This traffic was then distributed based upon the number of lots per internal zone;
- Several staged development scenarios have been assessed in the context of the Caversham North Local Structure Plan cell and which have been discussed in detail in Section 1.0 of this report. Each of these development scenarios has been disaggregated into sub-scenarios in order to address a variety of road infrastructure scenarios. The Stage 1 development scenario has been assessment with and without Lord Street extension, and the Stage 2 development scenario with the Lord Street extension and with and without the Arthur Street flyover;
- Each of the development and infrastructure scenarios was then considered in the development of three origin-destination matrices (Daily, AM Peak Hour and PM Peak Hour). These matrices were then assigned to a desktop model for the local structure plan area;
- Detailed traffic volumes were assigned to the boundary road intersections of West Swan Road / Patricia Street, West Swan Road / Arthur Street, Patricia Street / Bennett Street and Benara Road / Bennett Street intersections in order to assess these locations under AM and PM weekday peak hour conditions;
- The land uses south of Patricia Street and west of Arthur Street have been assumed to be broadly consistent with those outlined in the updated Caversham Structure Plan;
- Daily, AM and PM Peak Hour turning volumes for each of the development scenarios has been presented in Appendix C;
- Internal two-way daily volumes have also been estimated, based upon the outcomes of the traffic modelling exercise, and have been shown in Figure 4.1.

4.2 Desktop Modelling

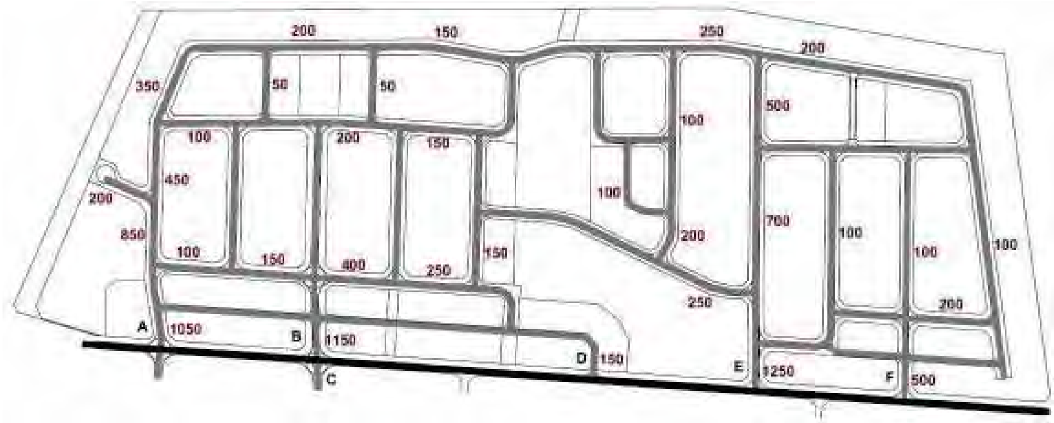
Trip generation for the proposed Caversham North Local Structure Plan area has been based upon Institute of Transportation Engineers (ITE) *Trip Generation 7th Edition (2003)* trip generation rates. These trip generation rates tend to be conservative, as they have been based upon high levels of private vehicle mode share. It is therefore assumed that the application of these rates to the study area is appropriate and would represent the 'worst case' scenario. Trip generation rates used for the desktop assessment are outlined in Table 4.1.

Table 4.1 Desktop Trip Generation Rates

Residential	Trip Generation Rate	In	Volume In	Out	Volume Out	Total
Daily	9.57/dwelling	50%	2,048	50%	2,048	4,096
AM Peak	0.75/dwelling	26%	105	74%	300	405
PM Peak	1.01/dwelling	64%	349	36%	196	545

Figure 4.1 shows the daily traffic volumes assigned to the internal road network. This assignment model forms the basis for the internal road network hierarchy and in turn informs proposed cross-section designs.

Figure 4.1 Anticipated Stage 2 (Ultimate) Daily (AADT) Traffic Volumes



In order to assign the abovenoted internal daily traffic volumes to Patricia Street, inputs from the Transcore *Caversham Structure Plan Traffic Study* (November 2008) were used, which have been sourced directly from the MRWA ROM model. The estimated trip distribution and assignment patterns for the development-generated traffic was derived from the model assumptions for the Stage 2 development scenario, which has been assumed to include both the Lord Street extension and the Arthur Street flyover under a 2031 horizon year and ultimate build-out of the overall Caversham Structure Plan area. Trip distribution assumed for the purposes of this assessment is outlined as follows:

- Reid Highway West 10%
- Benara Road West 8%
- Lord Street South 31%
- West Swan Road South 19%
- Reid Highway East 16%
- West Swan Road North 8%
- Perth-Darwin Highway North 8%

For the interim Stage 1 development scenario, however, trip distribution has been based upon a combination of the attractiveness of upgrades to the local established road system, with and without the extension of Patricia Street west to Bennett Street, Arthur Street and West Swan Road, spatial distribution of existing land uses and existing travel patterns in the area.

Traffic turning movement diagrams resulting from this desktop assessment have been are included in Appendix C for each of the development scenarios.

It should be noted that background traffic for the area has been derived from the daily traffic volumes outlined in the 2008 Transcore study for the overall structure plan area, which includes approximately 1,200 vehicles per day using Patricia Street as an alternative road connection between Altone Ward and West Swan Road under Stage 2.

4.3 SIDRA Intersection Assessment

Detailed intersection analysis was undertaken using the SIDRA intersection analysis program for each of the local intersections on Patricia Street for Stage 2 only and for the key external boundary road intersections under both Stage 1 and Stage 2 development scenarios. SIDRA is a commonly used intersection-modelling tool by traffic engineers for all types of intersections, and was originally designed by Austroads. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95th Percentile Queue. These characteristics are defined as follows:

- Degree of Saturation (DOS): is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for varied traffic flow up to one for saturated flow or capacity;
- Level of Service (LOS): is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of services, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow);
- Average Delay: is the average of all travel time delays for vehicles through the intersection; and
- 95th Percentile Queue: is the queue length below which 95% of all observed queue lengths fall.

4.3.1 Local Intersections

A SIDRA analysis for each of the local intersections along Patricia Street was undertaken for Stage 2 ultimate build-out of the overall Caversham Structure Plan area, based upon a 2031 horizon year. This analysis includes consideration of both the Arthur Street flyover and the Lord Street extension. Additional through traffic volumes as modelled in the MRWA ROM have been considered as part of this assessment, as indicated in Section 4.3.

Local intersections proposed between the internal road network and Patricia Street includes, from west to east, the following:

- 4-way roundabout intersection with Road A;
- 4-way roundabout intersection with Road B and Road C;
- 3-way stop-controlled intersection with Road D;
- 3-way stop-controlled intersection with Road E; and
- 3-way stop-controlled intersection with Road F.

Results of SIDRA analysis for intersections along Patricia Street shown in Table 4.2 through to Table 4.6 indicate that all local intersections along Patricia Street connecting with local roads within the Caversham North Structure Plan area are anticipated to operate at acceptable Levels of Service, with minimal delays and queuing, during the weekday roadway peak periods, under the Stage 2 ultimate build-out scenario.

Table 4.2 ***SIDRA Results for Patricia Street/Road A***

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – AM Peak Hour	**Road A South**	L	0.02	8.6	LOS A	1
		T	0.02	6.7	LOS A	1
		R	0.02	12.7	LOS B	1
	Patricia St East	L	0.20	5.5	LOS A	9
		T	0.21	5.4	LOS A	9
		R	0.21	11.4	LOS B	9
	Road A North	L	0.05	5.9	LOS A	2
		T	0.05	5.0	LOS A	2
		R	0.05	11.8	LOS B	2
	Patricia St West	L	0.12	5.3	LOS A	5
		T	0.12	4.4	LOS A	5
		R	0.12	11.2	LOS B	5
	Total		**0.21**	**5.7**		**9**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – PM Peak Hour	**Road A South**	L	0.02	8.3	LOS A	1
		T	0.02	6.4	LOS A	1
		R	0.02	12.5	LOS B	1
	Patricia St East	L	0.18	5.5	LOS A	8
		T	0.18	5.3	LOS A	8
		R	0.18	11.3	LOS B	8
	Road A North	L	0.04	6.5	LOS A	1
		T	0.04	5.6	LOS A	1
		R	0.04	12.4	LOS B	1
	Patricia St West	L	0.25	5.5	LOS A	11
		T	0.25	4.4	LOS A	11
		R	0.25	11.8	LOS B	11
	Total		**0.25**	**5.8**		**11**

Table 4.3 ***SIDRA Results for Patricia Street/Road B/Road C***

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – AM Peak Hour	**Road B South**	L	0.12	8.0	LOS A	6
		T	0.12	6.2	LOS A	6
		R	0.12	12.2	LOS B	6
	Patricia St East	L	0.14	5.6	LOS A	5
		T	0.14	5.4	LOS A	5
		R	0.14	11.5	LOS B	5
	Road C North	L	0.07	6.0	LOS A	3
		T	0.07	5.1	LOS A	3
		R	0.07	11.9	LOS B	3
	Patricia St West	L	0.13	5.5	LOS A	5
		T	0.13	4.5	LOS A	5
		R	0.13	11.4	LOS B	5
	Total		**0.14**	**6.0**		**6**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – PM Peak Hour	**Road B South**	L	0.09	8.2	LOS A	4
		T	0.09	6.3	LOS A	4
		R	0.09	12.4	LOS B	4
	Patricia St East	L	0.20	5.9	LOS A	8
		T	0.20	5.7	LOS A	8
		R	0.20	11.7	LOS B	8
	Road C North	L	0.05	6.5	LOS A	2
		T	0.05	5.5	LOS A	2
		R	0.05	12.3	LOS B	2
	Patricia St West	L	0.24	5.6	LOS A	10
		T	0.24	4.7	LOS A	10
		R	0.24	11.5	LOS B	10
	Total		**0.24**	**7.3**		**10**

Table 4.4 *SIDRA Results for Patricia Street/Road D*

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – AM Peak Hour	**Patricia St East**	T	0.08	0.8	LOS A	5
		R	0.08	9.2	LOS A	5
	Road D North	L	0.00	8.2	LOS A	0
		R	0.00	8.4	LOS A	0
	Patricia St West	L	0.10	8.2	LOS A	0
		T	0.10	0.0	LOS A	0
	Total		**0.10**	**0.6**		**5**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – PM Peak Hour	**Patricia St East**	T	0.12	0.9	LOS A	8
		R	0.12	9.3	LOS A	8
	Road D North	L	0.00	8.2	LOS A	0
		R	0.00	8.4	LOS A	0
	Patricia St West	L	0.10	8.2	LOS A	0
		T	0.10	0.0	LOS A	0
	Total		**0.12**	**0.7**		**8**

Table 4.5 ***SIDRA Results for Patricia Street/Road E***

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – AM Peak Hour	**Patricia St East**	T	0.07	0.7	LOS A	4
		R	0.07	9.2	LOS A	4
	Road E North	L	0.04	8.2	LOS A	0
		R	0.04	8.4	LOS A	0
	Patricia St West	L	0.10	8.2	LOS A	0
		T	0.10	0.0	LOS A	0
	Total		**0.10**	**0.7**		**4**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – PM Peak Hour	**Patricia St East**	T	0.14	0.7	LOS A	8
		R	0.14	9.2	LOS A	8
	Road E North	L	0.00	8.2	LOS A	0
		R	0.00	8.4	LOS A	0
	Patricia St West	L	0.10	8.2	LOS A	0
		T	0.10	0.0	LOS A	0
	Total		**0.14**	**2.4**		**8**

Table 4.6 *SIDRA Results for Patricia Street/Road F*

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – AM Peak Hour	Patricia St East	T	0.05	1.1	LOS A	3
		R	0.05	9.5	LOS A	3
	Road F North	L	0.02	8.2	LOS A	0
		R	0.02	8.4	LOS A	0
	Patricia St West	L	0.14	8.2	LOS A	0
		T	0.14	0.0	LOS A	0
	Total		**0.14**	**1.2**		**3**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 – Ultimate Build-Out of Caversham Structure Plan Area – PM Peak Hour	Patricia St East	T	0.15	0.8	LOS A	9
		R	0.15	9.3	LOS A	9
	Road F North	L	0.01	8.2	LOS A	0
		R	0.01	8.4	LOS A	0
	Patricia St West	L	0.10	8.2	LOS A	0
		T	0.10	0.0	LOS A	0
	Total		**0.15**	**1.4**		**9**

4.3.2 External Intersections

The traffic impacts associated with each of the Stage 1 and Stage 2 development scenarios upon the external road network has been modelled under each of the respective road infrastructure scenarios outlined below:

- Stage 1: With Lord Street extension;
- Stage 1: Without Lord Street extension;
- Stage 2: With Lord Street extension;
- Stage 2: With Arthur Street flyover; and
- Stage 2: With both Lord Street extension and Arthur Street flyover.

A detailed SIDRA assessment has been undertaken for the Bennett Street intersections at both Patricia Street and Benara Road for each of the Stage 1 and 2 development scenarios volumes (prior to construction of the Lord Street extension) to evaluate the potential impact of additional traffic on the roundabout intersections of Patricia Street/Bennett Street and Benara Road/Bennett Street.

The existing operation of these intersections, consistent with observations on 4 September 2009, is shown in Table 4.7 and Table 4.8.

Table 4.7 SIDRA Results for Patricia Street/Bennett Street – Existing Scenario

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Existing Scenario - AM Peak Hour	Patricia St East	L	0.03	7.2	LOS A	1
		R	0.03	11.1	LOS B	1
	Bennett St South	L	0.06	5.5	LOS A	2
		T	0.06	5.4	LOS A	2
	Patricia St West	T	0.03	4.4	LOS A	1
		R	0.03	11.3	LOS B	1
	Total		**0.06**	**8.0**		**2**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Existing Scenario - PM Peak Hour	Patricia St East	L	0.09	7.2	LOS A	4
		R	0.09	11.1	LOS B	4
	Bennett St South	L	0.04	5.4	LOS A	1
		T	0.04	5.4	LOS A	1
	Patricia St West	T	0.02	4.7	LOS A	1
		R	0.02	11.5	LOS B	1
	Total		**0.09**	**8.7**		**4**

The Patricia Street/Bennett Street intersection operates at acceptable Levels of Service during the weekday roadway peak periods, with minimal vehicular queuing and delays. This roundabout intersection currently services only a limited existing residential catchment of approximately 250 dwellings.

Table 4.8 SIDRA Results for Benara Road/Bennett Street – Existing Scenario

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Existing Scenario - AM Peak Hour	**Benara Rd East**	T	0.33	7.5	LOS A	19
		R	0.33	12.4	LOS B	19
	Bennett St North	L	0.22	6.9	LOS A	9
		R	0.22	12.7	LOS B	9
	Benara Rd West	L	0.28	5.4	LOS A	13
		T	0.28	4.5	LOS A	13
	Total		**0.33**	**7.4**		**19**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Existing Scenario - PM Peak Hour	**Benara Rd East**	T	0.41	7.1	LOS A	27
		R	0.42	12.0	LOS B	27
	Bennett St North	L	0.16	7.4	LOS A	7
		R	0.16	13.1	LOS A	7
	Benara Rd West	L	0.47	5.6	LOS A	28
		T	0.47	4.6	LOS B	28
	Total		**0.47**	**6.8**		**28**

The Benara Road/Bennett Street intersection currently operates at approximately 50% of practical capacity during the roadway weekday PM peak period, with minimal vehicular delays and queuing. Benara Road functions as a parallel alternate east-west reliever route to Reid Highway between Mirrabooka Avenue and West Swan Road.

The results of SIDRA assessment for the initial stage with 2010 background traffic base volumes, assuming the full completion of the Patricia Street link to Bennett Street and in the absence of the Lord Street extension is shown in Table 4.9 and Table 4.10.

Table 4.9 SIDRA Results for Patricia Street/Bennett Street – Stage 1: Scenario 1a

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Scenario 1a Interim Development AM Peak Hour	**Patricia St East**	L	0.06	7.2	LOS A	3
		R	0.06	11.2	LOS B	3
	Bennett St South	L	0.12	5.4	LOS A	5
		T	0.12	5.4	LOS A	5
	Patricia St West	T	0.04	4.6	LOS A	1
		R	0.04	11.5	LOS B	1
	Total		**0.12**	**7.5**		**5**
Scenario 1a Interim Development PM Peak Hour	**Patricia St East**	L	0.15	7.2	LOS A	8
		R	0.15	11.2	LOS B	8
	Bennett St South	L	0.10	5.4	LOS A	4
		T	0.10	5.3	LOS A	4
	Patricia St West	T	0.03	5.1	LOS A	1
		R	0.03	11.9	LOS B	1
	Total		**0.15**	**8.4**		**8**

With the very low levels of background traffic in the 2010 interim horizon year, these results show that the anticipated increase in traffic volumes as a result of Stage 1 development will have a minimal impact on the peak hour operations of the existing Patricia Street/Bennett Street roundabout and on the existing practical capacity of Bennett Street.

Table 4.10 SIDRA Results for Benara Road/Bennett Street – Stage 1: Scenario 1a

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Scenario 1a Interim Development AM Peak Hour	**Benara Rd East**	T	0.37	8.0	LOS A	22
		R	0.37	12.9	LOS B	22
	Bennett St North	L	0.29	7.1	LOS A	13
		R	0.29	12.9	LOS B	13
	Benara Rd West	L	0.30	5.5	LOS A	16
		T	0.30	4.5	LOS A	16
	Total		**0.37**	**8.0**		**22**
Scenario 1a Interim Development PM Peak Hour	**Benara Rd East**	T	0.47	7.7	LOS A	31
		R	0.47	12.6	LOS B	31
	Bennett St North	L	0.24	7.6	LOS A	11
		R	0.24	13.4	LOS A	11
	Benara Rd West	L	0.53	5.7	LOS A	35
		T	0.53	4.8	LOS B	35
	Total		**0.47**	**7.4**		**35**

Based upon existing traffic volumes along Benara Road in the vicinity of the Bennett Street roundabout intersection, the increases in traffic as a result of the Stage 1 – Scenario 1a development scenario will have a minimal impact on this intersection.

Based upon discussions and negotiation with the City of Swan, completion of this link to Bennett Street has been confirmed at or prior to the development of 250 lots, or just prior to completion of the evaluated Stage 1. The Level of Service modelled for both the Patricia Street/Bennett Street and Benara Road/Bennett Street roundabout intersections indicates that traffic operations at these locations will continue to operate at satisfactory Levels of Service under these conditions.

The anticipated Stage 2 (ultimate scenario) traffic operations have also been assessed for the intersection of Arthur Street and Patricia Street, based upon projected 2031 traffic volumes sourced from the Main Roads WA ROM, documented in the Transcore 2008 traffic assessment. Table 4.11 shows the results of this analysis.

Table 4.11 SIDRA Results for Patricia Street/Arthur Street – Stage 2

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Stage 2 -Ultimate 2031 Scenario - AM Peak Hour	**Arthur St South**	L	0.15	5.8	LOS A	9
		T	0.15	4.8	LOS A	6
		R	0.15	11.7	LOS B	6
	Patricia St East	L	0.20	8.2	LOS A	10
		T	0.20	7.3	LOS A	5
		R	0.20	14.2	LOS B	5
	Arthur St North	L	0.40	7.1	LOS A	23
		T	0.40	6.1	LOS A	3
		R	0.40	13.0	LOS B	3
	Patricia St West	L	0.24	6.5	LOS A	12
		T	0.24	5.6	LOS A	5
		R	0.24	12.5	LOS B	5
	Total		**0.40**	**7.2**		**23**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Stage 2 - Ultimate 2031 Scenario - PM Peak Hour	**Arthur St South**	L	0.53	7.1	LOS A	41
		T	0.53	6.0	LOS A	41
		R	0.53	12.9	LOS B	41
	Patricia St East	L	0.24	7.4	LOS A	12
		T	0.24	6.5	LOS A	12
		R	0.24	13.4	LOS B	12
	Arthur St North	L	0.32	6.8	LOS A	18
		T	0.32	5.9	LOS A	18
		R	0.32	12.7	LOS B	18
	Patricia St West	L	0.21	8.9	LOS A	12
		T	0.21	8.0	LOS A	12
		R	0.21	14.8	LOS B	12
	Total		**0.53**	**7.5**		**41**

The roundabout proposed for the Patricia Street/Arthur Street intersection is consistent with the intended use of Patricia Street as a low-speed environment neighbourhood connector and with equivalent intersections in the area, including the existing Benara Road/Lord Street intersection. The results of the assessment of this intersection suggests that under the ultimate 2031 scenario, taking into account the construction of the Arthur Street flyover, the proposed roundabout is anticipated to operate at acceptable Levels of Service with minimal delays and queuing. This scenario represents the 'worst-case' scenario for the Patricia Street/Arthur Street intersection as it takes into account the entire build-out of the overall Caversham Structure Plan and through traffic on Arthur Street from both the Albion and West Swan Structure Plan areas. As a result, only the Stage 2 development scenario has been assessed.

Traffic turning volumes for the intersections of West Swan Road / Patricia Street and West Swan Road / Arthur Street have been also been assessed to incorporate 2010 background volumes and the Stage 1 development scenario, without the Arthur Street flyover or Lord Street extension. These volumes are documented in Appendix C.

SIDRA analysis for the intersections of West Swan Road/Patricia Street and West Swan Road/Arthur Street under Scenario 1a (Patricia Street extended to Bennett Street in the interim scenario) has been presented in Table 4.12 and Table 4.13, respectively.

Table 4.12 SIDRA Results for West Swan Road/Patricia Street – Stage 1: Scenario 1a

Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Scenario 1a Interim Development AM Peak Hour	**West Swan Road South**	L	0.25	9.1	LOS A	0
		T	0.25	0.0	LOS A	0
	West Swan Road North	T	0.48	6.0	LOS A	78
		R	0.48	15.0	LOS B	78
	Patricia St West	L	0.02	13.2	LOS B	1
		R	0.33	37.8	LOS E	9
	Total		**0.48**	**5.4**		**78**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Scenario 1a Interim Development PM Peak Hour	**West Swan Road South**	L	0.23	9.1	LOS A	0
		T	0.23	0.0	LOS A	0
	West Swan Road North	T	0.17	2.9	LOS A	18
		R	0.17	16.1	LOS C	18
	Patricia St West	L	0.04	15.3	LOS C	1
		R	0.10	29.2	LOS D	3
	Total		**0.23**	**4.0**		**18**

The results of analysis for Intersection of West Swan Road with Patricia Street under the Stage 1 development Scenario 1a indicate that this intersection is anticipated to operate at acceptable Levels of Service during both AM and PM weekday roadway peak periods. However, the results of the assessment indicate that a reallocation of existing road space on West Swan Road, prior to the construction of the Lord Street extension, to incorporate a short right-turn pocket would result in improved outcomes for the southbound through movement. This right-turn pocket would be constructed to Type CHR standards as defined in Austroads' *Guide for Traffic Engineering Practice: Part 5 – Intersections at Grade* at subdivision clearance for any lots developed subsequent to those in the Early Release Area.

Existing high voltage power lines in the vicinity of the Patricia Street/West Swan Road intersection may require significant negotiation and/or engineering considerations in construction of the proposed interim and ultimate intersection forms. It may therefore be difficult for developers to expedite the construction of this intersection.

Table 4.13 SIDRA Results for West Swan Road/Arthur Street – Stage 1: Scenario 1a

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Scenario 1a Interim Development AM Peak Hour	West Swan Rd East	T	0.22	1.2	LOS A	18
		R	0.22	11.6	LOS B	18
	Arthur St North	L	0.02	12.8	LOS B	1
		R	0.14	24.7	LOS C	4
	West Swan Road West	L	0.11	9.1	LOS A	0
		T	0.11	0.0	LOS A	0
	Total		**0.22**	**1.8**		**18**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Scenario 1a Interim Development PM Peak Hour	West Swan Rd East	T	0.15	2.6	LOS A	15
		R	0.15	15.2	LOS C	15
	Arthur St North	L	0.03	14.9	LOS B	1
		R	0.06	26.4	LOS D	2
	West Swan Road West	L	0.21	9.1	LOS A	0
		T	0.22	0.0	LOS A	0
	Total		**0.22**	**1.9**		**15**

The results of analysis for the West Swan Road/Arthur Street intersection for the Stage 1 - Scenario 1a scenario indicate that this intersection is anticipated to operate at acceptable Levels of Service during both AM and PM Peak hours, with minimal associated queuing and delays. A right-turn pocket has been proposed, to be constructed to Type CHR standards as defined in Austroads' *Guide for Traffic Engineering Practice: Part 5 – Intersections at Grade* at subdivision clearance for any lots developed subsequent to those in the Early Release Area. There is no requirement for a channelised left-turn based upon the results of SIDRA assessment and Main Roads WA guidelines.

Additional SIDRA analysis was also undertaken for the intersections of West Swan Road/Patricia Street and West Swan Road/Arthur Street under the “worst case” Stage 1 - Scenario 1b (Patricia Street scenario not constructed to Bennett Street) has been presented in Table 4.14 and Table 4.15, respectively.

Table 4.14 SIDRA Results for West Swan Road/Patricia Street – Stage 1: Scenario 1b

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Scenario 1b Interim Development AM Peak Hour	**West Swan Road South**	L	0.13	9.1	LOS A	0
		T	0.13	0.0	LOS A	0
	West Swan Road North	T	0.23	1.5	LOS A	21
		R	0.23	12.1	LOS B	21
	Patricia St West	L	0.02	13.0	LOS B	1
		R	0.23	28.9	LOS D	6
	Total		**0.23**	**5.4**		**21**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Scenario 1b Interim Development PM Peak Hour	**West Swan Road South**	L	0.23	9.1	LOS A	0
		T	0.23	0.0	LOS A	0
	West Swan Road North	T	0.19	2.5	LOS A	17
		R	0.19	16.1	LOS C	17
	Patricia St West	L	0.03	15.3	LOS C	1
		R	0.09	30.0	LOS D	2
	Total		**0.23**	**4.0**		**17**

Table 4.15 SIDRA Results for West Swan Road/Arthur Street – Stage 1: Scenario 1b

Scenario	Approach	Movement	DOS	Delay	LOS	Queue
Scenario 1b Interim Development AM Peak Hour	**West Swan Rd East**	T	0.22	1.3	LOS A	18
		R	0.22	11.8	LOS B	18
	Arthur St North	L	0.03	12.9	LOS B	1
		R	0.27	27.0	LOS D	8
	West Swan Road West	L	0.12	9.1	LOS A	0
		T	0.12	0.0	LOS A	0
	Total		**0.27**	**2.7**		**18**
Scenario	**Approach**	**Movement**	**DOS**	**Delay**	**LOS**	**Queue**
Scenario 1b Interim Development PM Peak Hour	**West Swan Rd East**	T	0.19	1.7	LOS A	14
		R	0.19	15.6	LOS C	14
	Arthur St North	L	0.05	15.0	LOS B	2
		R	0.12	28.2	LOS D	3
	West Swan Road West	L	0.22	9.1	LOS A	0
		T	0.22	0.0	LOS A	0
	Total		**0.22**	**2.4**		**15**

The results of analysis for the West Swan Road/Arthur Street intersection for the Stage 1 – Scenario 1b scenario, in the absence of a Patricia Street connection through to Bennett Street, indicate that this intersection is anticipated to operate at acceptable Levels of Service during both AM and PM Peak hours, with minimal associated queuing and delays. Hence, the results of the assessment indicate that the construction of Patricia Street west of the Stage 1 development to connect with Bennett Street is not required from a practical traffic capacity perspective. It should also be noted that the need for the Lord Street extension would also not be triggered through the ultimate build-out of the Caversham North Structure Plan cell, prior to the development of the other cells within the overall Caversham Structure Plan area.

This assessment focused upon the impacts of development as a result of the additional traffic volumes generated by the Caversham North Local Structure Plan cell during the Stage 1 development scenario only. It should be noted that background volumes for West Swan Road are projected to increase to 17,000vpd by 2031, with volumes along Arthur Street increasing greatly to 10,000vpd by 2031. This increase in traffic is likely a result of increased urban development north of the Caversham area and the impact of the Arthur Street flyover on the proposed corridor as a parallel north-south route to West Swan Road.

The results of the SIDRA assessment of local access road intersections has also been undertaken in the context of both the Stage 1 and Stage 2 scenarios, respectively. This assessment shows that there is anticipated to be sufficient practical road capacity during peak periods to accommodate the proposed increases in trip generation under the Stage 1 development scenario; however, in the long term, under the Stage 2 or ultimate build-out scenario, improvements to the existing boundary road network will be required to accommodate long-term growth in background traffic and in overall structure plan traffic.

The intersections of Patricia Street/Bennett Street and Benara Road/Bennett Street have also been assessed under the assumption that the Lord Street extension is not completed under the Stage 1 scenario in order to determine the impacts of development on the local road system. The results of this analysis indicate that these intersections will continue to operate satisfactorily with the increased demand within the short-term with minimal impacts upon queuing and delays.

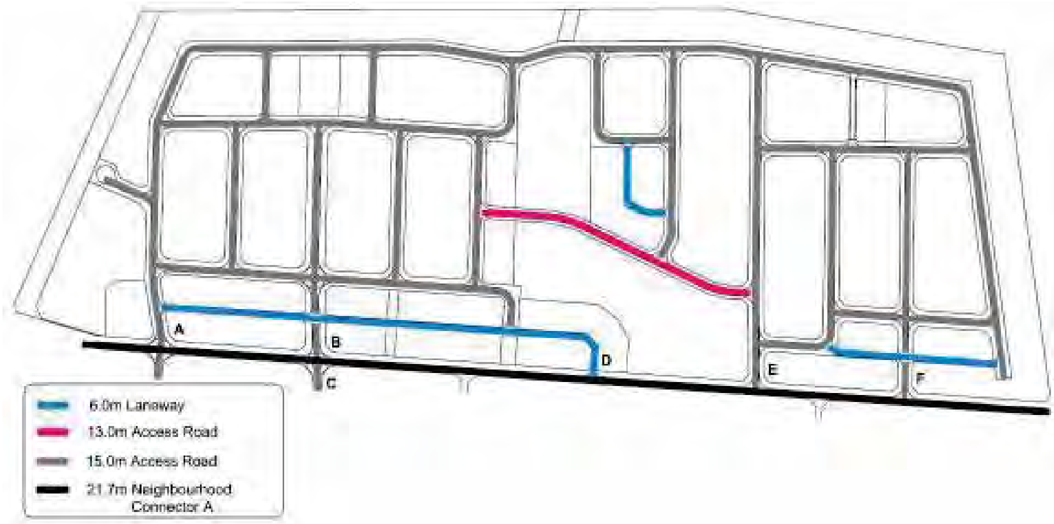
Intersections along West Swan Road including the Patricia Street and Arthur Street intersections have also been modelled for the Stage 2 scenario. The results of this assessment indicate that these intersections will operate satisfactorily under the modelled conditions. However, the increase in traffic associated with development further north along Arthur Street and West Swan Road will require some intersection modifications by the 2031 horizon year, as part of the build-out of the overall Caversham Structure Plan area and increased urban development to the north and west of the LSP.

5.0 PROPOSED INTERNAL ROAD NETWORK

5.1 Road Network Layout and Cross-Section

The Caversham North Local Structure Plan area is proposed to include a fully self-contained internal road network, with access to Patricia Street. No connections are proposed between the cell and Lord Street, Reid Highway or Arthur Street. The proposed internal road network and hierarchy within the Caversham North cell is shown in Figure 5.1. This figure shows a total of five (5) access points connecting the internal road network to Patricia Street, of which two (2) constitute 4-way roundabout intersections connecting across Patricia Street to the greater Caversham Structure Plan area to the south, east and south-east. The remaining three (3) intersections include a minor laneway access to Patricia Street, a major 3-way intersection towards the eastern side of the LSP area and a minor connection representing the easternmost connection to Patricia Street.

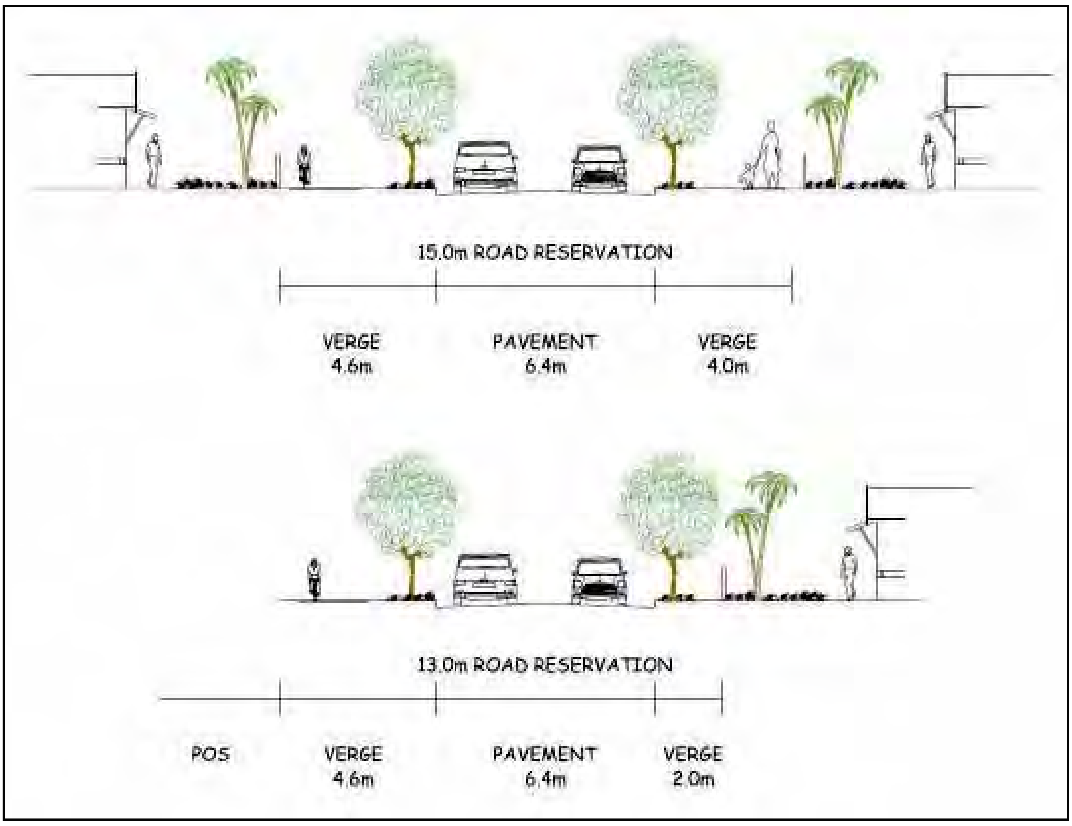
Figure 5.1 Proposed Internal Road Network Hierarchy



The balance of the roads within the subdivision will be designated as Access Roads C, with a road reservation of 15 metres, with the exception of local roads abutting public open space, where the road reservation will be 13 metres.

Proposed indicative local road cross-sections are shown in Figure 5.2.

Figure 5.2 ***Access Road Cross-Sections***



6.0 EXTERNAL ROAD NETWORK

6.1 Modifications to Road Network

In order to accommodate the proposed Caversham North Local Structure Plan, improved connections to the local road network are proposed at the Patricia Street termination to the west. The completion of this link to Patricia Street west of the proposed Lord Street extension will ensure connectivity between residents and Benara Road via Bennett Street. Patricia Street and Arthur Street will also be upgraded to an appropriate urban standard. However, it should be noted that this connection is not required from a practical road capacity perspective under the Stage 1 interim development scenario, as outlined in Section 4.

Potential modifications to the greater road network in the vicinity of the site have been outlined in detail in the SKM *Sub-Regional Transport Infrastructure Staging Brief* for the Swan Urban Growth Corridor completed in January 2008. This report has been referenced in order to establish a background framework for regional road planning in the area.

The potential staging plan for development of the Swan Urban Growth Corridor includes the extension of Lord Street south from Reid Highway to Benara Road, along the western boundary of the site (Stage A). The construction of this section of Lord Street, while not strictly necessary for the proposed Caversham North Local Structure Plan cell, will greatly improve connection to and from Reid Highway. Discussion of the requirements and implications of the Lord Street extension is included in Section 6.2 below.

Further staging for the Swan Urban Growth Corridor includes construction of a flyover on Arthur Street over Reid Highway as part of a Stage C plan. This infrastructure has been planned and designed to improve local road connectivity for residents and public transport providers as well as to provide an alternate north-south route to existing parallel routes such as Altone Street and West Swan Road,. Discussion of the impacts of an Arthur Street flyover is included in Section 6.3 below.

Stage D of the Swan Urban Growth Corridor plan includes construction of the first section of the Perth-Darwin Highway on the Lord Street extension alignment in the vicinity of the site. This would involve upgrading the section between Benara Road and Reid Highway to an arterial road standard. The impacts of this upgrade are discussed further in Section 6.4 below.

6.2 Lord Street Extension

The extension of Lord Street from Reid Highway to Benara Road has a number of constituent components. Those aspects that pertain to the proposed Caversham North Local Structure Plan include:

- The signalisation of the intersection of Reid Highway and Lord Street to accommodate the volume of traffic anticipated in the near term and to increase capacity for right-turning traffic onto Reid Highway; and
- A local road connection between Reid Highway and Benara Road, along the future Perth-Darwin Highway alignment to improve north-south connections and access to the Altone Ward and Caversham Structure Plan area.

The overall utilisation of the proposed link has been modelled by Main Roads WA in the Regional Operations Model and further analysed by Transcore in their Caversham Structure Plan Traffic Report. These studies suggest that the ultimate traffic volume projected for the 2031 horizon is in the order of 25,000 vehicles per day (vpd) including 2,300vpd north of Patricia Street and 1,400vpd south of Patricia Street to be generated by the overall Caversham Structure Plan area.

In order to identify the triggers for the Lord Street extension south of Reid Highway a desktop model was developed. The results of this model suggest that ultimate traffic volumes associated with Caversham North are in the order of 600vpd southbound and 1,000vpd northbound, based upon “worst case” or conservative projections. In addition, modelling of the road network in the absence of the Lord Street extension shows that the impact of the additional traffic generated by the Stage 1 development scenario, under either Scenario 1a or 1b Patricia Street infrastructure options, upon the adjacent intersections of Patricia Street/Bennett Street and Benara Road/Bennett Street is anticipated to be minimal. The results of this assessment suggest that the development of the Caversham North Structure Plan does not constitute a sufficient demand trigger for the construction of the Lord Street extension south of Reid Highway. Triggers for the development of the Lord Street extension and the associated Developer Contributions Plan will be outlined more fully in the Caversham Structure Plan.

6.3 Arthur Street Flyover

The existing road network provides no connection for Arthur Street across Reid Highway. This limits north-south connectivity to the major nearby intersections of Reid Highway/West Swan Road and Reid Highway / Altone Street. Justification for this connection as suggested by SKM includes improvements to local connectivity and provision for bus service.

The Arthur Street flyover has not been considered critical to accommodate locally generated traffic in the context of the Stage 1 scenario as other regional roads such as Henley Brook Avenue are considered to have more priority in the short- to medium-term. The flyover has therefore been assumed to be incorporated into longer-term staging plans, as indicated by the SKM *Staging Brief*.

6.4 Perth-Darwin Highway

The long-term staging plan for the Swan Urban Growth Corridor includes consideration for the Perth-Darwin Highway, planned to be constructed along the Lord Street alignment between Benara Road and Youle Dean Road. This would be constructed as a regional road, to be triggered when the Reid Highway/Lord street intersection reaches capacity. Upgrades include construction of a grade separated interchange at this intersection.

6.5 Patricia Street Road Reservation

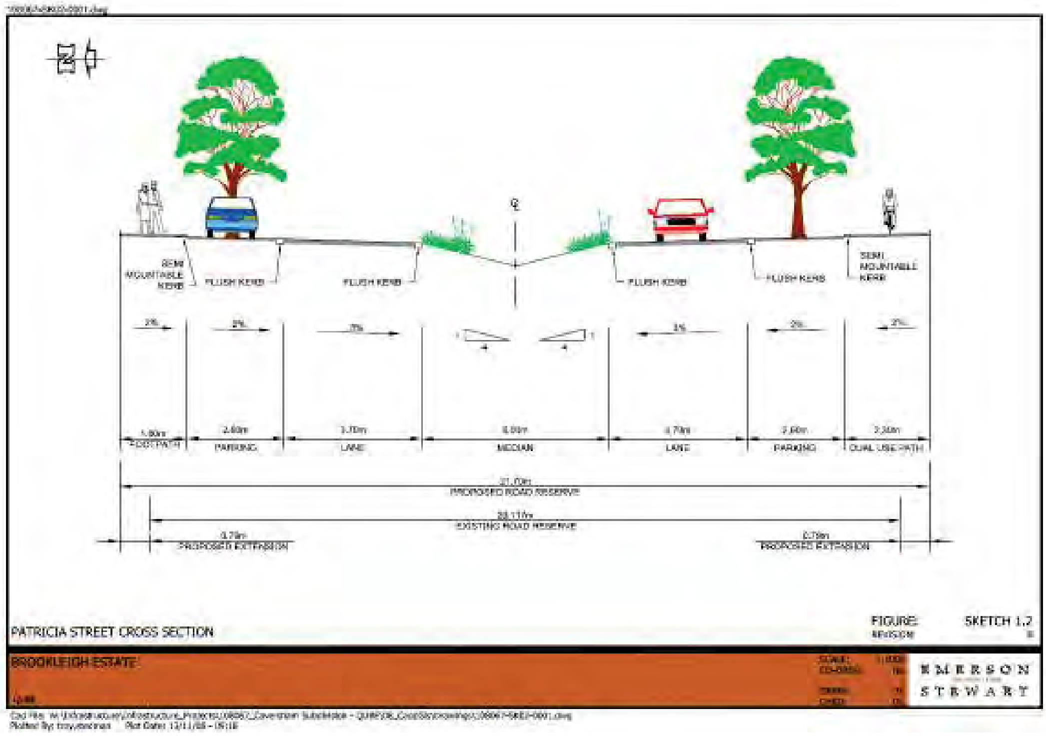
Patricia Street has been identified as a major Activity Corridor designed to service neighbourhood centre destinations and not intended as a higher order interzonal road connection. The proposed cross-section (shown in Appendix B) has been designed to accommodate traffic associated with local uses and public transport services. Total traffic volumes have been taken from the Main Roads WA Regional Operations Model (ROM) and validated through desktop modelling of the proposed land uses. Detailed traffic operations analysis using the SIDRA intersection assessment package has been undertaken for all relevant intersections along Patricia Street within the study area with the results detailed in Section 4.2.

The results of the modelling exercise demonstrate that the forecasted daily volume of traffic (to the nearest 100 VPD) on Patricia Street would likely vary between 3,800 VPD immediately west of Arthur Street to around 5,100 VPD near the far western boundary of the Caversham North cell near the Lord Street intersection. Based upon *Liveable Neighbourhoods* guidelines indicative daily traffic volume criteria and a review of the anticipated land uses proposed to flank both sides of Patricia Street, the future function of this road is consistent with a Neighbourhood Connector road classification and consistent with the findings of the 2008 Transcore review and the needs of the area in the short- to medium-term.

The resultant road reservation of 21.7 metres is deemed to be adequate for this section of Patricia Street and can accommodate both the minimum drainage requirements associated with the development of the cell, including a 5 metre drainage swale in the centre median, and the needs of pedestrians, cyclists and buses. A proposed cross-section for Patricia Street is shown in Figure 6.1.

Based upon a review of the City of Swan's Sub-Regional Structure Plan for the area and the predicted traffic volumes for Arthur Street of 7,000 VPD, it is anticipated that Arthur Street will function more like a Neighbourhood Connector A than a District Distributor A road, particularly following the construction of the Lord Street extension, and that a future road cross-section for Arthur Street would likely consist of a road reservation in the order of 24 metres. Details relating to these road reservation requirements will be addressed during the detailed design stages of the project.

Figure 6.1 ***Patricia Street Cross-Section***



This cross-section is proposed for the section of Patricia Street between Arthur Street and the western boundary of the Caversham Structure Plan area. The connection of Patricia Street west to the Bennett Street roundabout is proposed to be of a minimum standard consistent with City of Swan guidelines and deemed to be sufficient for interim traffic associated with the Caversham Structure Plan. It has been acknowledged that as a result of the future Lord Street extension, this section of Patricia Street will necessarily be temporary, precluding any requirement for continuation of the above cross-section design.

7.0 PUBLIC TRANSPORT SERVICES

7.1 Existing Bus Services

The Caversham North Structure Plan area, due to its very low existing residential catchment, is not easily accessible via the local public transport network. Bus services closest to the site include Transperth bus Route 337 (Ellenbrook – Bassendean Station) which runs approximately every 15 minutes during the weekday peak hours, and Transperth bus Route 52 (Midland – Morley) which currently operates very infrequently, though there is potential to increase service in the future when there is sufficient demand. Figure 7.1 shows the bus network in the vicinity of the Caversham North Structure Plan cell.

Figure 7.1 ***Existing Bus Network in the Vicinity of the Caversham North Cell***

Route maps for Transperth bus Routes 337 and 52 are shown in Figure 7.2 and Figure 7.3, respectively.

Figure 7.2 ***Route Map for Transperth Bus Route 337***

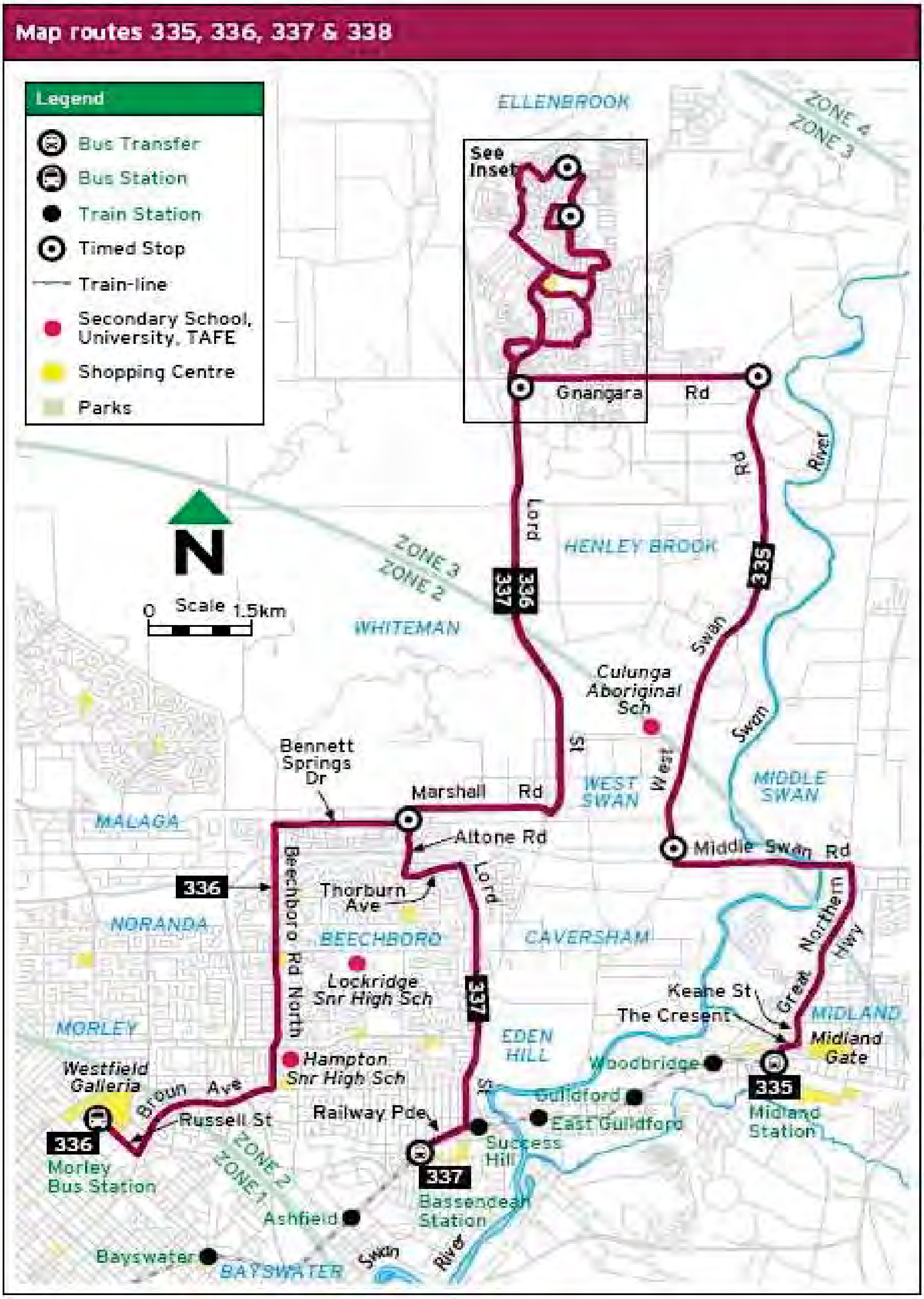


Figure 7.3 ***Route Map for Transperth Bus Route 337***

7.2 Potential Future Bus Services

Transcore reviewed the potential for the implementation of a line haul surface bus route which would operate along Patricia Street between Bennett Street and West Swan Road, in the overall Caversham Structure Plan Area Traffic Report issued in 2008, resulting in a modification of the existing Transperth bus Route 63. However, existing traffic volumes along West Swan Road indicate that delays for right-turning movements would be prohibitive at this point and that a bus turnaround facility would be required to the east of West Swan Road if this route alignment was utilised. Alternative alignments include the use of Arthur Street for north-south movements, based upon the construction of the Arthur Street Flyover under the Stage 2 development scenario.

However, discussions with the Public Transport Authority indicate that a bus route along into West Swan Road is not likely to occur in the short-term, further advising that a turning loop at the eastern end of Patricia Street would likely be required as right-turning movements into West Swan Road are not desirable and also the patronage in this area will likely not justify a bus route along this route. The road cross-sections proposed under Section 6.5 of this report are robust enough to accommodate line haul bus services along Patricia Street and it should be noted that bus routes could also be accommodated within the local road reservations proposed for Local Road C and Arthur Street, as outlined in the 2008 Transcore traffic study for the overall Caversham Structure Plan area.

Any bus routes ultimately proposed or modified are likely to be a result of growth in the region, particularly with respect to the overall Caversham Structure Plan area, the West Swan Structure Plan and Albion Structure Plan areas in addition to continued urban development to the north in Ellenbrook. Based upon a review of indicate patronage estimates associated with growth in the corridor, the local catchment associated with the Caversham North Structure Plan cell alone would not justify modification of existing bus route services in the short-term.

Ultimately, the Arthur Street flyover would provide some impetus to modify existing bus routes as Arthur Street progresses towards an Activity Corridor, as proposed in the *Sub-Regional Structure Plan for the Swan Urban Growth Corridor*.

8.0 PEDESTRIAN / CYCLING NETWORK

The proposed internal pedestrian network has been designed intended to provide connectivity within the Caversham North Local Structure Plan area and across Patricia Street to the proposed neighbourhood centre and primary school. The latter is particularly important as these connections will results in the best outcomes from a Safe Routes to Schools perspective.

The primary pedestrian and cycling generators are located on the south side of Patricia Street, opposite the Caversham North structure plan area. Pedestrian crossings in this vicinity of Patricia Street will therefore be required in order to maximise safety and minimise conflict and to creative attractive pedestrian links. The large internal public open space running through the centre of the Caversham North Local Structure Plan cell will also constitute a major attractor for pedestrians and cyclists.

In order to maximise the effectiveness of the pedestrian/cycle network, a 2.0m shared path is recommended through the proposed POS, acting as a central cycling corridor. Additional 1.5m pedestrian footpaths have been proposed along the majority of local internal roads to establish a comprehensive pedestrian-friendly network through the Structure Plan area. Consideration should also be made for a high-quality pedestrian/cycle crossing at the boundary of the proposed POS and Patricia Street to result in a safe route to the primary school at a likely crossing point.

Figure 8.1 shows the proposed internal pedestrian network, including shared paths and pedestrian footpaths.

Figure 8.1 ***Internal Pedestrian/Cycle Path Network***

9.0 SUMMARY AND CONCLUSIONS

This Transport Assessment has been prepared by Cardno Eppell Olsen for QUBE Caversham Development Pty Ltd to update the previous traffic assessment undertaken by Cardno and review the updated study completed by Transcore in 2008 for the overall Caversham Structure Plan in the context of the Caversham North development cell.

The anticipated road traffic impacts associated with the Caversham North Local Structure Plan area has been assessed in the context of a staged development approach: Stage 1 whereby approximately half of the Caversham North urban cell is developed along with approximately 100 residential lots within the cell immediately south of Patricia Street, between the Lord Street extension road reservation and Arthur Street and Stage 2 whereby full build-out of the overall Caversham Structure Plan area is realised.. The future road network, under Stage 1, has been modelled in the context of two Patricia Street infrastructure scenarios: Scenario 1a – full connection to Bennett Street and Scenario 1b – no connection west to Bennett Street, both without the Lord Street extension and the Arthur Street flyover. The Stage 2 scenario has been modelled upon 2031 horizon background road traffic volumes, sourced from the MRWA ROM model, and has taken into consideration of construction of both the Lord Street extension and Arthur Street flyover.

A traffic modelling exercise has been subsequently undertaken to determine the anticipated future daily traffic volumes on Patricia Street between Lord Street and Arthur Street as well as the future weekday roadway AM and PM peak hour turning volumes at the proposed local intersections with Patricia Street. The results of the SIDRA intersection analysis indicate that the proposed local road intersections on the north side of Patricia Street, within the Caversham North Structure Plan, are anticipated to function at acceptable Levels of Service during the weekday roadway AM and PM peak hours, under the 'worst case' scenario whereby the overall Caversham Structure Plan area has been fully developed.

A review of the development triggers for the Lord Street extension south of Reid Highway was also undertaken and the results of this review indicate that this extension is not required under the Stage 1 development scenario or if the entire Caversham North Structure Plan cell is built-out prior to the balance of the overall Caversham Structure Plan area. An interim scenario has also been modelled for the local roundabout intersections of Bennett Street with Benara Road and Patricia Street. This model investigated the impact connection of Patricia Street west to Bennett Street would have on local intersection operations in the absence of the Lord Street extension or Arthur Street flyover. Results from this assessment suggest that there would be sufficient capacity at both intersections to accommodate the additional traffic generated by the development in the initial stage. The results of the assessment undertaken under Stage 1 also indicate that the extension of Patricia Street west to Bennett Street is not required to accommodate the level of development traffic under Stage 1 and that the Patricia Street/West Swan Road and Arthur Street/West Swan Road intersections can accommodate the Stage 1 development-generated traffic without this connection in the interim scenario. The West Swan Road/Patricia Street intersection was also assessed under the Stage 1 development scenario and the results indicate that the implementation of a southbound right-turn pocket on West Swan Road within the existing reallocated road space would improve peak hour traffic operations at this location.

Following negotiations with the City of Swan, the upgrade of roads and intersections will be conducted as follows:

- Patricia Street will be initially upgraded from Arthur Street west to Road E, as designated in this report, to accommodate traffic associated with construction and Stage 1 residential demand for the Early Release Area.
- At the commencement of development outside the Early Release Area (106 lots) Patricia Street is to be upgraded to a rural standard from the intersection of Patricia Street and Arthur Street through to West Swan Road, with a carriageway width of 7.4 metres. This upgrade can only be viewed as an interim solution, for which an offset would only be appropriate under the proposed Development Contribution Plan if the extant works are able to form part of the final road treatment. The trigger for upgrading Patricia St to urban standard, between Arthur St and West Swan Road, will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the ultimate Patricia Street upgrade and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

- The intersections of West Swan Road with Arthur Street and Patricia Street will (including lighting to the Australian standard) be constructed before or at subdivision clearance of deposited plan that generates lots outside the Early Release Area. The trigger for construction of the ultimate arrangement at these intersections will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the West Swan Road/Arthur Street and West Swan Road/Patricia Street intersections and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
- Completion of Patricia St west of Arthur Street to connect to the roundabout intersection with Bennett Street will be constructed before or at subdivision clearance of deposited plan that generates the 250th lot (unit of equivalent demand). This will be constructed to a boulevard treatment as shown in Figure 6.1 to the western boundary of the Caversham DCA. Landowners will be required to contribute to the Patricia Street extension and its intersection treatment proposed with Lord Street to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.
- Although the Caversham North Structure Plan area contributes to the need for Lord Street between the Reid Highway and Benara Road, the development itself is not of sufficient size to warrant construction. The trigger for construction will be determined as part of the wider process of determining the proposed Caversham Structure Plan and Development Contribution Plan. Landowners will be required to contribute to the Lord Street extension and to secure these payments a deed of agreement shall be entered into by landowners within 28 days after approval of the Structure Plan for advertising or within 14 days after a Deed in common form capable of being executed is sent to the landowner, whichever is the later in order to satisfy Cl 5A.2.7.3 of LPS17 in the absence of an approved DCP.

It was also confirmed that a road reservation of 21.7 m for Patricia Street would be sufficient to accommodate the anticipated future daily traffic volumes and that the relevant future road classification would be a *Neighbourhood Connector A*, consistent with *Liveable Neighbourhoods* guidelines. The balance of the roads in the subdivision would be classified as *Access Roads C* and would have a proposed road reservation of 15 metres, with the exception being those roads which abut public open space which would have a road reservation of 13 metres.

Public transport services through the area will be considered by the Public Transport Authority once urban development in the corridor warrants extension of existing line haul bus services and/or establishment of new line haul services on Arthur Street and Patricia Street.

The proposed internal pedestrian network has been designed intended to provide connectivity within the Caversham North Local Structure Plan area and across Patricia Street to the proposed neighbourhood centre and primary school. The latter is particularly important as these connections will results in the best outcomes from a Safe Routes to Schools perspective.

Appendix A

Structure Plans

Appendix B

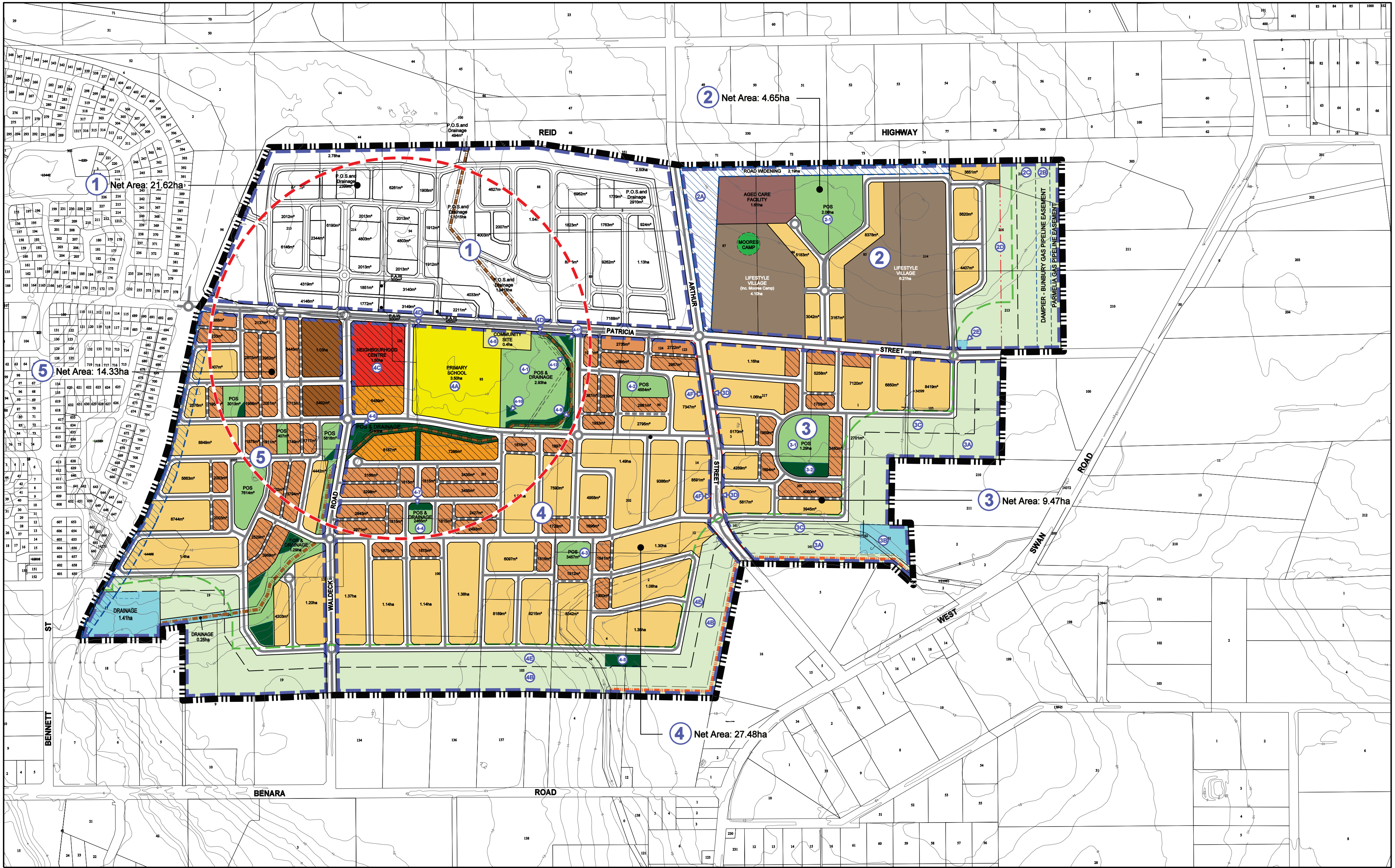
Transcore Traffic Study (November 2008)

Appendix C

Turning Movement Volumes

Appendix A

Structure Plans



LEGEND

- CAVERSHAM STRUCTURE PLAN AREA
- 400m WALKABLE CATCHMENT
- CELL BOUNDARY / NUMBER
- 18 METRE MULTIPLE USE CORRIDOR (DRAINAGE CHANNEL)
- DRAINAGE SWALE EASEMENT
- 75m RESIDENTIAL SETBACK TO HPGTP EASEMENT
- HIGH PRESSURE GAS TRANSMISSION PIPELINE EASEMENT
- ABORIGINAL HERITAGE SITE
- RESIDENTIAL R15
- RESIDENTIAL R20
- RESIDENTIAL R25
- RESIDENTIAL R30
- RESIDENTIAL R40
- RESIDENTIAL R60
- RETIREMENT VILLAGE R25/R50
- NEIGHBOURHOOD CENTRE
- COMMUNITY SITE
- TRANSITION LOT
- PUBLIC OPEN SPACE / DRAINAGE
- PRIMARY SCHOOL
- PRIVATE OPEN SPACE (Indicative Only)
- DRAINAGE
- DETAILED AREA PLAN REQUIRED AS PART OF SUBDIVISION APPROVAL

NORTH

0 100 200 300m

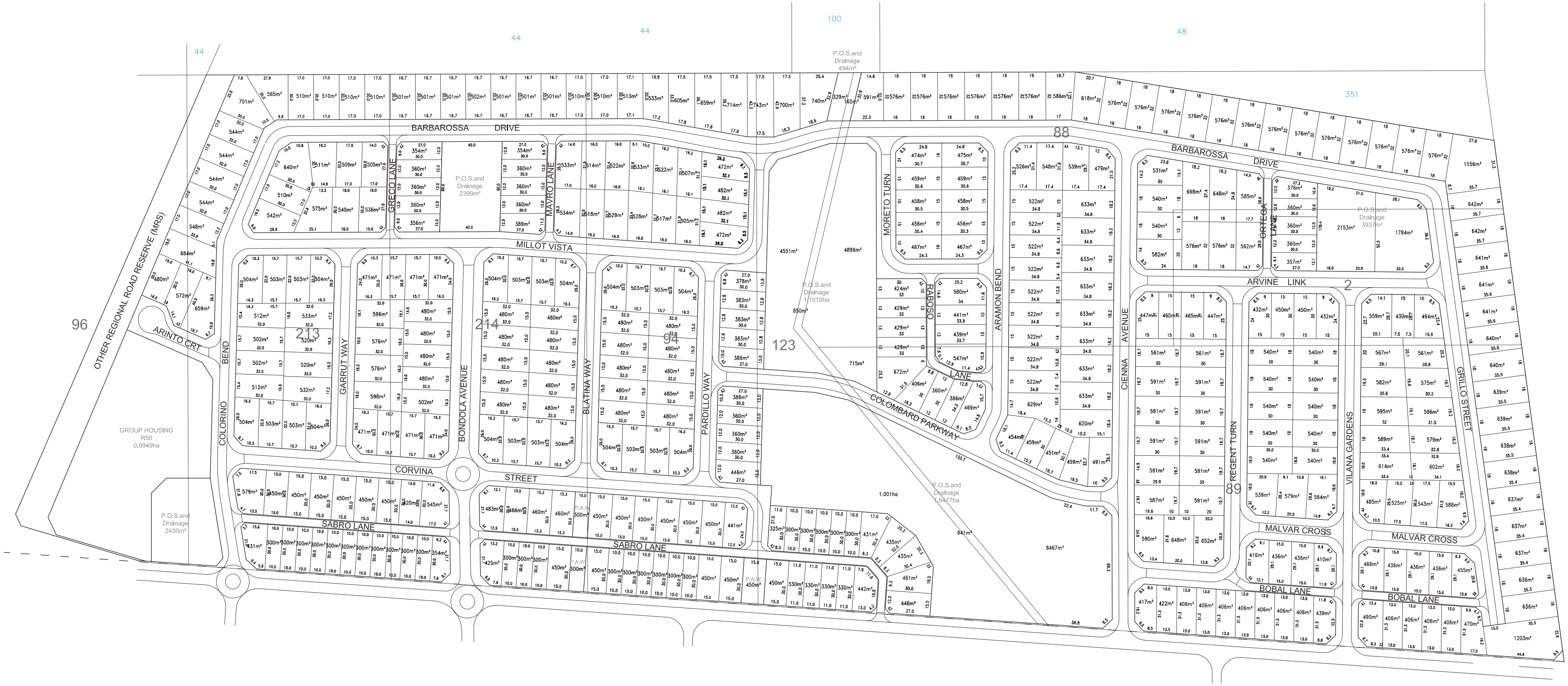
STRUCTURE PLAN - CAVERSHAM

NOTES

Base data supplied by Water Corporation
Aerial Photography dated January 2002 supplied by DOLA
Title information sourced from DOLA Dec 2002
Areas and dimensions are subject to final survey.

1:4,000@A1 1:5,000@A2 1:7,500@A3	:	SCALE
26 August 2009	:	DATE
dw-29652001m.dgn	:	PLAN No
m	:	REVISION
K.K	:	PLANNER
L.W	:	DRAWN

RPS koltasz smith
TOWN PLANNING PROJECT MANAGEMENT URBAN DESIGN DEVELOPMENT CONSULTING



Public Open Space

Lot	Lot Area	POS Required (10%)	POS Provided	Surplus/Defecit
WAPC Landholding (Balance of 96)	1.24ha	1240m²	2430m² *(19.6%)*	+1190m²
Caversham Land Developments Landholdings	30.97	30970m²	35308m² *(11.4%)*	+4338m²
	32.21ha	*3.221ha*	*3.7738ha (11.7%)**	***+5528m²***

** Does not include drainage reserve*

Lot Yield

Product	Frontage (m)		Depth (m)	Min. Area	Max Area.	Avg. Area	No.	% of Total
Cottage	10	(R)	30	300m²	461m²	326m²	33	7%
Cottage	12-14	(R)	30	354m²	672m²	415m²	56	13%
Cottage	15	(F/R)	32	420m²	579m²	469m²	98	22%
Traditional	15-20		30-36	451m²	1203m²	570m²	206	46%
Group Housing R50 (WAPC Landholding)							55du	12%
							448	

QUBE

Subdivision Concept Plan
Patricia Street, Caversham
City of Swan

ISSUE	DESCRIPTION	YYMMDD	DRAWN	APPV'D
D	POS Option 2	090824	BG	RD
C	POS Option 1	090824	BG	RD
B	Mods to Design	090729	SJ	RD
A	Subdivision Concept Plan	090728	SJ	RD

PROJECT
CAVERSHAM

CLIENT
QUBE PROPERTY GROUP PTY LTD

0 40 80m
SCALE 1:2000 SHEET A2

DRAWING NUMBER UD1 104 REV F

REFERENCE NUMBER QUB CAV

Issued for design intent only. All areas and dimensions are subject to detail design + survey.

robertsday
perth | sydney | melbourne | dubai
Level 1 | 130 Royal Street East Perth
Western Australia 6004 AUSTRALIA
T: 61 8 9218 8700 | F: 61 8 9218 8701
www.robertsday.com.au

Appendix B

Transcore Traffic Study (November 2008)

Caversham Structure Plan

Traffic Report

transport planning • traffic engineering • project management

Caversham Structure Plan
Traffic Report

Prepared for:
The Caversham Main Landowners Group
C/- RPS Koltasz Smith

November 2008

Prepared by:
TRANSCORE PTY LTD
3 Kimberley Street, West Leederville WA 6007
PO Box 42, Subiaco WA 6904
Telephone (08) 9382 4199
Facsimile (08) 9382 4177

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APPENDICES

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Appendix B	Land requirement of Lord Street extension
Appendix C	Land requirement of intersection of Reid Highway and Lord Street
Appendix D	Preliminary design of Lord Street/ Reid Highway grade separated intersection
Appendix E	Indicative cross sections

1.0 Introduction

1.1 Purpose of this report

This traffic report in support of the Caversham Structure Plan has been commissioned by Koltasz Smith on behalf of the Caversham Main Landowners Group (MLG).

A traffic report for the Caversham Structure Plan was originally prepared by Sinclair Knight Merz in November 2006. Following appointment of SKM to undertake work for the City of Swan in relation to the Urban Growth Management Strategy, Transcore assumed responsibility for traffic and transport planning work for the Caversham Structure Plan. Transcore provided a "preliminary update to traffic consulting advice" on 28 November 2006.

Transcore has now prepared this updated traffic report for the Caversham Structure Plan. The report remains largely as written by SKM except where Transcore has updated appropriate sections to reflect recent developments such as the *Sub Regional Structure Plan for the Swan Urban Growth Corridor* (draft May 2008)

This traffic report assesses the forecast daily traffic volumes resulting from the structure plan, recommends an appropriate road hierarchy, external intersection treatments, potential bus routes and pedestrian and bicycle routes.

The Caversham Structure Plan is shown in Figure 1.1.

1.2 Layout of this report

This report is divided into a further 6 sections:

- Existing and planned transport network
- Proposed development
- Traffic forecasting
- Road network assessment
- Pedestrian and cyclist network
- Public transport

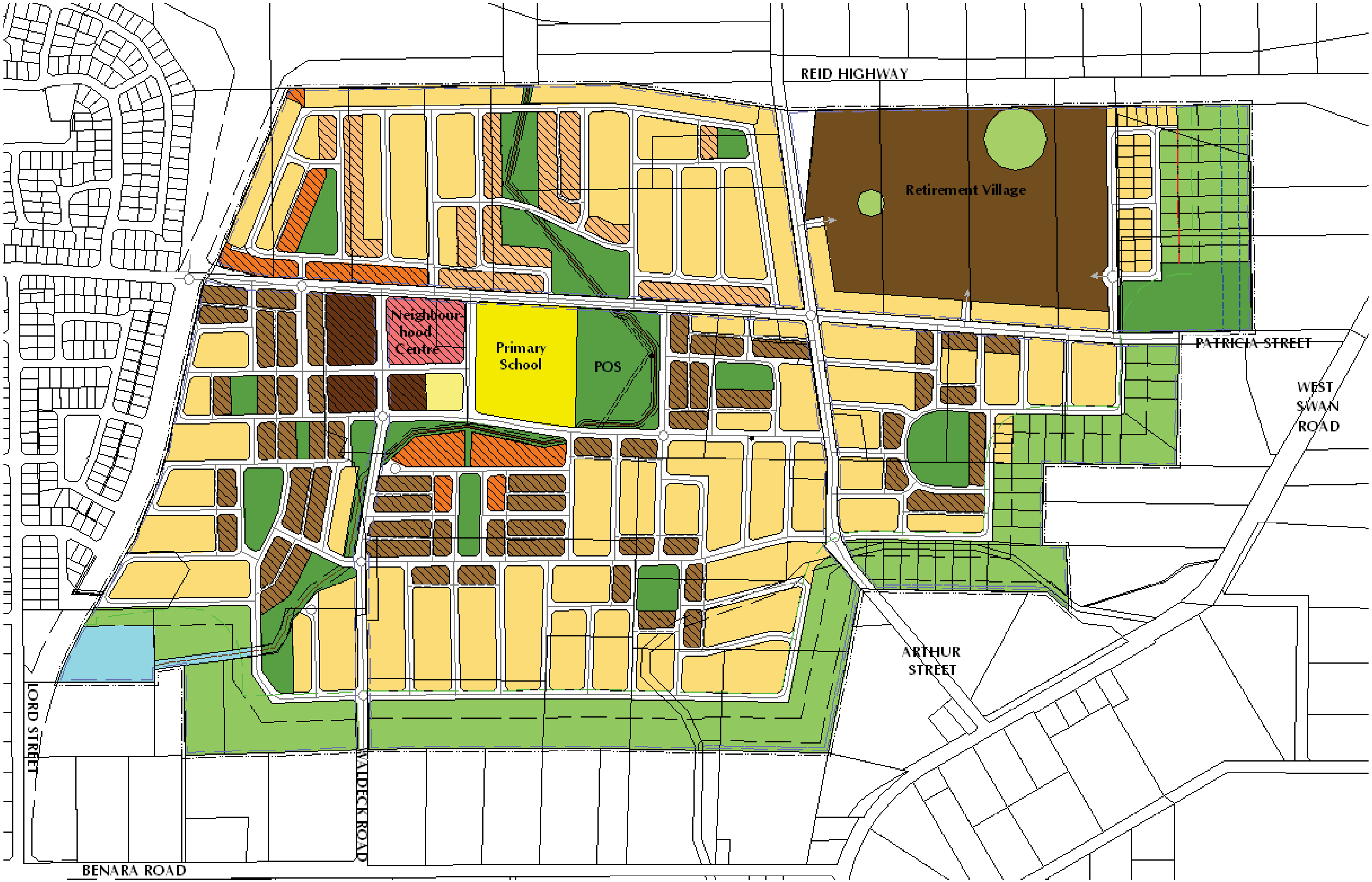

Figure 1.1. Structure plan

2.0 Existing and Planned Transport Network

2.1 Existing road network

The Caversham Structure Plan area is bordered to the west by the future Lord Street, to the south by Benara Road, to the east by the Dampier-Bunbury Natural Gas Pipeline and by private properties fronting West Swan Road and to the north by Reid Highway.

2.1.1 Reid Highway

Reid Highway is classified as a Primary Regional Road (PPR) under the Perth Metropolitan Region Scheme (MRS). The full extent of the existing MRS reserve for Reid Highway has been acquired, with no outstanding land that would affect the Caversham development. It is managed by Main Roads Western Australia (MRWA). The Department for Planning and Infrastructure (DPI) are finalising the final design for the section of Reid Highway from Lord Street to Great Northern Highway, which allows for a six-lane freeway with grade separated interchanges and provision for a public transport system in the median. A design and construct contract was awarded in August 2008 for construction of a 2.6km dual carriageway for Reid Highway between West Swan Road and Great Northern Highway. This section should be completed by February 2010.[1]

2.1.2 Benara Road

Benara Road is reserved as an Other Regional Road (ORR) under the MRS. Benara Road is classified as a District Distributor (A) Road and is a two lane single carriageway in the vicinity of Caversham managed by the City of Swan. The existing four-way intersection of Lord Street and Benara Road to the west of the development site is roundabout controlled. A second roundabout has been constructed for the intersection of Benara Road and Bennett Street to the immediate west of the development area. The location of this roundabout will ultimately mark the connection of Benara Road with the Lord Street extension, which is reserved under the MRS.

2.1.3 West Swan Road

West Swan Road is reserved as an Other Regional Road (ORR) under the MRS. West Swan Road is classified as a District Distributor (A) Road and is a two lane single carriageway managed by the City of Swan. There is no dualling proposed for West Swan Road, however the road reserve width across Reid Highway provides for a future flyover, the timing and funding for which has not been established by MRWA or the City of Swan.

The intersection of Reid Highway and West Swan Road is traffic signal controlled. The T-junction of Benara Road and West Swan Road is priority controlled.

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[1] Source: Main Roads WA website:
http:www.mainroads.wa.gov.au/BuildingRoads/Projects/UrbanProjects/Pages/reid_highway.aspx

2.1.4 Lord Street

Lord Street is reserved as an Other Regional Road (ORR) in the MRS. The existing MRS ORR reservation provides for Lord Street to be ultimately connected from Guildford Road, Bassendean through to Reid Highway immediately adjoining the project area. Lord Street is currently constructed between Guildford Road and Benara Road, though the 1km section immediately south of Benara Road currently lies to the west and outside the MRS reserved alignment.

The Lord Street extension forming the western edge of the project area between Benara Road and Reid Highway is not yet constructed.

2.1.5 Arthur Street

Arthur Street is not reserved under the MRS, excepting the section intersecting with Reid Highway where land is reserved as Primary Regional Road (PRR) for a future flyover. Arthur Street is classified as a Local Distributor managed by the City of Swan and has been divided into two segments by Reid Highway. There are no connections between the north and the south sections of this street. Because Reid Highway is a Controlled Access Highway there is no access between Arthur Street and Reid Highway. Road reserve widths across Reid Highway are planned to provide for a future flyover, however there is no program for the timing or funding of a flyover at this stage. In many cases MRWA funds the construction costs for land reserved as a primary regional road in the Metropolitan Region Scheme, though funding details will need to be agreed between the developer, MRWA and the City of Swan. It is considered that the Arthur Street flyover is not required in the shorter term; however it has benefits for sub-regional connectivity and, as the general road network is still developing in the area, it is assumed that Arthur Street will be timed to fit into staged construction of the network in the longer term. This issue is discussed further in section 2.2.3 of this report.

2.1.6 Patricia Street

Patricia Street is not subject to any reservation requirements and is a two lane single carriageway access Street managed by the City of Swan. It runs east-west through the area from West Swan Road to Bennett Street, with a short link in-between not yet constructed.

2.2 Future road network

Detailed information for each individual road is provided in this section. The hierarchy for the proposed future road network is discussed under section 5 and shown in Figure 5.1.

2.2.1 Reid Highway

Following discussion with the Department for Planning and Infrastructure (DPI), it is understood that Reid Highway is proposed to be upgraded to a dual carriageway with the transit corridor to be relocated into the central median. This may result in an expansion to the south of the Reid Highway reserve by up to 10m. The timing and detailed impact of any amendment to the Metropolitan Region Scheme Primary Regional Road reservation in this location can not be confirmed at this stage. In addition, we are also advised by Koltasz Smith that the Preliminary Ethnographic Study of the Caversham Project Area identified the presence of Aboriginal Sites including 'Moore's Camp' and Aboriginal wells within the project area.

Moores Camp is understood to lie immediately south of the Reid Highway reserve in the north east quadrant of the project area, with one of the known wells lying immediately south of the Reid Highway reserve in the northwest quadrant of the project area. Verbal discussion by Koltasz Smith with Mr Rory O'Connor, the project's consulting ethnographer, has indicated that difficulties would be faced by DPI and MRWA in attempting to widen Reid Highway on the southern side. The Caversham Structure Plan recognises the existing MRS reservation for Reid Highway. The proposed land requirement of Reid Highway is shown in Appendix A.

2.2.2 Lord Street

Lord Street, north of Reid Highway, will form the start of the Perth Darwin National Highway. This National Highway is reserved Primary Regional Road in the Perth Metropolitan Region Scheme.

Lord Street is planned to be relocated to the east of Bennett Street and the MRS in this area has provision for a grade separated interchange at this location. It is currently proposed as a standard diamond interchange with Lord St (connection to south) going over the top of Reid Highway (see Appendix D). In the interim, it is likely to be traffic signalised as part of the staging for the development of the road network. The extension of Lord Street south of Reid Highway is proposed but is not in the current construction program. The proposed land requirement of Lord Street is shown in Appendix B.

The proposed land requirement of Reid Highway – Lord Street intersection is shown in Appendix C. The southern end of the Lord Street extension will tie in to the existing roundabout at Bennett Street and Benara Road. Previous discussions with the City of Swan have indicated that the developer may be requested to fund one carriageway and earthworks for both carriageways. This is not uncommon practice and would bring forward the timing of construction.

2.2.3 Arthur Street

An overpass across Reid Highway has been proposed to connect the northern and southern section of Arthur Street. Assuming construction of the Lord Street extension, the flyover is not considered crucial to the Caversham development in traffic terms, however it is considered desirable in terms of overall connectivity in the regional area in the longer term. However, Arthur Street is also part of a proposed Activity Corridor, as discussed in section 2.2.5, and the Arthur Street overpass is important for that Activity Corridor.

2.2.4 Patricia Street

The City of Swan, DPI and Main Roads Western Australia (MRWA) have all indicated support for the linkage of Patricia Street between the east and west. The intersection control of the future relocated Lord Street and Patricia Street is discussed under section 5.4. Patricia Street is also part of a proposed Activity Corridor as discussed in section 2.2.5.

2.2.5 Proposed Activity Corridor

The draft *Sub Regional Structure Plan for the Swan Urban Growth Corridor* (SRSP) prepared for the Department for Planning and Infrastructure (May 2008) proposes a future Activity Corridor through Caversham, West Swan (East) and Henley Brook (Albion).

The SRSP indicates that the Activity Corridor functions to service the neighbourhood centre destinations, rather than acting as a high speed thoroughfare, with associated public transport and supportive land uses. This is in accordance with Network City principles".

The proposed Activity Corridor runs along Patricia Street (connecting to the future Lord Street alignment at Patricia Street) and northwards along Arthur Street to cross Reid Highway.

The SRSP therefore says, "A flyover is required where Arthur Street crosses Reid Highway linking Caversham with West Swan and Albion. The Arthur Street flyover is critical:

- To ensure local connectivity allowing residents to travel north/south without being forced to use the busier intersections; and
- For bus services to operate effectively along the Activity Corridor."

2.3 *Existing and future forecast traffic volumes*

Table 2.1 shows the existing traffic volume (AAWT)[2] on the major roads surrounding the Caversham development area from MRWA counts (most recent available). These are compared to the 2031 forecast traffic volume provided by the Main Roads Regional Operations Model (ROM), which is designed to estimate regional traffic volumes on regional and major local roads.

Table 2.1 Existing and forecast traffic volumes on major roads using MRWA traffic count data and the MRWA ROM model.

	Reid Hwy west of West Swan Rd	West Swan Rd north of Benara Rd	Benara Rd west of West Swan Rd	Perth Darwin Hwy/ Lord St
Existing traffic volumes	26,650 (March 2007)	11,088 (20/08/2001)	8,588 (06/08/2004)	-
MRWA 2031 forecast volume	49,500	18,100	11,000	15,600

Table 2.1 highlights the forecast changes in traffic over the next two decades in a strategic context.[3] As a primary distributor designed for regional traffic movements, Reid Highway is currently carrying over 26,000 vpd. By 2031 the regional traffic flow on this highway will almost double to 50,000 vpd. West Swan Road is a north-south road and is currently carrying over 11,000 vpd. Traffic on this road will increase by approximately 60% to 18,000 vpd in 2031. As an east-west district distributor, Benara Road is currently carrying over 8,600 vpd and an increase in traffic in the order of 30% would be expected. Lord Street/ Perth Darwin National Highway will carry approximately 15,600 vpd between Benara Road and Reid Highway in the MRWA forecast, but see Section 4 and Figure 4.1 for revised forecasts that indicate up to 25,000 vpd on this section of Lord Street in future.

[2] Average Annual Weekday Traffic (AAWT)

[3] The MRWA ROM model has taken into account the urban development in a strategic context, although the size of the Caversham development used in ROM may not be exactly the same as this proposal. The size difference is not expected to have any significant impact upon the strategic model.

3.0 Proposed Development

The structure plan area comprises approximately 198 hectares, with some 140 hectares or 80% of the project owned by landowners participating in the Caversham Main Landowners Group (MLG). A neighbourhood centre and a primary school have been proposed along with medium to high density dwellings. The neighbourhood centre is to be located at the intersection of Patricia Street and Waldeck Road extension with higher density land uses proposed for the 400 m ped shed surrounding the centre. These land uses and density are intended to promote alternative transport modes, such as walking, cycling and public transport. The proposed land uses are shown in Figure 1.1 and detailed data is listed in Table 3.1.

Table 3.1 Proposed land uses for the Caversham Structure Plan

Cell	No. of dwellings by residential density					Primary School (ha)	Neighbourhood Centre (ha)
	Transition	R15 - R25	R30 - R40	R60	Retirement		
1 (NW)		378	58				
2 (NE)	8	76			350		
3 (SE)	27	118	60				
4 (Mid)	32	391	236	23		3.5	1.5
5 (SW)	18	136	154	87			
Total	85	1099	508	110	350	3.5	1.5

A detailed centre layout incorporating land use as not been completed at this time for the Neighbourhood Centre, though the City of Swan Commercial Centres Strategy indicates a size range of 3,500 m^2 to 4,500 m^2 Net Leasable Area for the Caversham Village Centre. A separate retail study has been completed for the Caversham Project, which considers external travel demand as well as internal travel demand and recommends the now proposed village centre location. The catchment area for the primary school and the neighbourhood centre is largely within the area bound by Bennett Brook to the west, Reid Highway to the north, West Swan Road to the east and Benara Road to the south. For this traffic assessment it is assumed the Neighbourhood Centre is 4,000 m^2 NLA and 600 students are assumed at the primary school.

4.0 Traffic Forecasting

4.1 Development trip generation and distribution

A trip is a one-way movement from an origin to a destination. A trip rate of 6 vehicle trips per dwelling per day (vpd) is considered appropriate for the higher density residential land uses R60, with 7 vpd per dwelling considered appropriate for the medium density residential land uses R30 and R40. For the larger transition lots in the buffer areas and for residential densities of R15, R20 and R25 a trip rate of 8 vpd has been applied. For the retirement village a trip rate of 3 vpd per dwelling is appropriate. This results in a total trip production from the residential land uses of approximately 14,750 vpd. However, it is estimated that approximately 25% of these trips would be to internal trip attractors such as the primary school and neighbourhood centre.

The neighbourhood centre and the primary school would attract approximately 4,800 and 1,200 vpd respectively. Most of the vehicle trips related to these two facilities would be characterised as drop off/ pickup or shopping activities on the way to other destinations as a secondary trip purpose. It is estimated that 60% of the trips associated with the neighbourhood centre and the primary school will be internal trips (ie. trips originating from within the development area).

A sub area matrix from the MRWA model has been used to determine the internal/ external trip distribution pattern. The vehicle trips generated by the proposed development are shown in Table 4.1.

Table 4.1 Forecast trip generation for the Caversham development

Cell	Internal trips to/from primary school and neighbourhood centre (trips per day)	I-E & E-I trips per day	Distribution to/from external road network (derived from MRWA 2031 sub area model)						
			Reid Hwy West (A)	Benara Rd West (B)	Lord St South (C)	West Swan Rd south (D)	Reid Hwy east (E)	West Swan Rd north (F)	PDNH north (G)
			10.36%	7.97%	30.61%	18.88%	16.48%	8.04%	7.67%
1	843	2587	268	206	791	488	426	208	198
2	423	1299	135	103	397	245	214	104	100
3	389	1191	123	95	365	225	196	96	91
4	1272	6318	655	504	1933	1193	1041	508	485
5	696	2136	221	170	654	403	352	172	164
Total	3624	13530	1402	1078	4140	2554	2230	1088	1038

4.2 Through traffic

Through traffic are the external trips that are not generated by the proposed development but travel through the study area on the internal road network or surrounding roads.

Traffic generated by the proposed West Swan and Henley Brook (Albion) developments was evaluated by SKM for a September 2007 transport workshop for the *Sub Regional Structure Plan for the Swan Urban Growth Corridor*. This showed a through traffic flow of 7,000 vpd on Arthur Street from West Swan Road, through Caversham and across Reid Highway at the future Arthur Street flyover.

The SKM plan also showed future total traffic volumes on the surrounding major road network based on Main Roads WA transport modelling.

Another report, the *Caversham North Local Structure Plan Transport Review* (April 2008) by Cardno BSD, considered total traffic volumes on Patricia Street (including through traffic) and found that total volumes would range from 5,100 vpd to 3,800 vpd.

4.3 Traffic flow forecast

The trips generated by the proposed Caversham development were assigned onto the road network to estimate the forecast traffic volumes on individual roads.

The traffic forecast is based on the road network proposed within the Caversham Structure Plan and assumes the Lord Street extension between Reid Highway and Benara Road has been constructed. As the planning authorities are adamant that the Arthur Street flyover will ultimately be constructed across Reid Highway this link has been included in the road network for this traffic assignment. The traffic volumes generated by the Caversham development on the main elements of the internal road network are shown in Figure 4.1. Other local roads within this development have not been evaluated individually but can each expect less than 1,000 vpd.

Inclusion of the Arthur Street flyover attracts less than 1,000 vpd of the traffic generated within Caversham so the volumes on the internal road network will generally not be significantly affected by the presence or absence of this link.

Arthur Street itself is the only internal road that is expected to carry a significant amount of through traffic if the flyover is constructed. Local traffic on Arthur Street is expected to range from approximately 1,000 vpd in the north to 3,000 vpd in the south. Therefore, addition of the anticipated 7,000 vpd of through traffic will result in total volumes ranging from approximately 8,000 vpd at the Arthur Street flyover to 10,000 vpd at the southern end of Arthur Street. Total traffic volumes on Arthur Street and the surrounding major road network are shown in brackets in Figure 4.1.

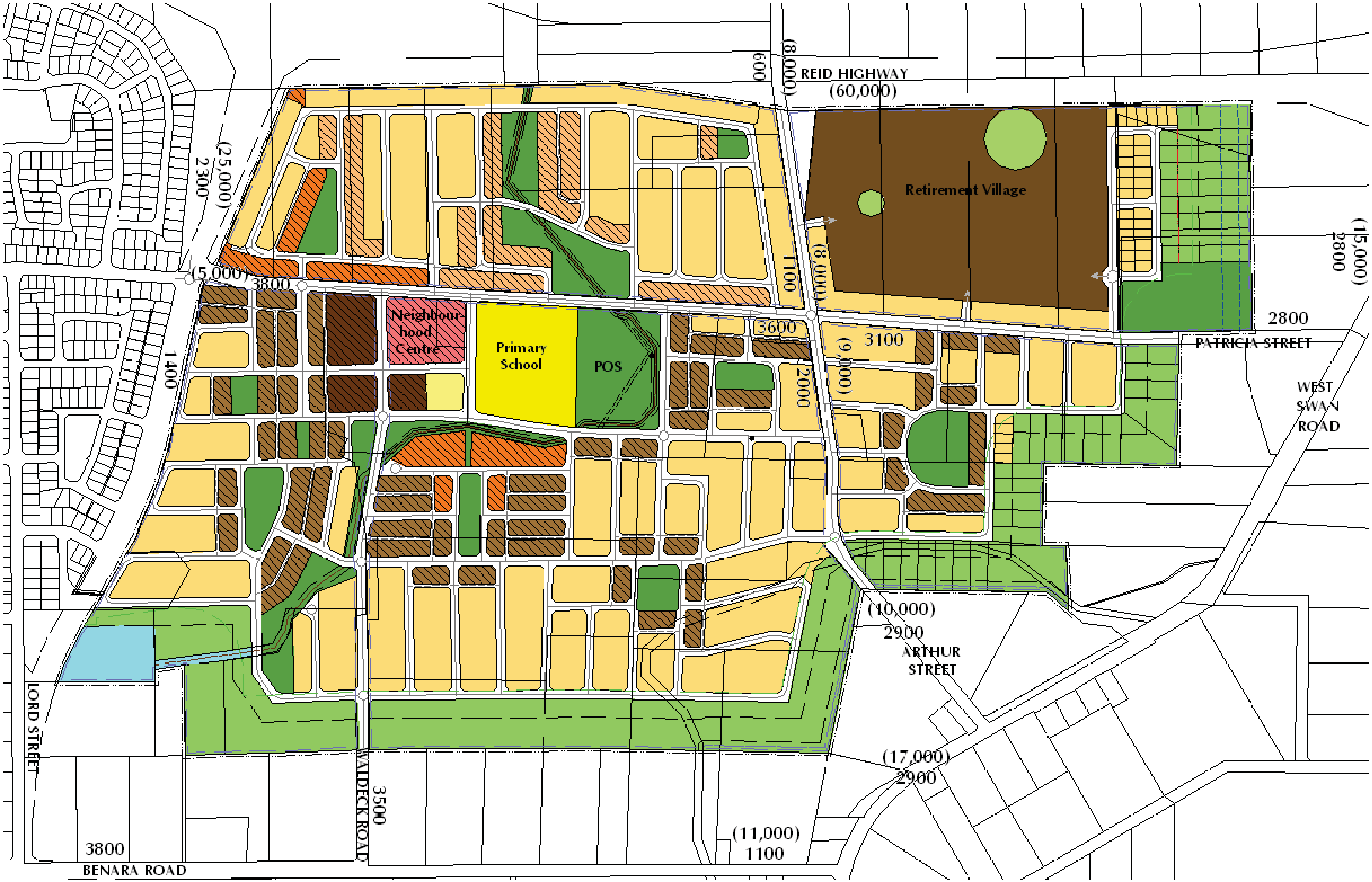


Figure 4.1. Daily traffic volumes (with Arthur Street flyover)

5.0 Road Network Assessment

5.1 Road hierarchy

Assuming the full development of the Caversham Structure Plan area the major roads within the development area can be expected to have the following classifications under *Liveable Neighbourhoods* (October 2007). The road hierarchy has been determined based on projected traffic volumes and expected functionality of the roads. The road hierarchy is also shown in Figure 5.1 (prior to Arthur Street flyover) and in Figure 5.2 (following construction of the flyover).

Reid Highway - Primary Distributor

West Swan Road - Integrator Arterial A

Lord Street - Integrator Arterial A

Benara Road - Integrator Arterial B

Patricia Street - Neighbourhood connector A

Waldeck Road - Neighbourhood connector B

Arthur Street - Design for a District Distributor (but will operate as a neighbourhood connector B until the flyover is constructed)

All other subdivision roads within the development can be classified as access streets.

Without construction of the flyover across the Reid Highway, the forecast traffic volumes for Arthur Street are less than 3,000 vpd. However, Arthur Street is currently classified as a local distributor road under the Metropolitan Functional Road Hierarchy and the City of Swan has advised that it should be designed as a District Distributor road in the future. Design for this road must take into account its potential future functionality and the cross section in the following section reflects this.

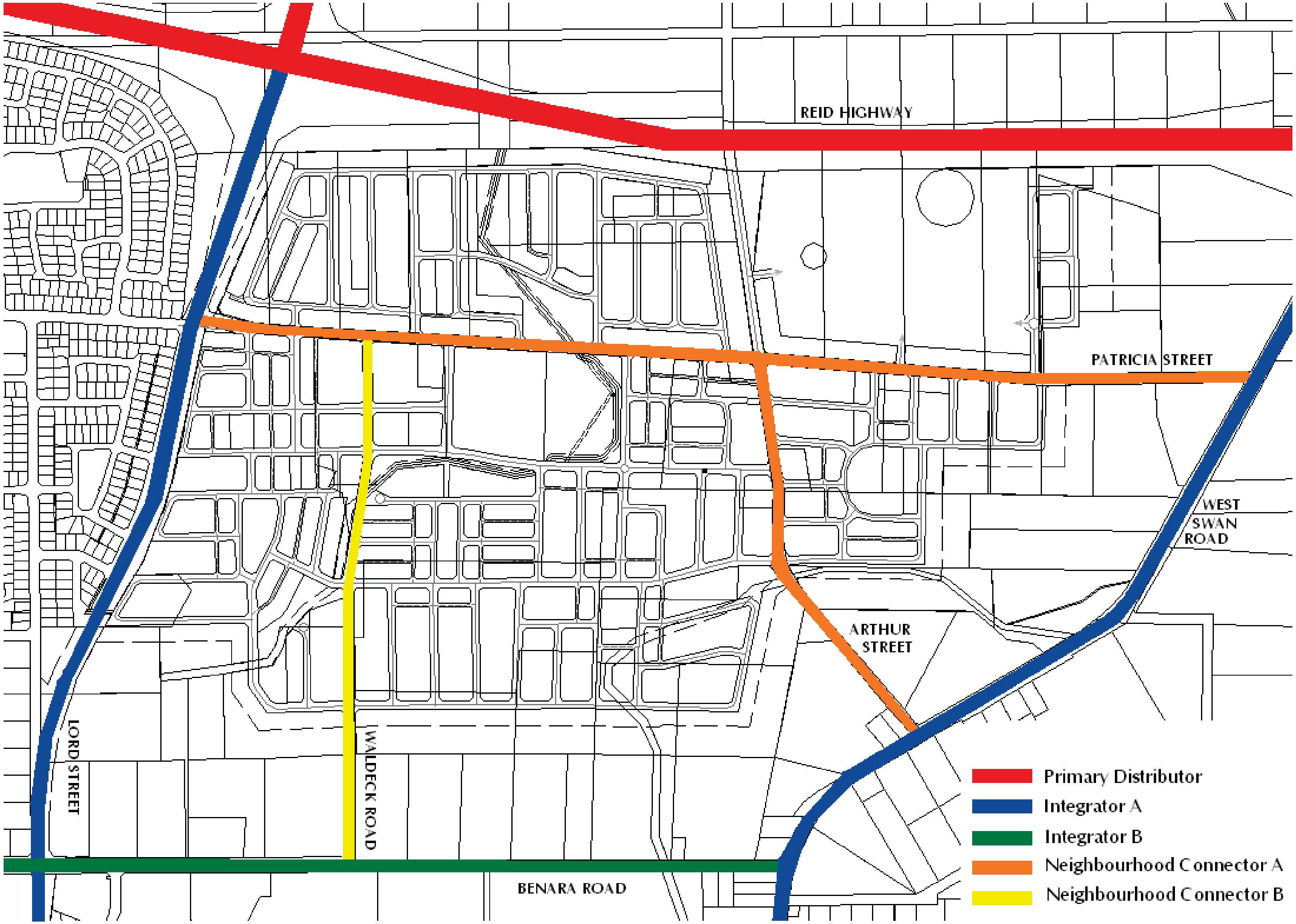


Figure 5.1. Road hierarchy (without Arthur Street flyover)

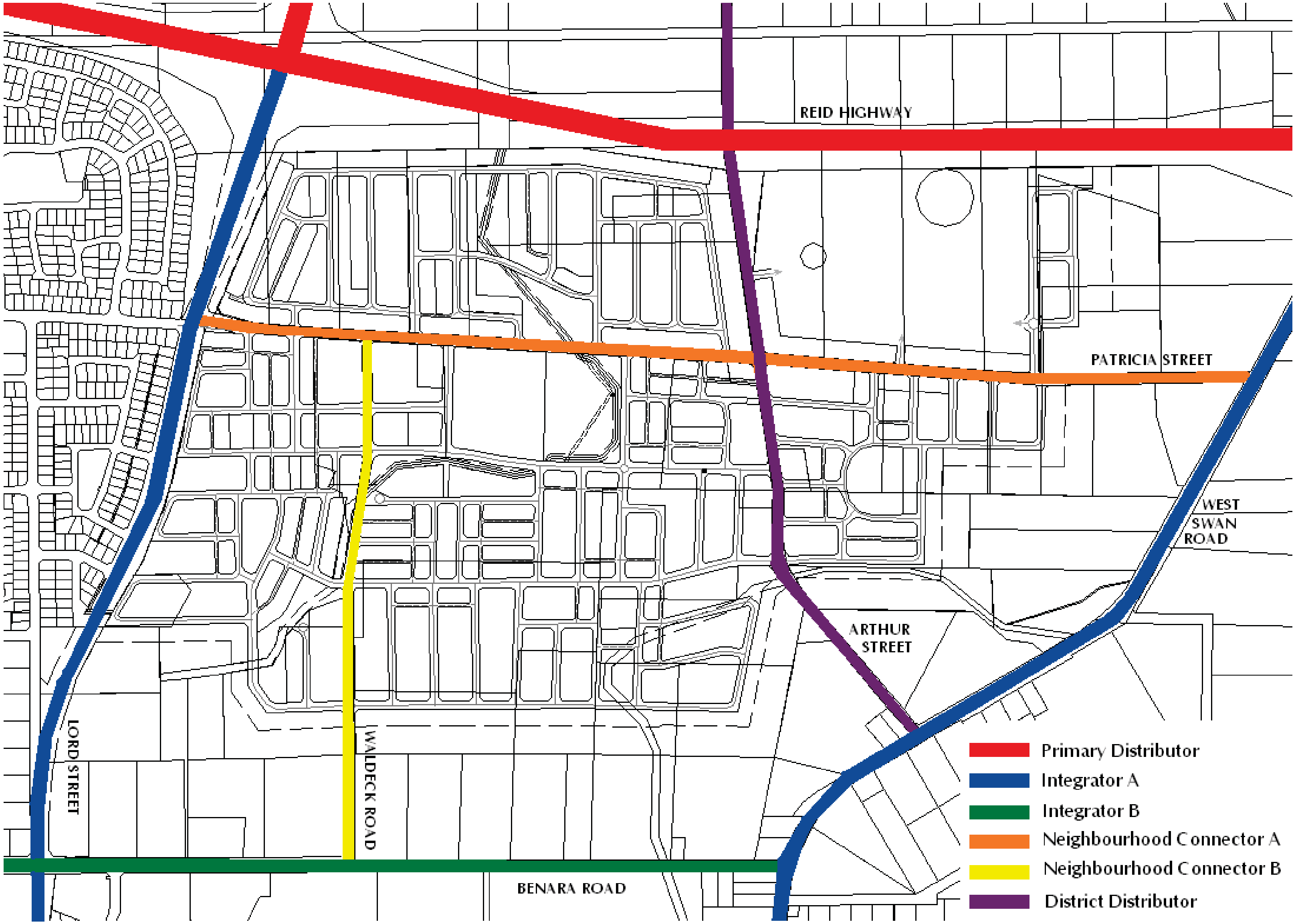


Figure 5.2. Road hierarchy (with Arthur Street flyover)

5.2 *Cross sections*

Indicative cross sections for typical roads within the Caversham development are provided in Appendix E.

Most minor access streets are proposed to have a 15m road reserve. This reserve will allow for informal parking (staggered) on both sides of the street and an indicative cross section is provided in Figure A. Leg lengths on these streets will need to be kept to a minimum and traffic speeds controlled to a recommended 30 km/h. These streets are appropriate for low traffic volumes.

If more formal parking is desired, the reserve will need to be widened to 16m, as shown in Figure B.

A proposed road reserve of 13m is proposed for most access streets abutting public open space (see Figure C).

Indented parking is proposed for streets providing main access to activity nodes and uses such as public open space. The parking in these locations would either be indented on both sides of the road or would be provided on the side of the road abutting the land use generating the parking requirement.

Individual cross sections are presented for Patricia Street, Arthur Street and Waldeck Road in Appendix E.

The proposed Patricia Street 21.5m road reserve allows for indented parking adjoining activity and traffic generating land uses and the proposed 3.5m traffic lanes are appropriate for this future bus route. Figure D suggests an indicative cross section for Patricia Street and includes a median to allow for safe pedestrian crossings. The *Caversham North Local Structure Plan Transport Review* (April 2008) by Cardno BSD indicated that the central median would be designed as a drainage swale and the City of Swan's response to that report indicated a 5m swale would be accepted. Front lot access is considered acceptable given traffic volumes in the order of 5,000 vpd or less on Patricia Street.

It is considered that a road reserve of 25 m for Arthur Street is sufficient to carry future traffic levels, including future traffic generated by the development north of Reid Highway, post construction of the Arthur Street flyover. Figure E suggests an indicative cross section for Arthur Street and includes a median for safe pedestrian crossing, cycle lanes, bus access, indented parking and shared use paths along both sides.

The City of Swan has advised that it is likely that Arthur Street will become a key public transport route in the future (hence the need to consider buses within cross section design) and cycle lanes and shared use paths are recommended to reflect its future importance in terms of north-south connectivity.

Figure F does not include cycle lanes and is proposed for Waldeck Road (20 m reserve).

5.3 Road works timing and funding

Discussion with MRWA, the Department for Planning and Infrastructure and the City of Swan indicates that the extension of Lord Street could be undertaken in staged construction, initially from Reid Highway south to Patricia Street and that funding would be sought from the developer. Previous discussions indicate that the City of Swan would request the developer to fund one carriageway and the earthworks for both carriageways, as well as to contribute in part to the construction of traffic signals at the Reid Highway/ Lord Street intersection.

Contributions from development to the west of the Lord Street extension have been used by the WAPC to purchase land requested for Lord Street and will not be available for construction of the extension. The City of Swan advised that the Caversham project will be required to fund the construction cost of one carriageway however detailed discussions will be required to determine the extent of co-funding for the extension between the developers and the City of Swan.

It is proposed at this time that the Lord Street extension be undertaken in staged construction, with the extension south of Reid Highway to Patricia Street providing access to the development in the interim phase. The following staging plan has been proposed:

- Suggested construction stage 1: Single carriageway from Reid Highway to Patricia Street This should be timed to coincide with the release of land in cell 1, 4 and 5. The earthworks for the rest of the full extension (from Patricia Street to Benara Road) can also be incorporated in this stage.

- Suggested construction stage 2: Single carriageway from Patricia Street to Benara Road. This should be timed to coincide with works for the remaining construction of the development project.

- Suggested construction stage 3: Ultimate dual carriageway from Reid Highway to Benara Road. At this stage, it is expected that stage 3 construction would be undertaken by City of Swan.

The Arthur Street flyover is not considered critical for the development as outlined in the Caversham Structure Plan however it is considered desirable in terms of connectivity in the longer term. While it is recognised that the flyover is not required for the Caversham development in the shorter term; as it is included within the MRS and will improve connectivity in the overall area, it is accepted that it will be constructed in the longer term as the surrounding road network is developed further.

5.4 *Intersection control*

5.4.1 Intersections with external road network

- Arthur Street/ West Swan Road

The T-intersection between Arthur Street and West Swan Road would initially operate under priority control. It is recommended that a median be constructed on West Swan Road to allow for two stage crossing. In the future, if the Arthur Street flyover is constructed over Reid Highway, traffic signals or a roundabout may be required.

- Patricia Street/ West Swan Road

The T-intersection between Patricia Street and West Swan Road would operate under priority control. It is recommended that a median be constructed on West Swan Road to allow for two stage crossing.

- Lord Street/ Reid Highway

The MRS in this area has provision for a grade-separated interchange at this intersection. It is currently proposed as a standard diamond interchange with Lord St (connection to south) going over the top of Reid Highway. In the interim, it is likely to be signalised as part of the staging for the development of the road network.

- Lord Street/ Benara Road

Lord Street and Benara Road are both classified as integrator arterials. The SKM analysis for the Sub Regional Structure Plan indicates future traffic volumes in the order of 25,000 vpd on Lord Street south of Reid Highway. Traffic signal control is considered desirable for this intersection; however the intersection could operate under roundabout control depending on site conditions.

- Lord Street/ Patricia Street

It is proposed for Lord Street to become an integrator arterial (A) road and Patricia Street to operate as a neighbourhood connector at its intersection with Lord Street. Access from Lord Street to Patricia Street is clearly an inherent principle in the *Sub Regional Structure Plan for the Swan Urban Growth Corridor* as the concept of an Activity Corridor along Patricia Street to Arthur Street depends upon this connection.

The following comment is based on Lord Street remaining an arterial road without controlled access highway status.

Stage one - T junction with Lord Street north and Patricia Street west and east.

A two staged construction is proposed for the Lord Street extension. The first stage is proposed to be constructed between Reid Highway and Patricia Street. The intersection during this phase would operate as a modified T-junction with priority given to the traffic movements between Lord Street and Patricia Street west of the intersection. A GIVE WAY sign would be required on Patricia Street east approach.

Ultimate stage - four way intersection

Discussion with City of Swan suggested that at this stage there is no concrete proposal for the type of control at the intersection of Lord Street and Patricia Street, however roundabout control may be appropriate. It is suggested that, given the proximity to proposed traffic signal control at the Lord Street / Reid Highway intersection and other factors affecting safe vehicle movements at this intersection, more detailed analysis of the most appropriate ultimate intersection control at the Lord Street / Patricia Street intersection be undertaken prior to the detailed design phase.

- Waldeck Road / Benara Road

The T-intersection between these two roads would operate satisfactorily under priority control with widened median on Benara Road to allow for 2 stage right turn crossing from Waldeck Road.

5.4.2 Intersections within Caversham

- Patricia Street / Waldeck Road

The intersection between Patricia Street and Waldeck Road will be in close proximity to the proposed Neighbourhood Centre. A priority controlled T-intersection is considered appropriate.

- Patricia Street/ Arthur Street

The four-way intersection between Patricia Street and Arthur Street is proposed to be constructed as a roundabout. This will help to control traffic speeds on both roads and allow safe operation of this four-way intersection both with and without the additional traffic associated with the future Arthur Street flyover.

- Other minor intersections

Several other four-way intersections (particularly along Patricia Street, Arthur Street and Waldeck Road) within the development area will also be constructed as roundabouts as shown on the Caversham Structure Plan. Other four-way intersections should be avoided where possible, for example through the construction of staggered right-left intersections. Where additional four-way intersections are still proposed they will need to be designed with suitable traffic management treatments to slow traffic on the side streets to ensure safe intersection operation.

6.0 Cyclists and Pedestrians

6.1 Objective

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 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.

6.2 Pedestrian and cyclist provision

Existing facilities for cyclists are shown in the Department for Planning and Infrastructure's Perth Bike Maps. The map extract in Figure 6.1 shows the existing shared paths and cycle lanes on the roads surrounding the Caversham Structure Plan area.

Figure 6.1: Existing cycle network

The Caversham Structure Plan aims to maximise pedestrian and cyclist connections to the local and regional pedestrian / cycle network.

The neighbourhood centre and primary school can be easily accessed on foot from most of the residential lots in cells 1, 4 and 5. Pedestrian / cyclist movements between the cells within the structure plan area can be made along Patricia Street, Arthur Street and Waldeck Road. Local movements within the cell are readily facilitated by other local streets, which provide direct or indirect linkage to the three major streets namely Patricia Street, Arthur Street and Waldeck Road.

It is proposed to accommodate on-street cycle lanes on Arthur Street as shown in Figure 6.2 to connect with the existing cycle lanes on Reid Highway and West Swan Road south of Arthur Street.

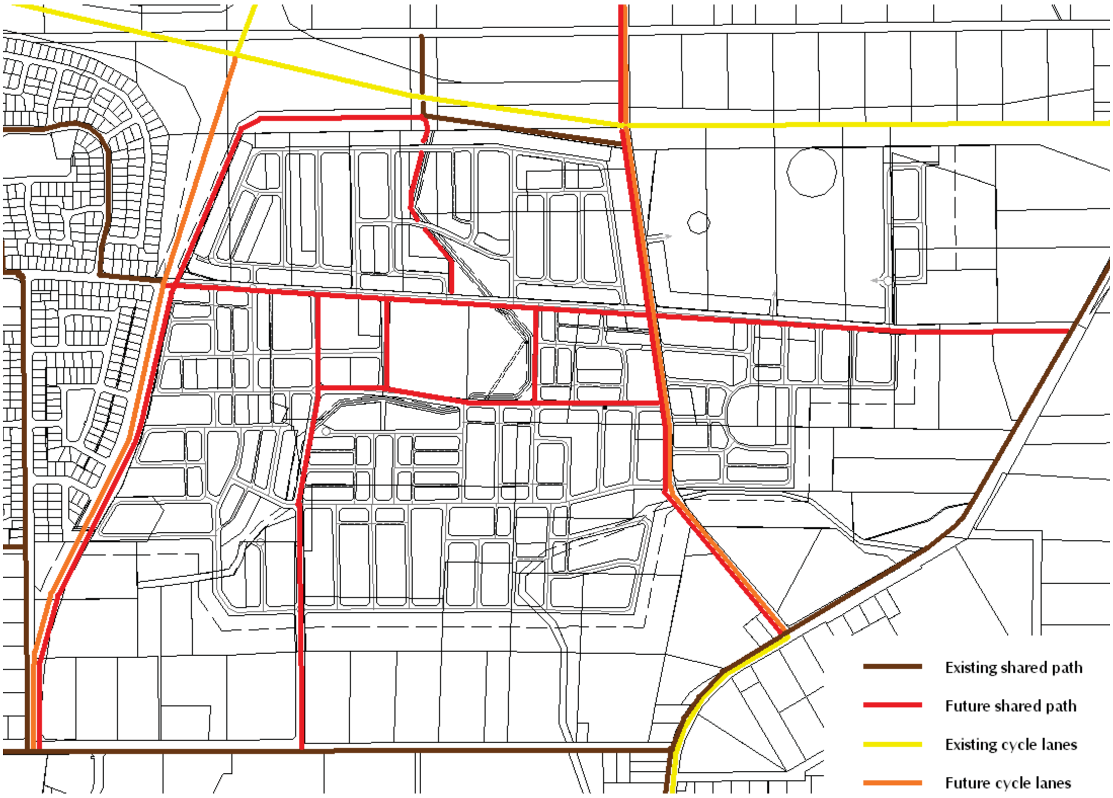


Figure 6.2: Future cycle network

Patricia Street and Waldeck Road are will not face the higher traffic volumes that Arthur Street could potentially carry if the flyover is built and are more likely to cater for school students than commuter cyclists. Therefore on-street cycle lanes are not considered necessary on Patricia Street and Waldeck Road.

Provision has been made within the cross sections of Arthur Street, Patricia Street and Waldeck Road for a 2.5m shared use path along one side of these neighbourhood connectors (and Arthur Street potential district distributor). A shared path is also proposed along three access streets that serve the neighbourhood centre, primary school and central public open space (POS). Another shared path is proposed along the linear POS between Patricia Street and Reid Highway to connect to the existing shared path north of Reid Highway as shown on Figure 6.2. The existing shared path on Reid Highway will be extended to Lord Street and a shared path will be included on the eastern side of the Lord Street extension abutting the development.

On local access roads it is envisaged that cyclists will share the roadway with motorists due to low traffic volumes and small speed differential (assisted by the introduction of the 50 kph speed limit in built up areas).

Footpaths should be provided along at least one side of all streets within the development, except very minor local access streets. These footpaths have a minimum recommended width of 1.5m.

The proposed pedestrian and cyclist network will provide efficient access to activity nodes such as the neighbourhood centre, as well as the primary school, public open space and public transport stops.

7.0 Public Transport

Bus route 337 services Lord Street to the west of the development and operates during the peak hours from Monday to Friday. Bus route 52 operates along Benara Road and route 63 has been extended to service the Bennett Brook Estate; however this is currently an infrequent service. Bus route 52 runs from Benara Road along West Swan Road (turning into Middle Swan Road), however this is also a very infrequent service.

In discussion with the PTA it has been suggested that a future bus route may operate from Bennett Street (current route for bus 63) along the extension of Patricia Street towards West Swan Road.

However, it is not envisaged that the bus route will continue into West Swan Road. PTA has advised that a turning loop at the eastern end of Patricia Street would likely be required as right turning movements into West Swan Road are not desirable and also the patronage in this area does not justify a bus route along West Swan Road. The road cross sections proposed under section 5.2 provide for bus access along Patricia Street. Bus access could also be accommodated within the 20m road reserves proposed for Waldeck Road and Arthur Street.

Bus routes will be re-assessed when more detailed timing is available for the staged construction of Lord Street and when structure planning has progressed further.

Ultimately, if the Arthur Street flyover is constructed across Reid Highway and Patricia Street – Arthur Street becomes an Activity Corridor as proposed in the draft *Sub Regional Structure Plan for the Swan Urban Growth Corridor* then it is anticipated that bus services will also run along this Activity Corridor. The Sub Regional Structure Plan indicates that services from Ellenbrook to Morley and Ellenbrook to Bassendean, which currently use Lord Street, would operate along the Activity Corridor in future.

These future possible bus routes are shown in Figure 7.1.

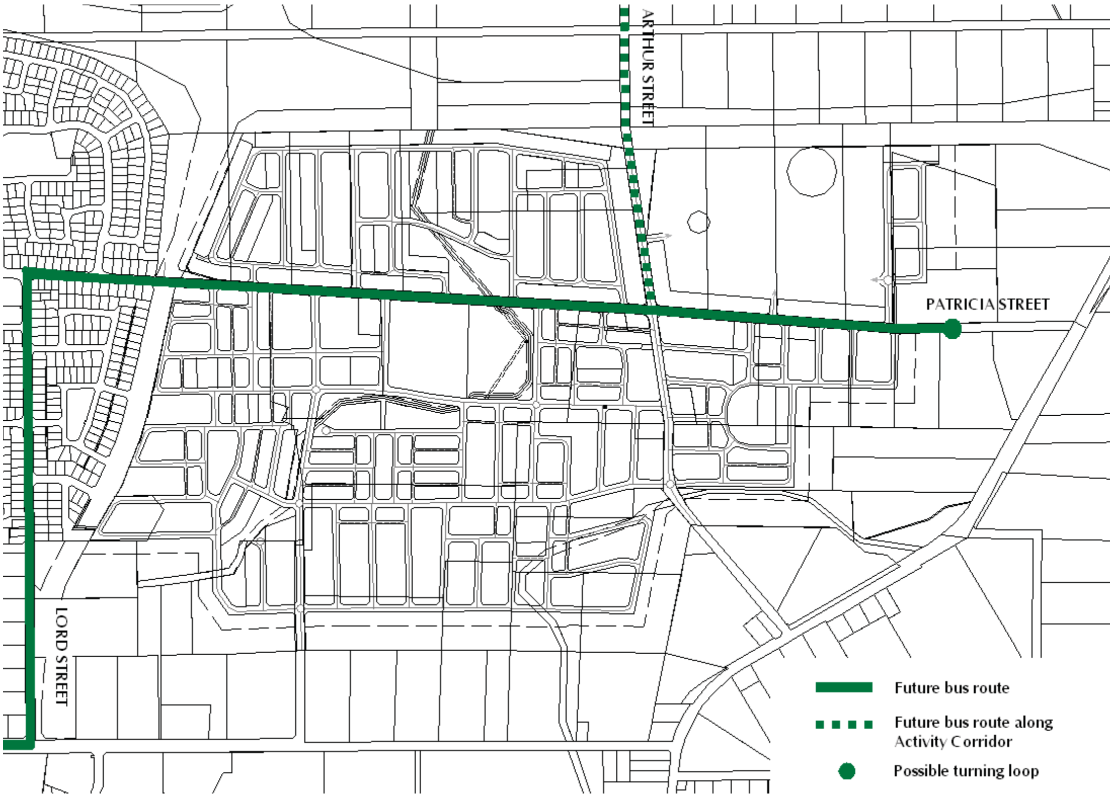


Figure 7.1: Future public transport

8.0 Summary

The main findings of the traffic study for the Caversham Structure Plan are outlined below.

- Traffic volumes in the order of 25,000 vpd are forecast for the proposed Lord Street extension.
- Traffic volumes of up to 20,000 vpd are forecast for West Swan Road.
- Traffic volumes in the order of 5,000 vpd are forecast for Patricia Street to the west and in the order of 3,000 vpd to the east towards the intersection with West Swan Road.
- Traffic volumes of up to 3,500 vpd are forecast for the southern end of Waldeck Road.
- Traffic volumes ranging from 1,000 to 3,000 vpd are forecast for Arthur Street (without flyover).
- Traffic volumes ranging from 8,000 to 10,000 vpd are forecast for Arthur Street with connection through to the north following construction of the flyover.
- The Arthur Street flyover is not considered critical to the Caversham development in terms of traffic flow or access, however it is considered desirable in terms of strategic planning for a future Activity Corridor and is reserved for construction under the MRS in the longer term.
- The detail with respect to timing, funding and construction for the Lord Street extension needs to be refined in an agreement between the developer and the City of Swan. At this stage it is expected that the extension will be, at least in part, developer funded and will likely be constructed in a three stage process.
- The classification of Lord Street will need to be finalised before the details of an intersection between Lord Street and Patricia Street can be decided, although a connection here is assumed in the draft *Sub Regional Structure Plan for the Swan Urban Growth Corridor*.
- The pedestrian network is intended to provide direct and legible access within the development and to major land uses such as the neighbourhood centre and primary school.
- It is proposed that on-street cycle lanes be provided on Arthur Street to connect to the existing external cycle network.
- Shared paths are to be provided on one side of Arthur Street, Patricia Street and Waldeck Road and several other access streets serving the neighbourhood centre and primary school. A shared path will also be provided along linear open space between Patricia Street and Reid

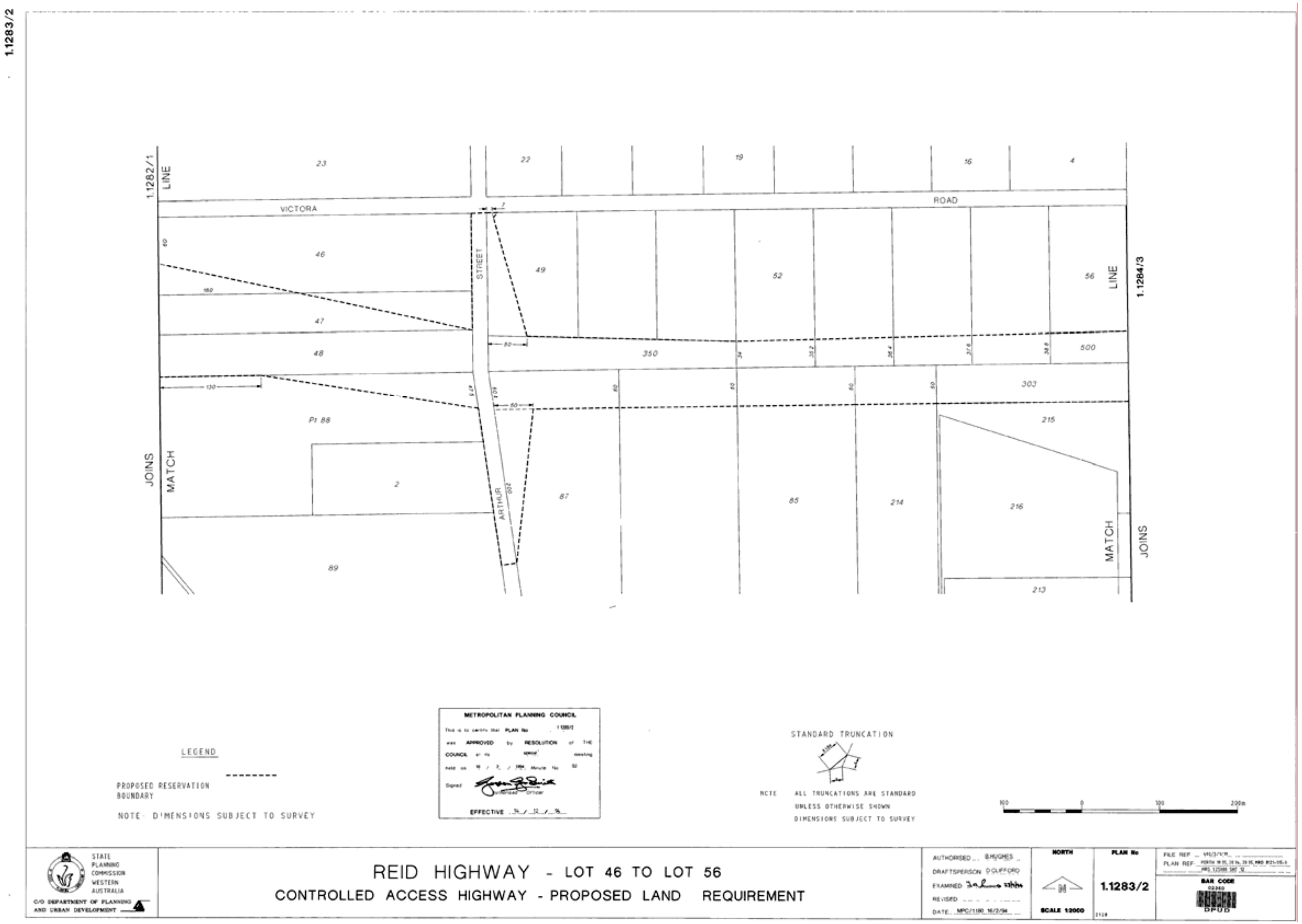
Highway to connect to an existing shared path at Reid Highway. The existing shared path on Reid Highway will be extended to Lord Street and a shared path will be included on the eastern side of the Lord Street extension abutting the development.

- Current access to public transport in the Caversham development area is relatively low, with the general area serviced by three separate routes operating during peak hour only. The PTA have advised of the potential for a future bus route to operate along the extension of Patricia Street towards West Swan Road (not connecting into West Swan Road).

- Ultimately, if the Arthur Street flyover is constructed across Reid Highway and Patricia Street – Arthur Street becomes part of an Activity Corridor as proposed in the draft *Sub Regional Structure Plan for the Swan Urban Growth Corridor* then it is anticipated that some Ellenbrook bus services will also operate along this Activity Corridor.

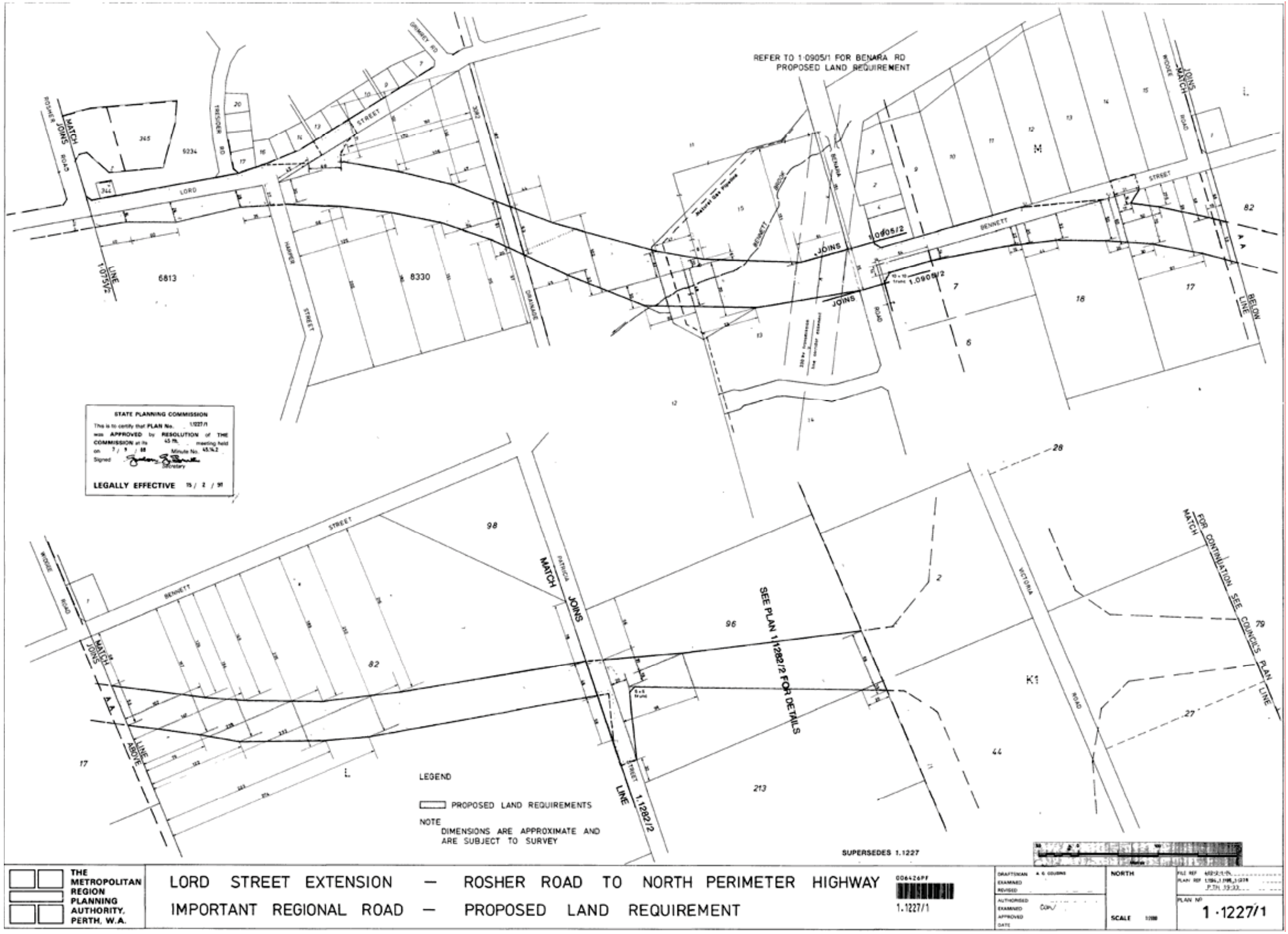
Appendix A

Land requirement of Reid Highway


1.1283/2
VICTORA
ROAD
STREET
ARTHUR
MATCH
JOINS
LINE
1.1282/1
1.1284/3
LEGEND
PROPOSED RESERVATION BOUNDARY
NOTE: DIMENSIONS SUBJECT TO SURVEY
METROPOLITAN PLANNING COUNCIL
STANDARD TRUNCATION
NOTE ALL TRUNCATIONS ARE STANDARD UNLESS OTHERWISE SHOWN DIMENSIONS SUBJECT TO SURVEY
STATE PLANNING COMMISSION WESTERN AUSTRALIA
C/O DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT
REID HIGHWAY - LOT 46 TO LOT 56
CONTROLLED ACCESS HIGHWAY - PROPOSED LAND REQUIREMENT
NORTH
PLAN No
1.1283/2
SCALE 1:2000
BAR CODE

Appendix B

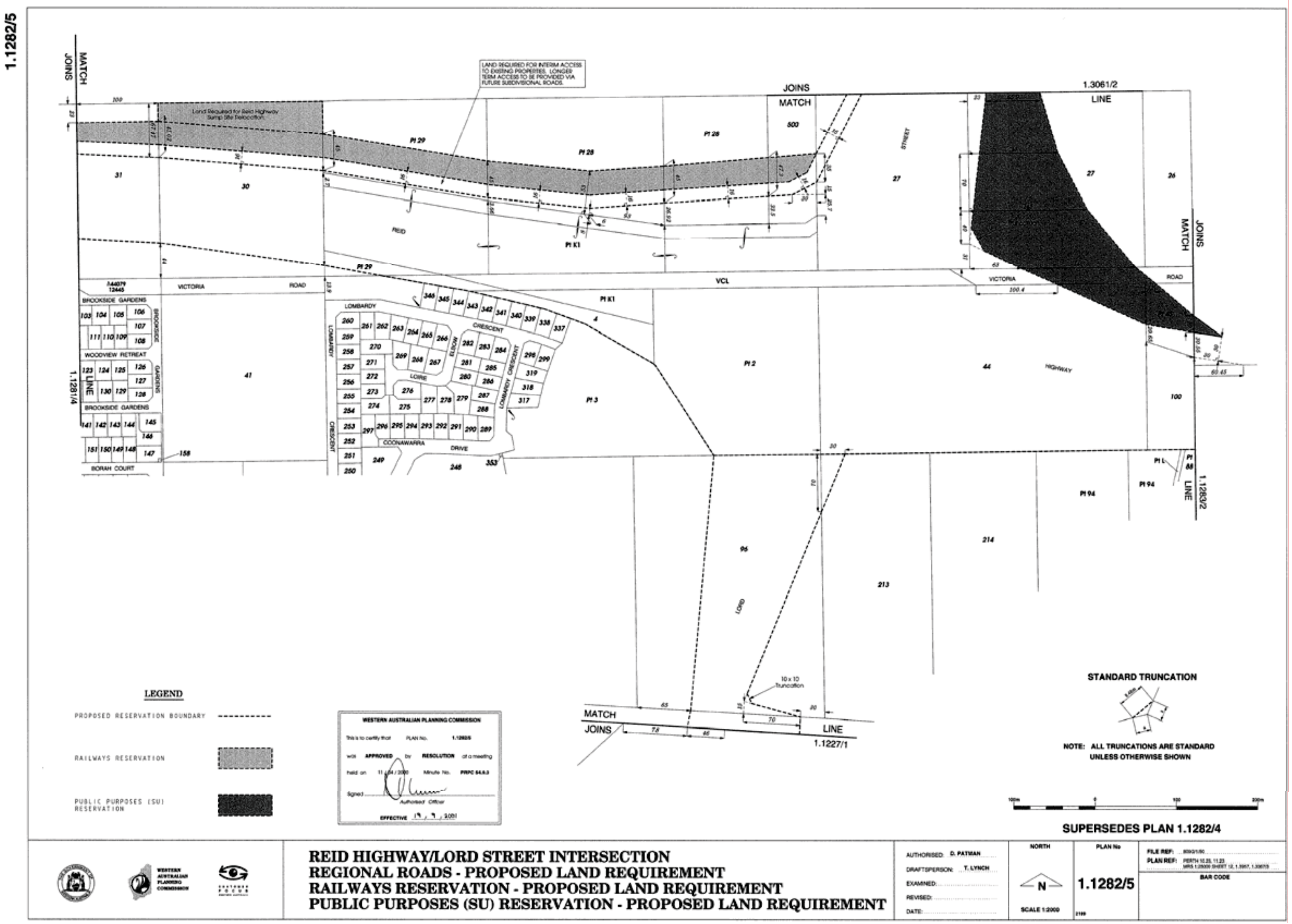
Land requirement of Lord Street extension


REFER TO 1·0905/1 FOR BENARA RD
PROPOSED LAND REQUIREMENT
LORD
STREET
BENNETT
STATE PLANNING COMMISSION
LEGALLY EFFECTIVE
SEE PLAN 1/1282/2 FOR DETAILS
MATCH LINE FOR CONTINUATION SEE COUNCIL'S PLAN
LEGEND
PROPOSED LAND REQUIREMENTS
NOTE
DIMENSIONS ARE APPROXIMATE AND
ARE SUBJECT TO SURVEY
SUPERSEDES 1.1227
THE METROPOLITAN REGION PLANNING AUTHORITY, PERTH, W.A.
LORD STREET EXTENSION — ROSHER ROAD TO NORTH PERIMETER HIGHWAY
IMPORTANT REGIONAL ROAD — PROPOSED LAND REQUIREMENT
NORTH
SCALE
1·1227/1

Appendix C

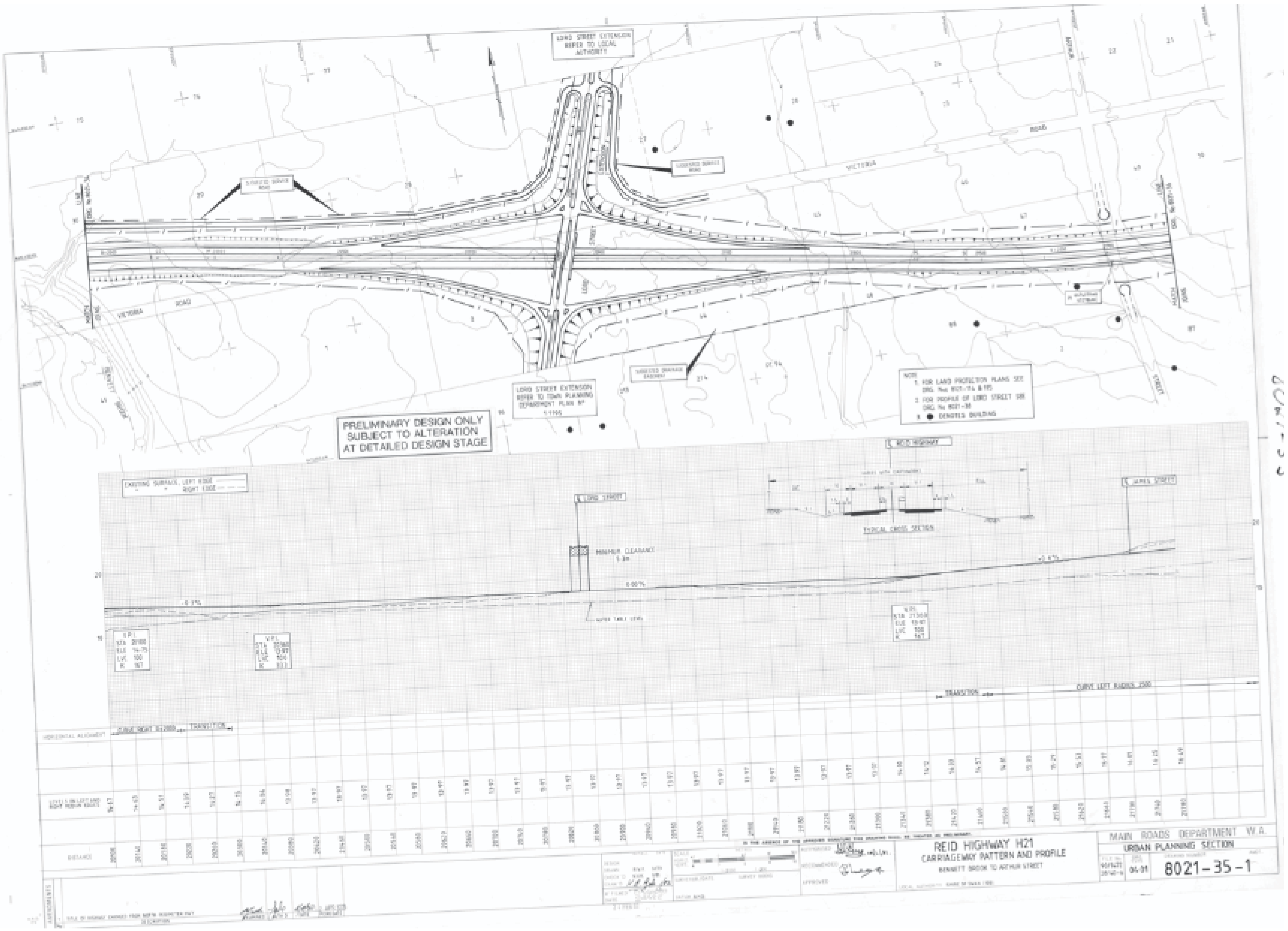
Land requirement of intersection of

Reid Highway and Lord Street


1.1282/5
MATCH
JOINS
LINE
1.3061/2
VICTORIA
ROAD
REID
HIGHWAY
LORD
STREET
LOMBARDY
CRESCENT
COONAWARRA
DRIVE
BROOKSIDE GARDENS
WOODVIEW RETREAT
BORAH COURT
1.1281/4
1.1283/2
1.1227/1
LEGEND
PROPOSED RESERVATION BOUNDARY
RAILWAYS RESERVATION
PUBLIC PURPOSES (SU) RESERVATION
WESTERN AUSTRALIAN PLANNING COMMISSION
STANDARD TRUNCATION
NOTE: ALL TRUNCATIONS ARE STANDARD UNLESS OTHERWISE SHOWN
SUPERSEDES PLAN 1.1282/4
REID HIGHWAY/LORD STREET INTERSECTION
REGIONAL ROADS - PROPOSED LAND REQUIREMENT
RAILWAYS RESERVATION - PROPOSED LAND REQUIREMENT
PUBLIC PURPOSES (SU) RESERVATION - PROPOSED LAND REQUIREMENT
AUTHORISED: D. PATMAN
DRAFTSPERSON: T. LYNCH
EXAMINED:
REVISED:
DATE:
NORTH
SCALE 1:2000
PLAN No
1.1282/5
FILE REF:
PLAN REF:
BAR CODE

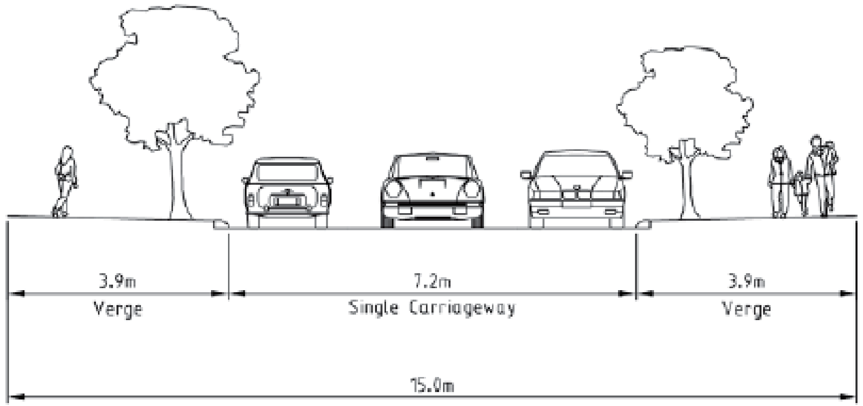
Appendix D

Preliminary design of Lord Street/ Reid Highway grade separated intersection


PRELIMINARY DESIGN ONLY
SUBJECT TO ALTERATION
AT DETAILED DESIGN STAGE
REID HIGHWAY H21
CARRIAGEWAY PATTERN AND PROFILE
BENNETT BROOK TO ARTHUR STREET
MAIN ROADS DEPARTMENT W.A.
URBAN PLANNING SECTION
8021-35-1

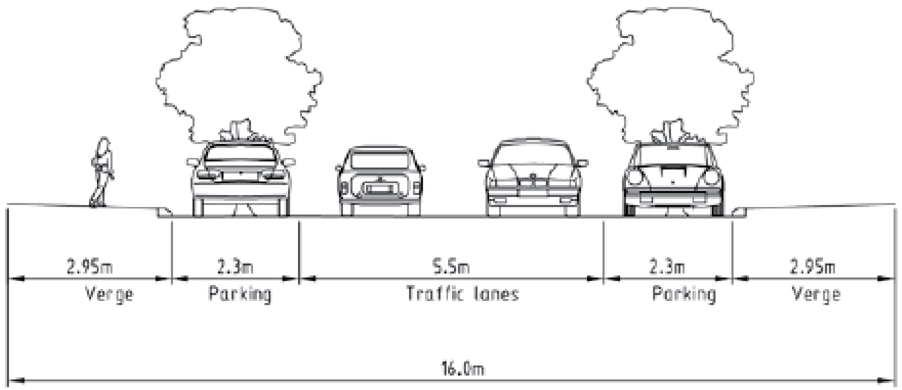
Appendix E

Indicative Cross Sections



A

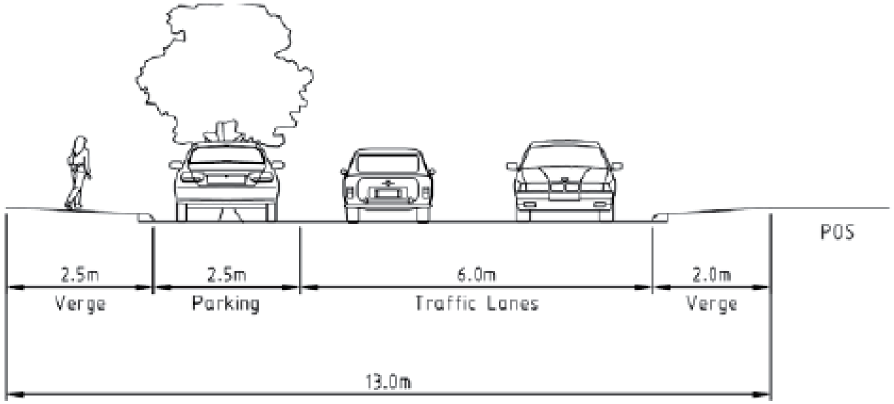
- Minor access road
- Standard single lots
- No cycle lane
- Informal parking (staggered)
- Low traffic volumes



B

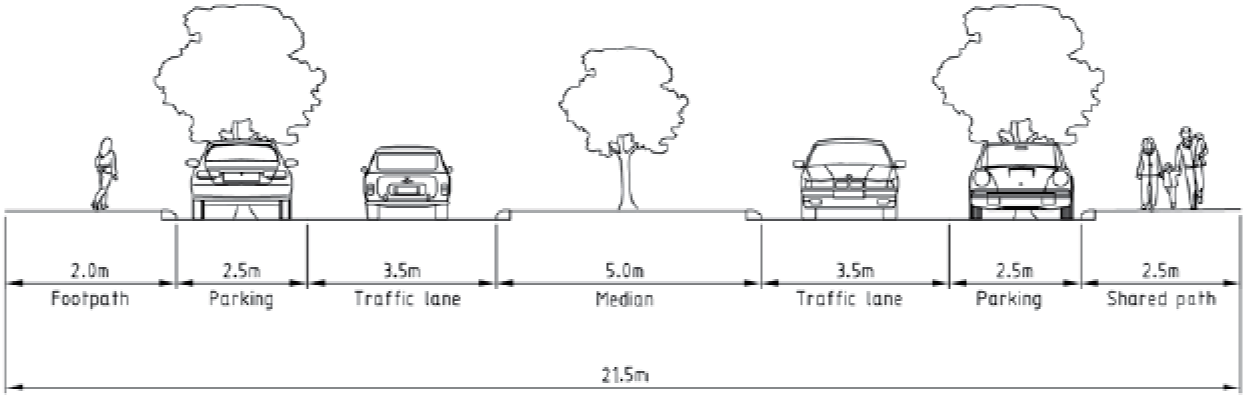
- Minor access road
- Alternative cross-section to ‘A’ where more formal parking is desired.

Cross sections are indicative only and will be subject to consultation with approval authorities at detailed design stage.



C

- Minor access road abutting P.O.S.
- Parking one side
- No cycle lane
- Low traffic volumes

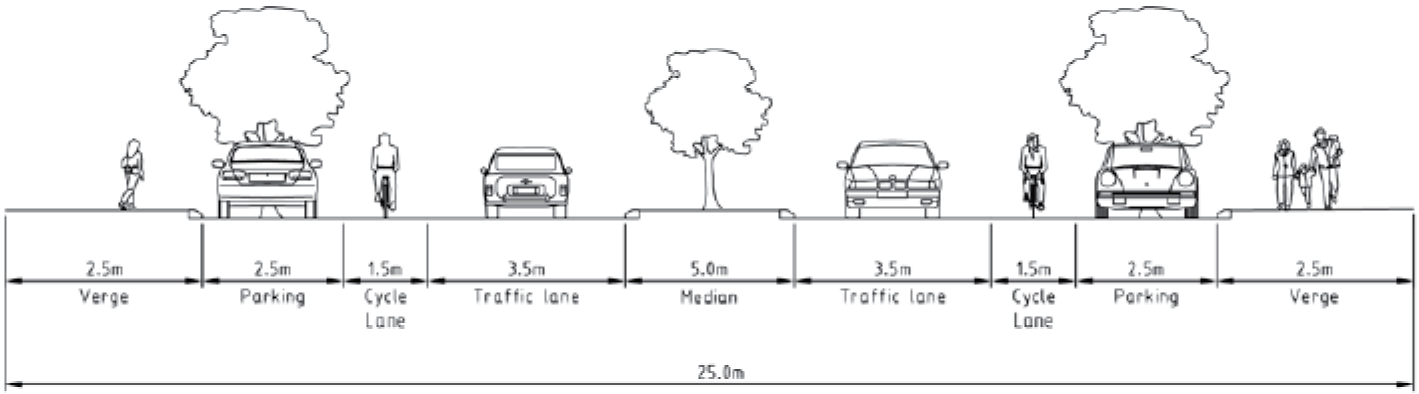


D

Patricia Street

- Neighbourhood Connector
- Indented parking
- No cycle lanes
- Shared path on one side
- Median is drainage swale
- Lane width accommodates buses

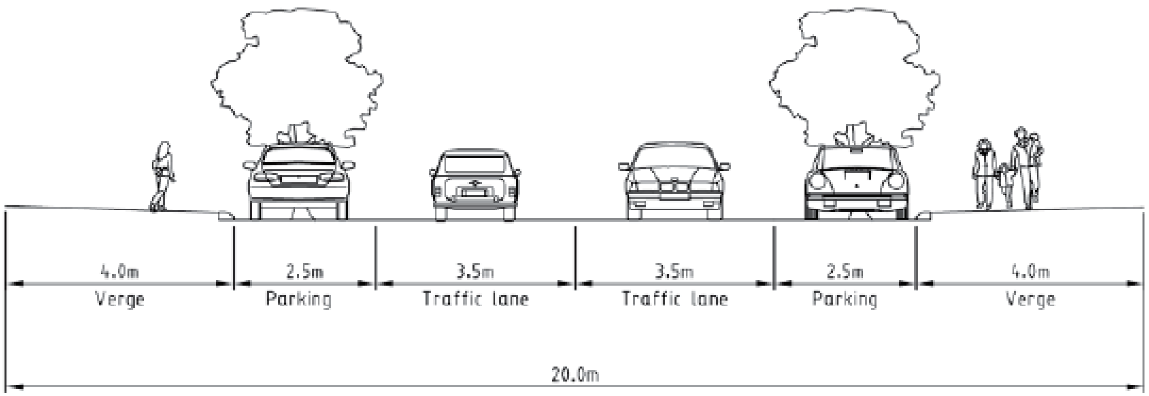
Cross sections are indicative only and will be subject to consultation with approval authorities at detailed design stage.



E

Arthur Street

- Future district distributor
- Indented parking
- Cycle lanes
- Shared path on one side
- Right turn pockets in median
- Lane width accommodates buses



F

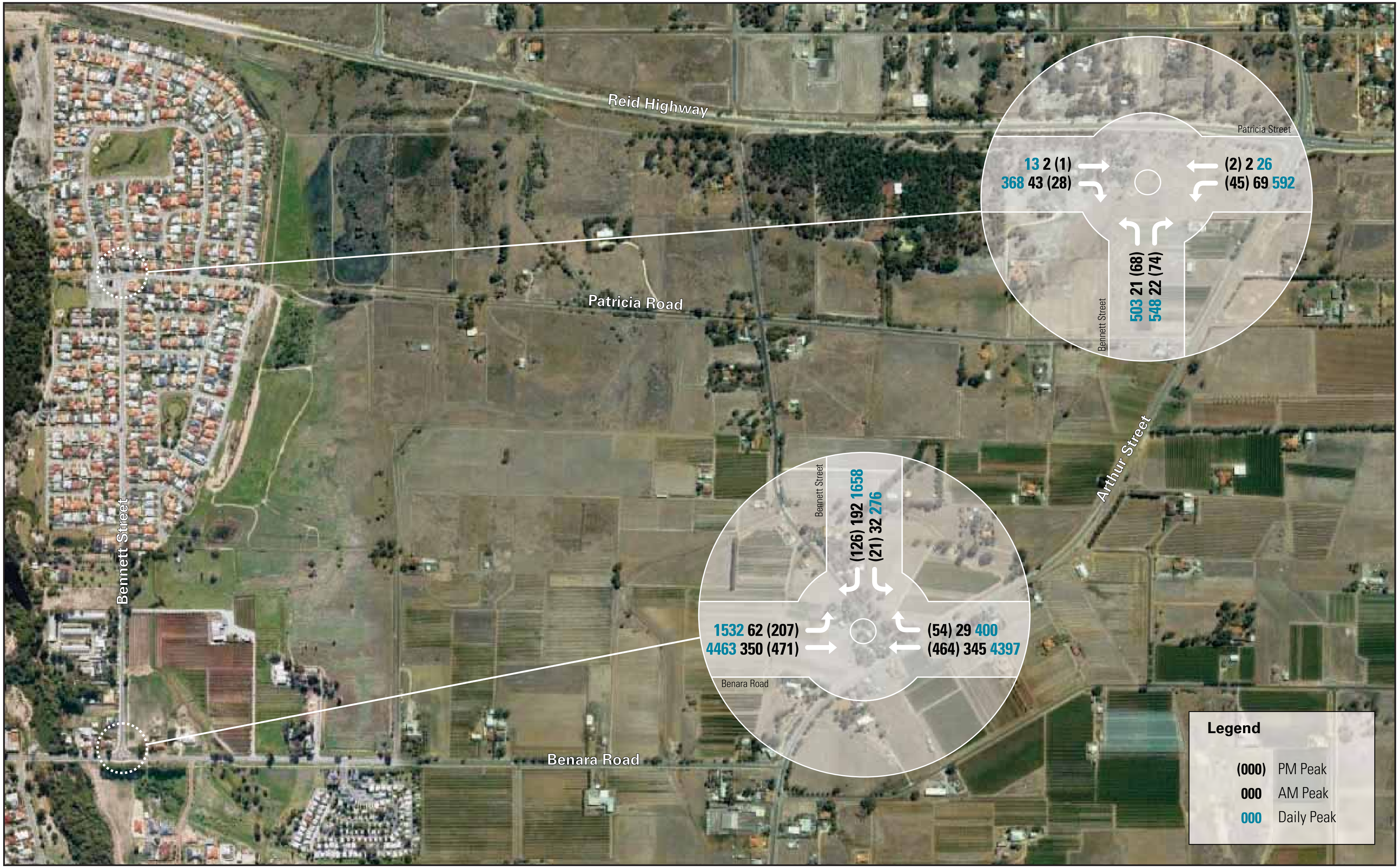
Patricia Street

- Neighbourhood Connector
- Indented parking
- No cycle lanes
- Shared path on one side

Cross sections are indicative only and will be subject to consultation with approval authorities at detailed design stage.

Appendix C

Turning Movement Volumes



Cardno EppellOlsen
Shaping the Future

Existing Scenario - Turning Movements

Appendix C1 | T08003

08 | 10 |2009

C:\CK Shared Artwork Folder\Perth\T08003_Volumes\T08003_Existing Scenario.CK.cdr

Cardno EppellOlsen
Shaping the Future

Stage 1 Scenario 1a - Development Turning Movements (with Patricia Street connection)

Appendix C2 | Job Number: T08003

08 | 10 |2009

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Shaping the Future

Stage 1 Scenario 1b - Development Turning Movements (without Patricia Street connection)

Appendix C3 | Job Number: T08003

08 | 10 |2009

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Shaping the Future

Stage 2 Development Scenario - Turning Movements

Appendix C4| Job Number: T08003

08 | 10 |2009

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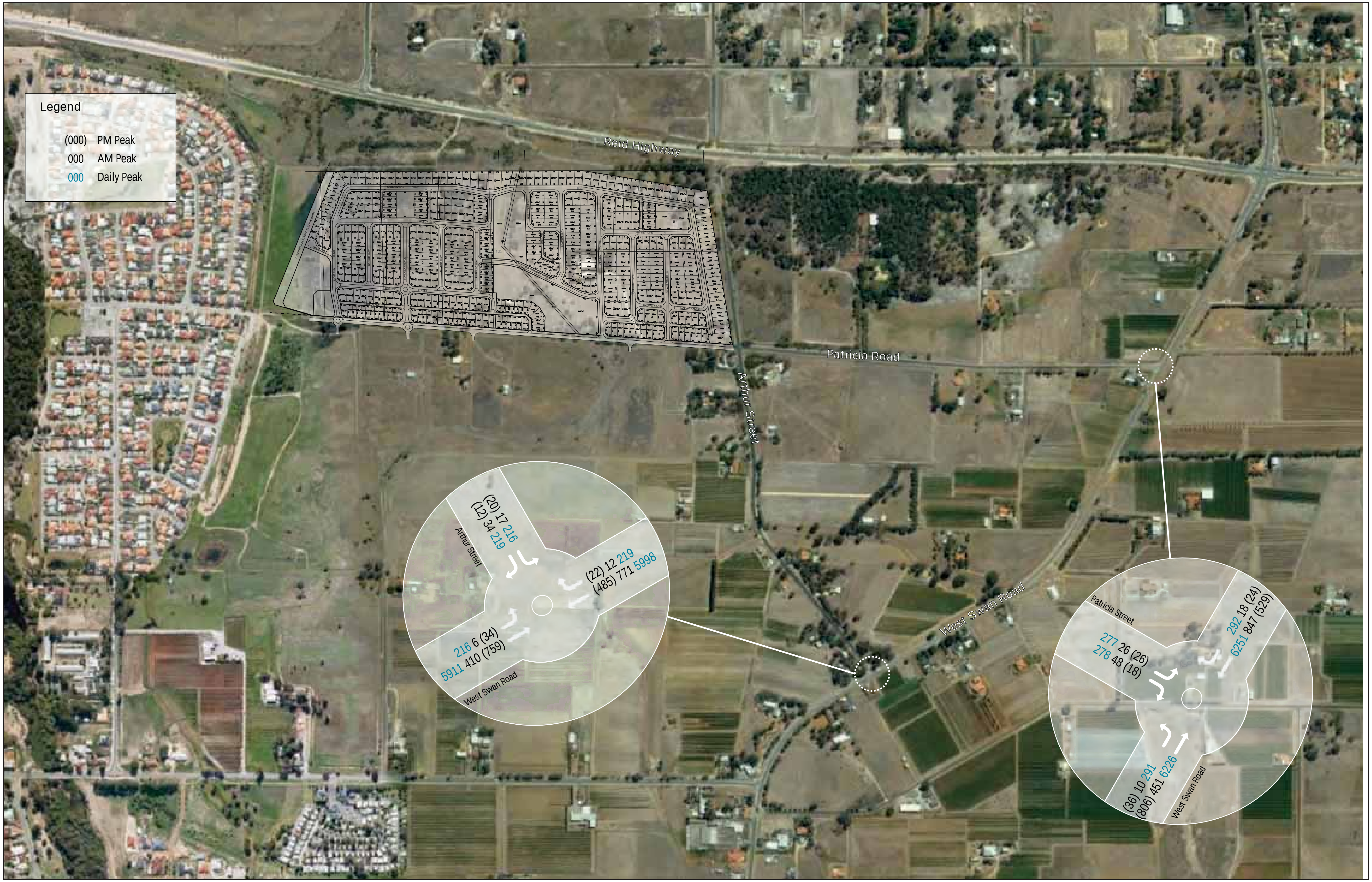

Cardno EppellOlsen
Shaping the Future

Stage 1 Scenario 1a - West Swan Road Turning Movements (with Patricia Street connection)

Appendix C5 | Job Number: T08003

08 | 10 |2009

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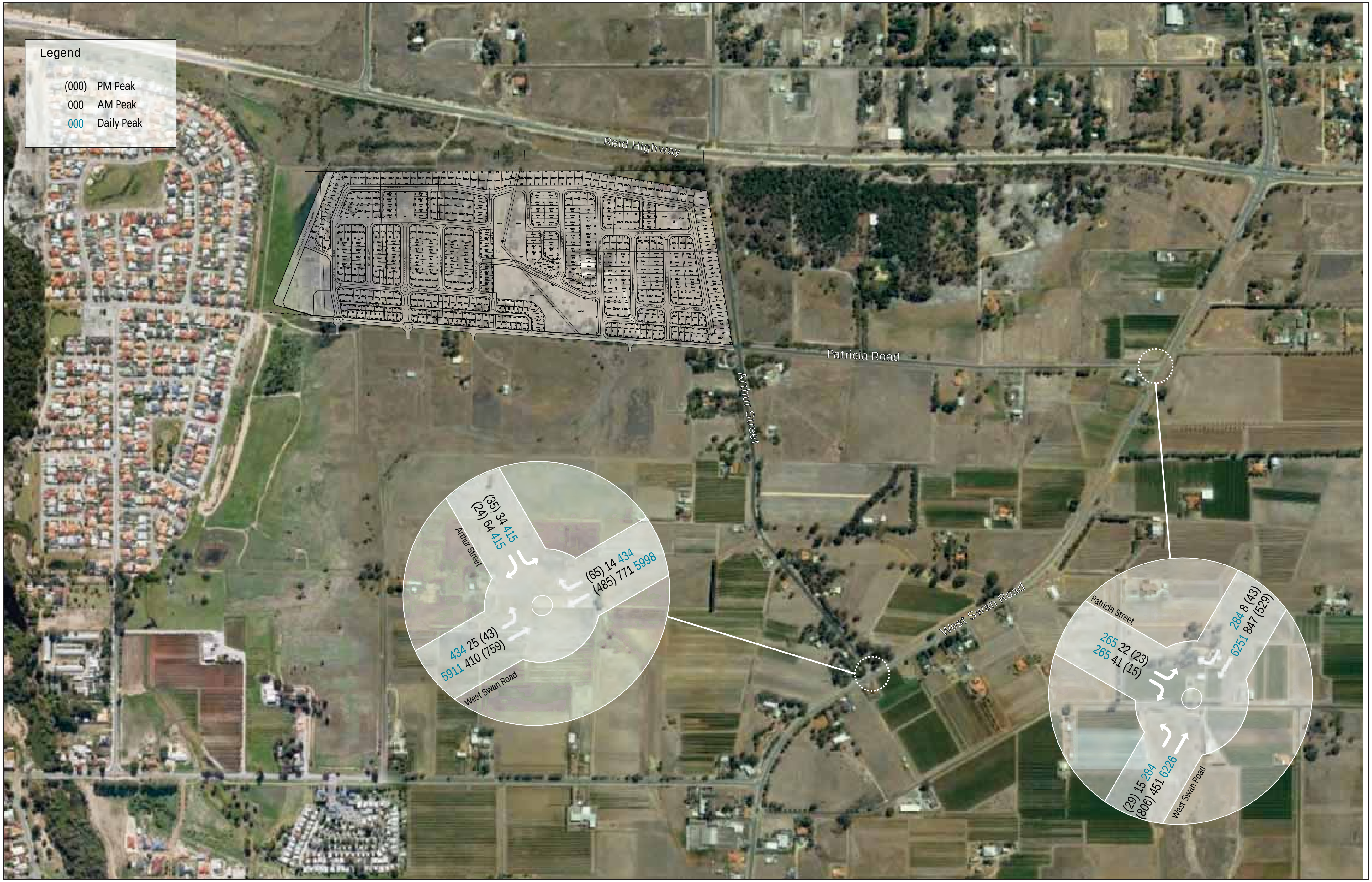

Cardno EppellOlsen
Shaping the Future

Stage 1 Scenario 1b - West Swan Road Turning Movements (without Patricia Street connection)

Appendix C6 | Job Number: T08003

08 | 10 |2009

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