CITY OF SWAN
Planning Information
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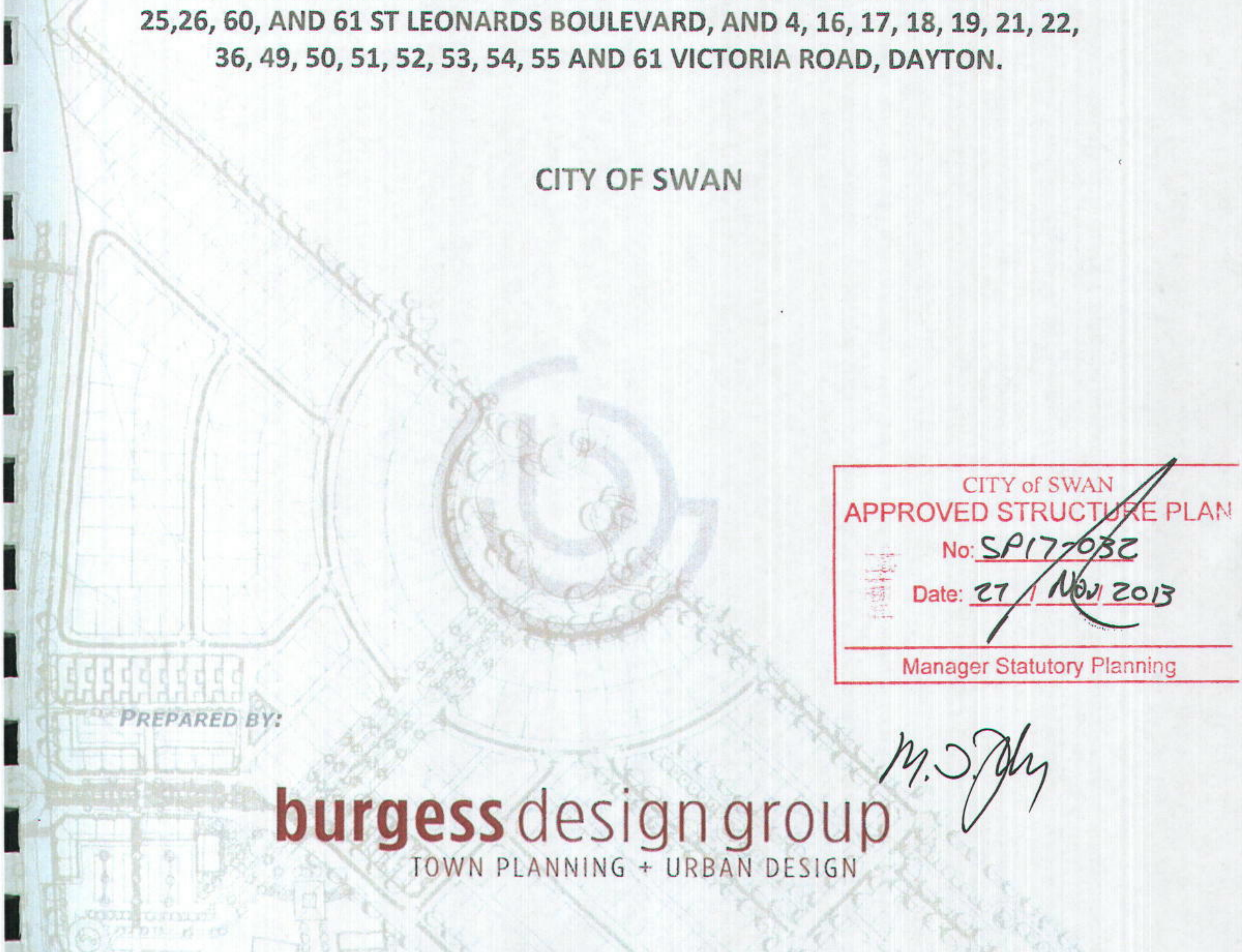
DAYTON
LOCAL STRUCTURE PLAN 2A

LOTS 22 ARTHUR STREET, 3, 2, 7, 8, 9, 10, 13, 16, 18, 19, 20, 21, 22, 24, 25,26, 60, AND 61 ST LEONARDS BOULEVARD, AND 4, 16, 17, 18, 19, 21, 22, 36, 49, 50, 51, 52, 53, 54, 55 AND 61 VICTORIA ROAD, DAYTON.

CITY OF SWAN



CITY of SWAN
APPROVED STRUCTURE PLAN
No: SP17/032
Date: 27 / NOV 2013
Manager Statutory Planning

PREPARED BY:

burgess design group
TOWN PLANNING + URBAN DESIGN

RECEIVED
9 DEC 2014
CITY OF SWAN - CUSTOMER SERVICES

DEPT OF PLANNING
06 JAN 2015
FILE SPN/0566

LOTS 22 ARTHUR STREET, 3, 2, 7, 8, 9, 10, 13, 16, 18, 19, 20, 21, 22, 24, 25, 26, 60, AND 61 ST LEONARDS BOULEVARD, AND 4, 16, 17, 18, 19, 21, 22, 36, 49, 50, 51, 52, 53, 54, 55 AND 61 VICTORIA ROAD, DAYTON.

City of Swan

DAYTON LOCAL STRUCTURE PLAN NO.2A

Issue 7: November 2014

Prepared for: **St. Leonards Estate Pty Ltd**

Prepared by: Burgess Design Group
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Project Planner: Mark Szabo
Job code: ASP WES LSP2A
File reference: 141118RLGA_Local Structure Plan 2A (WAPC amendments).doc
Revision No: 7

Quality Assurance

Issue/Version:	Date:	Author:	Reviewer:
Issue 1	28 February 2012	Karen Wright	Mark Szabo
Issue 2	9 April 2013	Karen Wright	Mark Szabo
Issue 3	30 April 2013	Karen Wright	Mark Szabo
Issue 4	23 May 2013	Kelley O'Neill	Mark Szabo
Issue 4	17 January 2013	Kelley O'Neill	Mark Szabo
Issue 5	17 June 2014	Mitch Bisby	Jaclyn Drummond
Issue 6	25 August 2014	Zarina MacDonald	Jaclyn Drummond
Issue 7	18 November 2014	Mitch Bisby	Mark Szabo

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

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

11 February 2015

In accordance with Schedule 2, Part 4, Clause 28 (2) and refer to Part 1, 2. (b) of the *Planning and Development (Local Planning Schemes) Regulations 2015.*

Date of Expiry: 19 October 2025

TABLE OF MODIFICATIONS TO PART ONE AND STRUCTURE PLAN MAP FOR

LOTS 22 ARTHUR STREET, 3, 2, 7, 8, 9, 10, 13, 16, 18, 19, 20, 21, 22, 24, 25, 26, 60, AND 61 ST LEONARDS BOULEVARD,
AND 4, 16, 17, 18, 19, 21, 22, 36, 49, 50, 51, 52, 53, 54, 55 AND 61 VICTORIA ROAD, DAYTON,
CITY OF SWAN

Modification No.	Description of Modification	Date endorsed by Council	Date endorsed by WAPC
1	Replacement of portion of the General Commercial land to Residential. Reclassify centre from ‘Neighbourhood’ to ‘Local’ with a maximum retail cap of 1500m2 NLA. Include reference to referring to City of Swan for POS contributions Various minor text modifications	28 July 2021	21 December 2021
2	Rezoning portion of Lot 10 from Residential to General Commercial and Lot 2 from General Commercial to Residential’, and removing the north-south laneway Various related text and plan modifications	18 November 2022	27 January 2023

EXECUTIVE SUMMARY

Burgess Design Group has been engaged by St Leonards Estate Pty Ltd, the registered landowners of Lot 22 Arthur Street, Lots 20-22, 24, and 25 St Leonards Boulevard, and Lots 22, 49-51, and 61 Victoria Road, Dayton (forming part of the land within Local Structure Plan No.2A(LSP2A)), to prepare and lodge the Local Structure Plan for land that is generally bound by Arthur Street to the west, Marshall Road to the north, the Dampier Bunbury Gas Pipeline easement to the east, and Reid Highway to the south.

The subject land is currently zoned “Urban” under the Metropolitan Region Scheme (MRS) and “Special Use No.11” under the City of Swan Local Planning Scheme No.17 (LPS17) and is subject to the provisions of Schedule 4 of LPS17. LSP2A has evolved from the high level structure planning that has occurred over the West Swan area, including; the Sub-Regional Structure Plan for the Swan Urban Growth Corridor that was endorsed by the Western Australian Planning Commission (WAPC) in 2009 and the (West Swan East Dayton) District Structure Plan that was endorsed by the WAPC in early 2012.

In summary, the LSP 2A proposes:

- Approximately 1113 (realistic) residential lots at densities ranging from R20 to R60, facilitating lot sizes from 150m2 to 450m2 ;
- 4.30ha of public open space to accommodate drainage and local recreational needs (including the preservation of an Aboriginal Heritage Site);
- A 1500m2 local centre adjacent to a ‘special use’ community site and Local Open Space (the latter two elements contained within Local Structure Plan area 1) to provide a strong community focus; and,
- An integrated transport and servicing network.

This Local Structure Plan report has been prepared in consultation with a number of subconsultants and is informed by a suite of technical investigations and documentation (copies of which can be found as the appendices) that includes: Environmental Assessment, Traffic Impact Assessment, Civil Engineering and Servicing Report, Local Water Management Strategy and a Landscape Management Plan.

Once endorsed, this Local Structure Plan will dictate the zoning or reservation and the Residential Design Code, where applicable, to individual land holdings and form the framework for landowners to proceed towards subdivision and development in a well planned and logical manner. The LSP2A will also enable the relevant government agencies to assess such future proposals in a coordinated fashion.

This Local Structure Plan is located within Development Contribution Area 2 (DCA2) Dayton.

TABLE 1 STRUCTURE PLAN SUMMARY TABLE

Item	**Data**	**Section Number referenced within the**
Total area covered by the Structure Plan:	61.3064 hectares	1.2.2
Area of each land use proposed: - Residential - Public Utility Reserve - Gas Pipeline easement - Commercial	 36.3837 hectares 0.4489 hectares 2.3727 hectares 0.4135 hectares	4.1
Maximum Potential Lot/Dwelling Yield:	1510 lots/dwellings	4.2
Estimated Actual Lot/Dwelling Yield:	1113 lots/dwellings	4.2
Estimated minimum residential site density:	31 dwellings per site hectare	4.2
Estimated population:	2,850 people	4.2
Number of high schools	Nil high schools	-
Number of primary schools:	Nil primary schools	-
Estimated commercial floor space (for activity centres if appropriate):	1500m2 net lettable area	4.3
Employment self sufficiency targets:	1,219 jobs ÷ 4,354 workers = 28 % (whole of Dayton)	4.3
Estimated number and % of public open space: - Regional open space - District open space	 Nil hectares Nil hectares	-
Estimated area and number: - Local parks	4.30 hectares 4 parks	4.4
Estimated number and area of natural area and biodiversity assets	Nil hectares Nil sites	2.1.1

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LIST OF APPENDICES

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PART ONE – IMPLEMENTATION

1. STRUCTURE PLAN AREA

This Structure Plan shall apply to Lots:

- 22 Arthur Street;
- 3, 2, 7, 8, 9, 10, 13, 16, 18, 19, 20, 21, 22, 24, 25, 26, 60, and 61 St Leonards Boulevard; and,
- 4, 16, 17, 18, 19, 21, 22, 36, 49, 50, 51, 52, 53, 54, 55 and 61 Victoria Road.

The subject land, contained within the inner edge of the line denoting the structure plan boundary, can be seen on the Structure Plan Map (refer to **Plan 1 – Structure Plan Map**).

2. STRUCTURE PLAN CONTENT

This Structure Plan comprises:

a) **Part One** – Statutory Section (Implementation)
This section contains the structure plan map and statutory planning provisions and requirements.

b) **Part Two** – Non-Statutory (Explanatory) Information
This section is to be used as a reference guide to interpret and justify the implementation of Part One.

c) **Appendices** – technical reports, plans, maps and supporting documents.

3. INTERPRETATION AND SCHEME RELATIONSHIP

Unless otherwise specified in this part, the words and expressions used in this Structure Plan shall have the respective meanings given to them in the City of Swan Local Planning Scheme No.17 (the Scheme) including any amendments gazetted thereto.

The Structure Plan Map (refer to **Plan 1 - Structure Plan Map**) outlines land use, zones and reserves applicable within the structure plan area. The zones and reserves designated under this Structure Plan apply to the land as if the zones and reserves were incorporated into the Scheme.

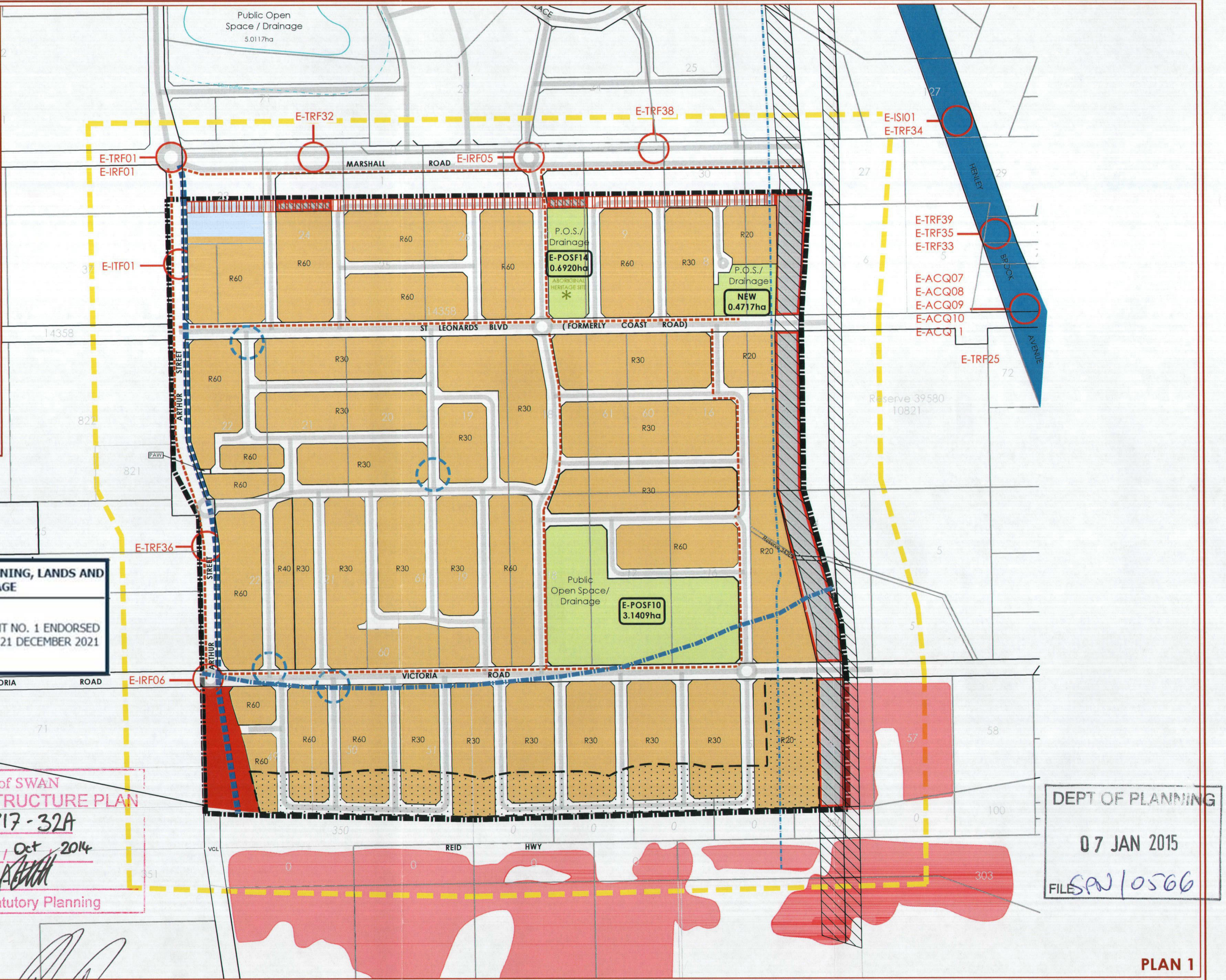
Pursuant to clause 5A.1.12.3 and 5A.1.12.4 of the Scheme:

a) The provisions, standards and requirements specified under Part One of this Structure Plan shall have the same force and effect as if it were a provision, standard or requirement of the Scheme. In the event of there being any variations or conflict between the provisions, standards or requirements of the Scheme and the provisions, standards or requirements of this Structure Plan, then the provisions, standards or requirements of the scheme shall prevail to the extent of any inconsistencies;

b) Any other provision, standard or requirement of Part One of the Structure Plan that is not otherwise contained in the Scheme, shall apply to the structure plan area as

NOTES:

1. The road layout is subject to final design at subdivision. See Traffic Assessment Report (Appendix 5).
2. The detailed function and design of Public Open Space areas are subject to refinement as part of Landscape Management Plans to be approved prior to construction.
3. No dwellings permitted within gas pipeline buffer. Notifications on title apply to lots containing gas pipeline buffer.
4. Use and development within the designated 330KV Powerline Easement shall be subject to approval by Western Power and the City of Swan, the intention being for this corridor to be utilized for low maintenance open space, community garden opportunities, pedestrian/cyclist path network, road reserves and car parking in a manner consistent with the existing power line easement.
5. Any artificial dam located within the Structure Plan area is to be formally closed via City of Swan engineering certification as part of the subsequent development of the land by the applicable landowner/developer.
6. A 5m Road Widening is required on eastern side of Arthur Road.
7. No development of residential uses are permitted within the 70m gas pipeline buffer - refer WAPC Planning Bullettin. A Notification on Title is to be placed on all lots within the pipeline buffer advising of the presence of the pipeline and resulting building restrictions.
8. Prior to subdivision of Lots 7 or 15 Coast Road or Lots 4 or 56 Victoria Road, a Risk Management Plan must be prepared in accordance with the requirements of the WAPC's Planning Bulletin 87. Such Risk Management Plan is to be approved by the Parmelia Gas Pipeline operator and implemented to the satisfaction of the Western Australian Planning Commission.
9. Lots may extend into the Building Protection Zone, however dwellings must be setback outside of the Building Protection Zone, unless it can be demonstrated that the fire risk has varied since the preparation of this Structure Plan.
10. Lots at end of street blocks can be designated a residential density coding of R40 except lots in street blocks abutting the pipeline corridor. This could apply even if road patterns change.
11. Dwellings within the Noise Exposure Level 2 area will require a notification to be placed on the Certificate of Title advising of the possible noise impacts associated with nearby transport routes. Additionally, DAP's will be required for any lots within this level 2 area. In accordance with State Panning Policy 5.4, DAP's are to detail the required quiet house design measures, and in the case of two storey development the need for any further acoustic assessment. Prospective purchasers are to be advised in writing that although incremental construction of an acoustic wall along the southern boundary of the LSP area is planned, noise attenuation will be limited until completion of the wall.



LEGEND

- ▭ Subject Area: LSP 2A

ZONES

- 🟧 Residential Zone
- 🟦 Service Commercial

RESERVES

- 🟥 MRS Important Regional Road
- 🟦 MRS Other Regional Road
- 🟩 Public Open Space/Drainage
- ▥ 330KV Powerline Easement & Road Reserve
- ▨ Gas Pipeline Easement
- ▭ Public Utilities Reserve

OTHER

- ▭ Indicative Carriageway
- ▬ Activity Corridor - Home Based Business / Home Office Opportunites
- ▬ Shared Path
- ▬ 70m Buffer to Parmelia Gas Pipeline
- ⑫ DCP Item (s6.2 Table 6)
- ○ Left In / Left Out only subject to detailed design at subdivision stage
- ▭ Bushfire Prone Area - AS 3959 Construction Zone
- ▬ Bushfire Hazard Assessment Area (LSP boundary 100m offset)
- 🟥 Identified Vegetation (Moderate-Extreme Risk)
- ▬ Extent of noise attenuation measures (with 2.7m wall along southern boundary of LSP area)

All areas and dimensions are subject to survey, engineering and detailed design and may change without notice. © Copyright of Burgess Design Group.

DEPARTMENT OF PLANNING, LANDS AND HERITAGE

GOVERNMENT OF WESTERN AUSTRALIA

AMENDMENT NO. 1 ENDORSED BY WAPC: 21 DECEMBER 2021

CITY of SWAN
APPROVED STRUCTURE PLAN
No: SP17-32A
Date: 31 Oct 2014
Coord. Statutory Planning

DEPT OF PLANNING
07 JAN 2015
FILE SPN/0566

Signed by an officer duly authorised by the Western Australian Planning Commission pursuant to section 24 of the *Planning and Development Act 2005*

NORTH

LOCAL STRUCTURE PLAN 2A
DAYTON

CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN

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Plan No: ASP WES 2A 3-16 SP
Client: St Leonards Estate Pty Ltd
Date: 31.10.14
Planner: MS

0 50 75 100 150
SCALE 1:5,000 (A4)

though it is incorporated into the Scheme, and shall be binding and enforceable to the same extent as if part of the Scheme; and

c) Part Two of this Structure Plan and all appendices are to be used as a reference only to clarify and guide interpretation and implementation of Part One.

4. OPERATION

In accordance with clause 5A.1.12 of the Scheme, this Structure Plan shall come into effect when it is certified by the Western Australian Planning Commission (WAPC) pursuant to clause 5A.1.10 of the Scheme, or adopted, signed and sealed by the Council pursuant to clause 5A.1.9 of the Scheme, whichever is the latter.

5. LAND USE AND SUBDIVISION REQUIREMENTS

The Structure Plan Map outlines land use, zones and reserves applicable within the Structure Plan area. The zones and reserves designated under this Structure Plan apply to the land within it as if the zones and reserves were incorporated into the Scheme.

5.1 Land Use Permissibility

Land use permissibility within the Structure Plan area shall be in accordance with the corresponding zone or reserve under the Scheme with the exception of the following:

<table>
<tr><th>Applicable Zone</th><th>Additional Use Class & Permissibility</th></tr>
<tr><td>Residential</td><td>‘Sales Office’ is an ‘A’ use
(Sales Office definition: - A building of either a temporary or permanent nature, and incidental car parking, used directly in relation to the sale of land and dwelling in new residential estates.
Display Home Centre: - A group of two or more dwellings and incidental car parking which are intended to be open for public inspection as examples of dwelling design.)</td></tr>
<tr><td colspan="2"><i>In accordance with Local Planning Scheme No.17, the land use ‘Shop’ is a ‘P- Permitted’ use within the ‘General Commercial’ zone. The combined net lettable area limit for shop-retail is 1500m2.</i></td></tr>
</table>

5.2 Residential Zoned Land

5.2.1 Dwelling Target

a) An estimated minimum of 1113 dwellings within the Structure Plan area.

5.2.2 Density

a) The Structure Plan Map defines the residential density that applies to specific areas within the Structure Plan.

b) The WAPC may approve a variation to a density code where the variation is consistent with a Council approved Local Area Plan.

c) All corner lots that are coded R30 can be developed/subdivided to a maximum density of R40.

d) End of cell lots can be developed at a density of R40; this would apply even if road patterns change.

e) All lots abutting the pipeline corridor are to be developed at a density of R20.

5.3 Public Open Space

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

The broader Dayton area provides over 13.9% of Public Open Space, well in excess of that which is required for the whole area by the District Structure Plan and Liveable Neighbourhoods.

The Public Open Space must be considered in the context of the surrounding LSP's. Figure 7 (Site Context Plan) of LSP2A demonstrates that all areas of residential development are within 250 meters of POS. This is further refined within Figure 10 (Public Open Space). This plan demonstrates that all residential areas are within a 400m Ped Shed of POS thus meeting the aims of the DSP and Liveable Neighbourhoods that require most dwellings be within 400m of an area of POS, with the vast majority of residential lots being within 200m Ped Sheds.

Details of the Public Open Space provision as it relates to this Structure Plan, and more broadly across the District Structure Plan area, are provided at Part 2 and Appendix 3.

5.4 Bushfire Management

In accordance with the recommendation of the Bushfire Management Plan, refer Appendix 7 two areas are identified on the Structure Plan requiring bushfire considerations, staging of development will also require consideration of Bushfire Management as required below;

AS 3959 Construction Zone – Notwithstanding any statement to the contrary within AS3959- 2009 (or relevant equivalent), any buildings to be erected on lots designated as AS3959 Construction Zone shall comply with the requirements of AS 3959-2009, or equivalent Australian Standards.

Building Protection Zone – No dwellings are permitted within the Building Protection Zone unless it can be demonstrated that the fire risk has varied since the preparation of this Structure Plan.

Staging considerations - Each development stage will require a 100 metre Hazard Separation surrounding the perimeter and located within the lot boundary. This will be achieved by clearing vegetation in this zone as stages are developed. It is the responsibility of the developer to establish the temporary staging and perimeter BPZ including landscaping in the power line easement.

5.5 Dampier to Bunbury Natural Gas Pipeline Easement

The land containing the Dampier to Bunbury Natural Gas Pipeline easement will be ceded free of cost to the crown, vested in the Department of Regional Development and Lands with a Management Order to the Dampier to Bunbury Natural Gas Pipeline.

5.6 Noise Attenuation

In accordance with the recommendation of the Noise Impact Assessment undertaken as part of the District Structure Plan, and further to State Planning Policy 5.4 'Road and Rail Transport Noise and Freight Considerations in Land Use Planning', noise attenuation measures will be required to minimise the exposure to and impact of noise associated with the adjoining Reid Highway, to sensitive land uses. The following attenuation methods shall therefore be implemented at the subsequent planning stages:

Acoustic Wall – A 2.7 metre high noise wall, or similar approved measure, is to be constructed on the southern boundary and part of the western boundary of the subject site, at the time of subdivision works to the specifications of Main Roads WA and the City of Swan. This acoustic barrier will result in noise levels on the subject land being reduced to a maximum Exposure Level 2 or less.

A masonry acoustic wall with a height of 2.4m is to be constructed along the southern boundary of the Local Centre site, and shall be imposed by a condition of development approval on the determination of the Local Centre

Quiet House Design – Dwellings that are located within Exposure Level 2 will require Quiet House Design measures to be applied to dwellings to achieve the recommended acceptable internal noise levels of AS107:2000.

Additionally any multi-storey developments within Exposure Level 2 will need further acoustic assessments carried out at building permits stages to determine any additional architectural treatments to improve the internal amenity of upper floor levels.

Notifications on Titles – Any lot located within Exposure Level 2 (50dBA and above at night time) will further require a notification on the Certificate of Title advising prospective purchasers of possible noise impacts and the need for higher construction standards to achieve acceptable indoor noise levels.

5.7 Conditions of Subdivision Approval

At the time of subdivision the City of Swan may recommend conditions to the WAPC as applicable, requiring the preparation and/or implementation of the following:

a) Urban Water Management Plan which is to give recommendations in MGL;
b) Local Development Plans ; and
c) A Section 70A Notification on each Certificate of Title within the AS 3959 construction zone.

The notification shall alert purchasers and successors in title, to these exposed lots, of the responsibilities of the Fire Management Plan and bushfire building construction requirements.

6. DEVELOPMENT REQUIREMENTS

6.1 Local Development Plans

Local Development Plans must to be prepared in accordance with 5A.1.15 of the Scheme prior to any subdivision and/or development of:

a) grouped/multiple housing sites;
b) lots that are accessed by a public laneway;
c) lots that abut public open space;
d) lots that are adjacent to an activity corridor;
e) lots within noise exposure level 2. These are required to detail quiet house design measures (to achieve the recommended internal noise levels of AS2107:2000 or equivalent) and in the case of two storey development the need for any further acoustic assessment as per the Lloyd Acoustics report (September 2009);

f) Lots impacted by a bushfire attack level requiring construction standards in accordance with the AS 3959 construction zone; and/or

g) Any other lot that requires specific development standards as identified by the City or the WAPC.

7. DAYTON DEVELOPMENT CONTRIBUTION PLAN

The West Swan East District Structure Plan area, which includes LSP2A, is identified as ‘Developer Contributions Area 2’ (DCA2) within Schedule 13 of LSP 17, which gives effect to the Dayton Development Contributions Plan (DCP).

The object of the DCP is to ensure equitable distribution of development costs between stakeholders and is the mechanism that delivers the Swan Urban Corridor Sub Regional Structure Plan, the Urban Growth Corridor – Sub Regional Planning Community Facilities Analysis and the West Swan East District Structure Plan outcomes.

More details of the DCP and how it relates to LSP2A are provided in part two, Section 6.

PART TWO | EXPLANATORY SECTION

1. PLANNING BACKGROUND

1.1 Introduction and Purpose

This Local Structure Plan (LSP) and report has been prepared on behalf of St Leonards Estate Pty Ltd, in consultation with landowners within the LSP area. The LSP has been prepared in accordance with the City of Swan Local Planning Scheme provisions Part 5A-Structure Planning Areas. The LSP refines the adopted District Structure Plan for West Swan East, more recently referred to as Dayton as it applies to the south-eastern cell known as Local Structure Plan 2A (LSP2A).

The LSP has been prepared by Burgess Design Group with inputs from a multidisciplinary team comprising;

Tabec	Civil Engineering
JDA	Local Water Management Strategy
Transcore	Traffic and Transport
Emerge	Landscape Management Plan

1.2 Land Description

1.2.1 Location

The subject land parcel is located approximately 16 kilometres north-east of the Perth CBD, 8 kilometres from the Midland Regional Centre, north of the Reid Highway and west of the Swan Valley. The site is accessed via Lord Street through the adjoining Local Structure Plan 1 area thru Marshall Road, St Leonards Boulevard and Victoria Road and also via the adjoining Arthur Street. From the east, the subject land is accessible from West Swan Road via the existing local road network of Victoria Street and St Leonards Boulevard (refer to Location Plan at **Figure 1**).

The LSP2A area is generally bound by Arthur Street to the west, Marshall Road and the abutting 330KV powerlines to the north, the eastern extent of the Dampier to Bunbury Natural Gas Pipeline to the east, and Reid Highway to the south. The LSP2A is the third structure plan to evolve as part of the ongoing planning and expansion of the suburb of Dayton (previously known as West Swan East and also now marketed as ‘St Leonards Estate’), and as such forms an important expansion area of the Perth Metropolitan Area.

1.2.2 Area and Land Use

The LSP2A area comprises 61.30ha of rural residential type uses reminisce of its previous semi-rural status, as is evident in the Aerial Photograph (see **Figure 9**), as well as construction of residential lots approved as part of an ‘Early Release’ subdivision approval within St Leonards Estate Pty Ltd owned land. The existing road networks of Arthur Street, St Leonards Boulevard, Victoria Street, Reid Highway and Marshall Road are also evident from the aerial photograph.

Several lots along the most eastern periphery are impacted upon by the existing gas pipelines and as such, their current rural residential use may partially continue into the longer term, reflective of the zoning of those lots.

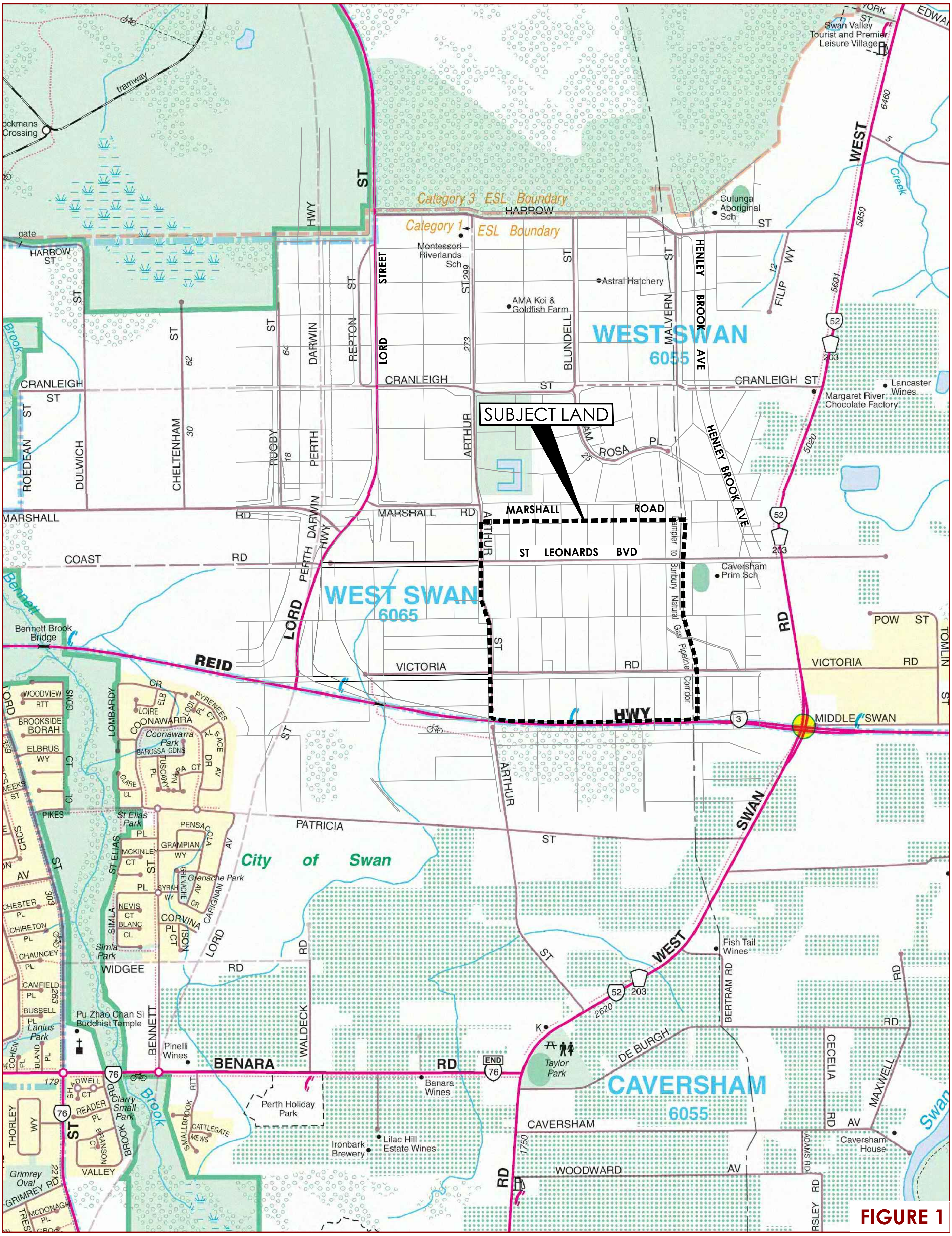

FIGURE 1

LOCATION PLAN
LSP 2A
DAYTON
CITY OF SWAN

NORTH

Planner: KW
Client: St Leonards Estate Pty Ltd
Date: 30.04.13
Plan No: ASP WESLSP2A 7-01a

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All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

FIGURE 9

LEGEND

▭ LSP2A

NORTH

AERIAL PHOTO
LSP 2A DAYTON
CITY OF SWAN

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Plan No: ASP WES 2A 3-02p
Date: 01.05.13
Client: St Leonards Estate Pty Ltd
Planner: KW

0 25 50 75 100m
SCALE 1:4,000 (A3)

The former operating mushroom farm is located on Lot 52 Victoria Road, has recently ceased operation and procedures and applications for the removal of the buffer are progressing through the planning process. Consequently, a buffer is not identified to the mushroom farm.

1.2.3 Legal Description and Ownership

The LSP2A area is owned by a range of different entities, including St Leonard's Estate and a multitude of individual landowners, many of whom reside on the land.

The current (as of late 2012) ownership within LSP2A is summarised within **Figure 2**.

1.3 Planning Framework

1.3.1 Zoning and Reservations

Metropolitan Region Scheme

The subject land is zoned 'Urban' and has been zoned as such since 2002. The 'Urban' zone boundary at the most eastern extent of the LSP does not correlate with lot boundaries and instead is defined by the location of the gas pipeline easement, refer **Figure 3**. The proposed development of the LSP2A area is consistent with the 'Urban' zoning, however those lots partially outside the LSP2A and partially outside the extent of the 'Urban' zone shall remain dual zoned (part Urban and part Rural) with only their 'Urban' portion having any development potential consistent with the LSP2A plan.

The nearby MRS 'Primary Regional Road' reservations applicable to the Reid Highway and future Perth-Darwin Highway to the west of the subject land help to form the logical boundary to the wider district area whilst also defining where access and grade separation (being two future flyovers, one at Marshall Road and another at Arthur Street) to the highways may be achieved in the interim and the future. The currently unconstructed Henley Brook Avenue to the east of the LSP2A is reserved as an 'Other Regional Road' under the MRS and shall ultimately carry traffic in a north south direction, replacing some of the traffic function of West Swan Road.

City of Swan Local Planning Scheme

The City of Swan Local Planning Scheme No.17 (LPS 17) zones the subject land and the surrounding Dayton as 'Special Use – West Swan' (refer **Figure 4**). The MRS dual zoned lots along the most eastern periphery of the LSP shall also remain dual zoned under the LSP, with their western extent having urban development potential under the LSP2A and their eastern extent retained in the adjoining 'General Rural' zoning of the LSP.

The relevant objectives and Scheme provisions relating to the 'Special Use' zone are included within Schedule 4 of the Scheme text and guide both the preparation of the District Structure Plan (DSP) as well as this Local Structure Plan, and subsequent local structure plans.

This LSP2A has been prepared in accordance with both the generic Scheme provisions relating to structure plan sites and also Schedule 4 - the objectives of the Special Use zone as detailed further below in **Table 1**.

All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

7	80 Coast Rd	West Swan	P002235	1302-545	LN & MP COMISKEY
8	94 Coast Rd	West Swan	P002235	1489-715	Domenico PALAMARA
30	Coast Rd	Dayton	D052896	1489-714	Domenico PALAMARA
9	Coast Rd	Dayton	P002235	1298-478	Anita PETRILLO, Gaetano Anthony LAGANA, Jakaby Pty Ltd, Nicholas PETRILLO
10	108 Coast Rd	Dayton	P002235	1389-941	Tang Piew HAM
26	126 Coast Rd	Dayton	P002235	1769-960	Complete Residential Pty Ltd
3	150 Coast Rd	Dayton	D096761	2151-868	Project Development WA Pty Ltd
2	154 Coast Rd	Dayton	D096761	2151-869	Project Development WA Pty Ltd
23	200 Arthur St	Dayton	P002235	1914-957	Project Development WA Pty Ltd
9017	Coast Rd	Dayton	P71426	2785-133	Kubiriraya DIRORIMWE & Shuvai Ancila CHABATA
15	77 Coast Rd	West Swan	P002235	2127-596	Catherine Sook Ngee YAP
16	95 Coast Rd	Dayton	P002235	1400-981	Dean WILLIAMS & Josephine Ann LUCKMAN
60	99 Coast Rd	Dayton	D71471	1757-581	Troy Anthony PARKER, Kerrie Diane DOBBYN, Neil Trestrail DOBBYN & Jennifer Dianne STUBBS-MILLS
61	105 Coast Rd	Dayton	D71471	1757-582	Pauline DISS & John Raymond DISS
18	107 Coast Rd	Dayton	P002235	1462-671	Vincent BORG
19	117 Coast Rd	Dayton	P002235	1383-764	Colin Lloyd CHAVE
20	135 Coast Rd	Dayton	P002235	2034-738	St Leonards Estate Pty Ltd
21	145 Coast Rd	Dayton	P002235	1406-685	St Leonards Estate Pty Ltd
22	166 Arthur St	Dayton	P002235	1367-827	St Leonards Estate Pty Ltd
8011				LR3161-841	State of WA
1000	2 Firewood Wy	Dayton	P071426	2785-101	Roslyn Michelle WILLIS & David Stewart Gordon JOLLY
1001	4 Firewood Wy	Dayton	P071426	2785-102	Assad Ali ASGHARI
1002	6 Firewood Wy	Dayton	P071426	2785-103	Ali Mohammad SULTAN
1003	8 Firewood Wy	Dayton	P071426	2785-104	Natasha Marie BROOKS
1004	10 Firewood Wy	Dayton	P071426	2785-105	Kavita Pareshkumar SHIYANI & Pareshkumar Ravji SHIYANI
1005	12 Firewood Wy	Dayton	P071426	2785-106	Baldev SINGH
1006	14 Firewood Wy	Dayton	P071426	2785-107	Caleb Joseph CUPPLES, Bree Shannon NASH
1007	16 Firewood Wy	Dayton	P071426	2785-108	Daniel John LIVERMORE & Vanessa Susan LIVERMORE
1008	18 Firewood Wy	Dayton	P071426	2785-109	Trivenee LESTE & Andre Clifford LESTE
1009	17 Teliqua Cnr	Dayton	P071426	2785-110	Sady Jean-Baptiste EVENOR & Marie-Claire EVENOR
1010	15 Teliqua Cnr	Dayton	P071426	2785-111	Rebecca Jane BOLTON
1011	13 Teliqua Cnr	Dayton	P071426	2785-112	Kimberley Joy VLAHOV & Jonathon Peter VLAHOV
1012	11 Teliqua Cnr	Dayton	P071426	2785-113	Kim Sidney RIPP & Lana Marie RIPP
1013	9 Teliqua Cnr	Dayton	P071426	2785-114	Jarrad Neil BURNS & Justine Kate McBEATH
1014	7 Teliqua Cnr	Dayton	P071426	2785-115	Heidi Carol SHIRRA & Matthew Stanley CONDOR
1015	5 Teliqua Cnr	Dayton	P071426	2785-116	David John McCARTHY
1016	3 Teliqua Cnr	Dayton	P071426	2785-117	Loretta SASSANELLI & Michelle SASSANELLI
1017	1 Teliqua Cnr	Dayton	P071426	2785-118	Rajesh Kumar BANSAL
1018	2 Preissina Wy	Dayton	P071426	2785-119	Nico PRUIS & Eunice Carol PRUIS
1019	4 Preissina Wy	Dayton	P071426	2785-120	Claire Elizabeth LESLIE-GREEN & Anthony James HOLBERTON
1020	6 Preissina Wy	Dayton	P071426	2785-121	Chirag PATEL
1021	8 Preissina Wy	Dayton	P071426	2785-122	Renae Louise REGNAULT & Patrick Laurence CONWAY
1022	10 Preissina Wy	Dayton	P071426	2785-123	Armina Sanjaykumar & Sunjaykumar Ramniklal VAGHELA
1025	9 Preissina Wy	Dayton	P071426	2785-124	Alanda Dawn BINSTEAD & David BINSTEAD
1026	7 Preissina Wy	Dayton	P071426	2785-125	Marisa Jacqueline CORBY & Troy Wallace JOHNSON
1027	5 Preissina Wy	Dayton	P071426	2785-126	Brent Lee BERNARD & Linda Margaret BERNARD
1028	10 Teliqua Cnr	Dayton	P071426	2785-127	Vergel Mallari YANEZA
1029	12 Teliqua Cnr	Dayton	P071426	2785-128	Daniel James BEILKEN & Raymond Charles BEILKEN
1030	14 Teliqua Cnr	Dayton	P071426	2785-129	Maria Avelia Mendiola & Albert Alfaro NEPOMUCENO
1031	16 Teliqua Cnr	Dayton	P071426	2785-130	Kristian Peter MILLS & Donelle Anne PARKIN
1032	18 Teliqua Cnr	Dayton	P071426	2785-131	St Leonards Estate Pty Ltd
1033	20 Teliqua Cnr	Dayton	P071426	2785-132	Thomas William REELY & Kylie Marie BOX
1034	22 Teliqua Cnr	Dayton	P071426	2785-133	Kumbirayi DIRORIMWE & Shuvai Ancila CHABATA
22	170 Victoria Rd	Dayton	P2746	1923-430	Alana Edith YOUNG & Michael John YOUNG
21	164 Victoria Rd	Dayton	P2746	1367-918	Maria GHIZZO
60	160 Victoria Rd	Dayton	D95351	2186-269	Sandra Rose & Terry William MAYES
61	154 Victoria Rd	Dayton	D95351	2186-270	St Leonards Estate Pty Ltd
19	138 Victoria Rd	Dayton	P2746	12-17A	Peter Donald OSTLE & Erica Lousie BENSON
18	134 Victoria Rd	Dayton	P2746	1416-64	Zbigniew & Zofia MUSZYNSKI
17	124 Victoria Rd	Dayton	P2746	14-307A	Geoffrey WILLIAMS
16	112 Victoria Rd	Dayton	P2746	1305-133	Reginald Joseph & Jean Helen LEE
4	104 Victoria Rd	Dayton	D48370	1409-95	Philipp Norbert Keller & Marija Stanka Keller
49	157 Victoria Rd	Dayton	P2746	1925-467	St Leonards Estate Pty Ltd
50	157 Victoria Rd	Dayton	P2746	1925-467	St Leonards Estate Pty Ltd
51	157 Victoria Rd	Dayton	P2746	1925-467	St Leonards Estate Pty Ltd
52	139 Victoria Rd	Dayton	P2746	1984-677	John Bruce & Julieta Dejano MARTIN
53	129 Victoria Rd	Dayton	P2746	2007-447	Bendan Enterprises Pty Ltd
54	115 Victoria Rd	Dayton	P2746	2165-524	Vincenzo VINCIULLO
55	103 Victoria Rd	Dayton	P2746	2012-386	St Andrews Property Development Pty
56	101 Victoria Rd	Dayton	P2746	1710-91	Alin Susan & John Mark McSHERA

FIGURE 2

NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

LAND OWNERSHIP PLAN
LSP2A DAYTON
CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN
PO Box 374 Northbridge WA 6865
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P (08) 9328 6411
F (08) 9328 6511

Plan No: ASP WES 2A 3-02p
Date: 01.05.13
Client: St Leonards Estate Pty Ltd
Planner: KW

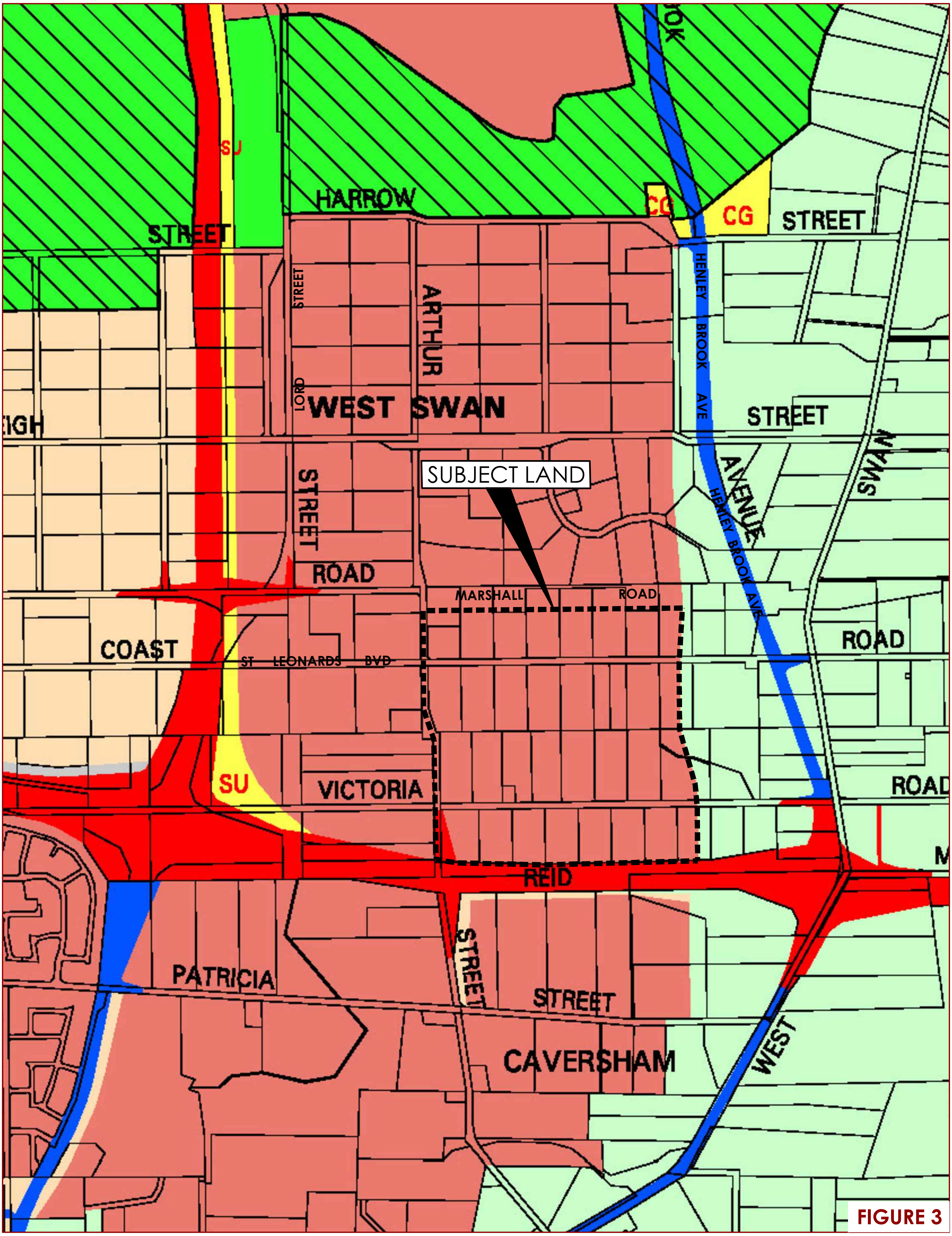

FIGURE 3

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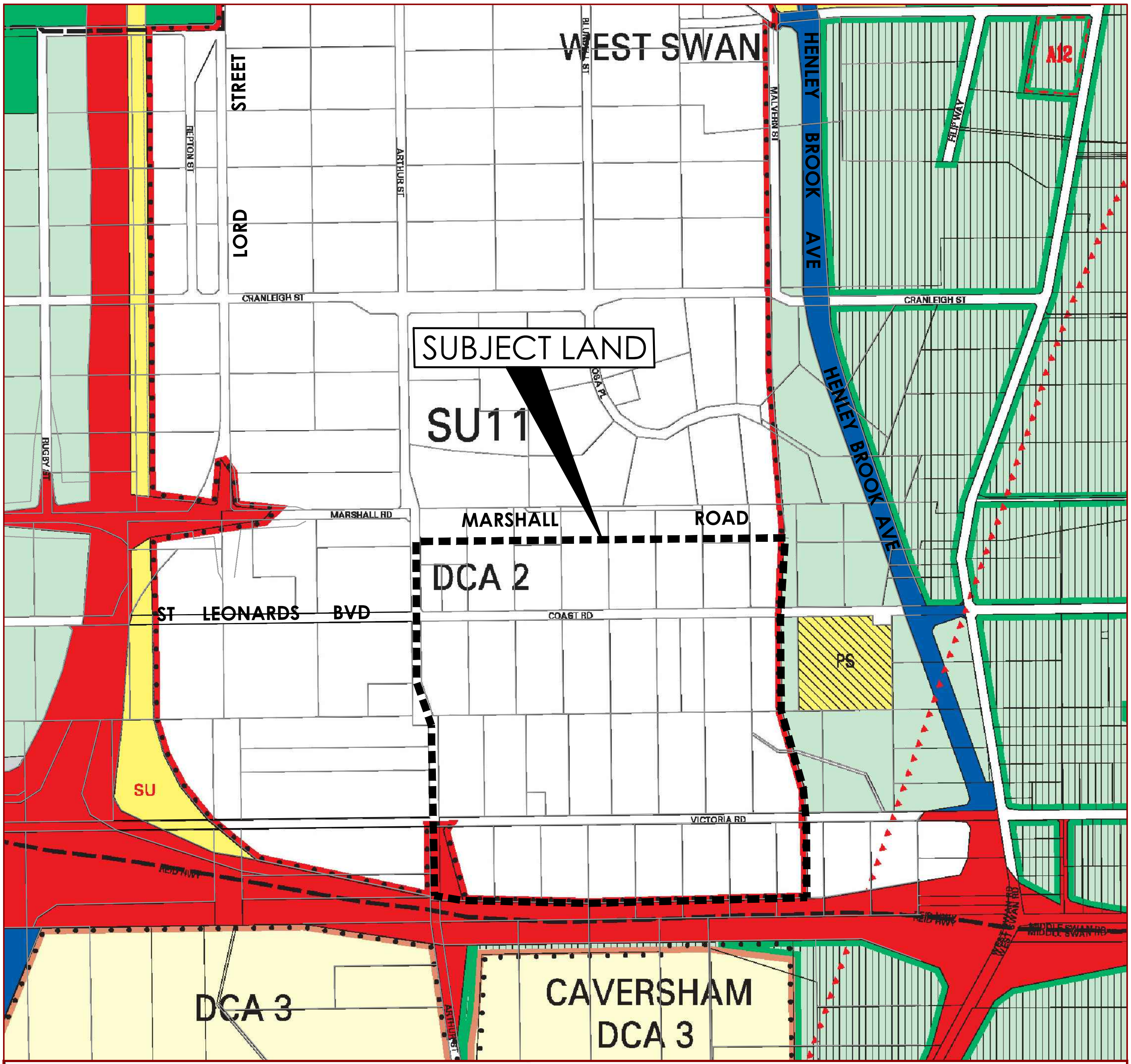
NORTH

METROPOLITAN REGION SCHEME MAP

LSP 2A DAYTON

CITY OF SWAN

Planner: KW
Client: St Leonards Estate Pty Ltd
Date: 05.02.13
Plan No: ASP WESLSP2A 7-01a



LEGEND

METROPOLITAN REGION SCHEME RESERVES

- 🟩 PARKS AND RECREATION
- 🟥 PRIMARY REGIONAL ROADS
- 🟦 OTHER REGIONAL ROADS
- 🟨 PUBLIC PURPOSES - DENOTED AS FOLLOWS:
  - H HOSPITAL
  - CG COMMONWEALTH GOVERNMENT
  - SU SPECIAL USES

LOCAL SCHEME RESERVES

- ☐ LOCAL ROAD
- ▨ PUBLIC PURPOSES DENOTED AS FOLLOWS:
  - PS PRIMARY SCHOOL
- ▨ RECREATION

ZONES

- 🟧 RESIDENTIAL
- ☐ RESIDENTIAL DEVELOPMENT
- 🟥 SPECIAL USE
- 🟩 GENERAL RURAL
- 🟫 RURAL RESIDENTIAL
- 🟨 SPECIAL RURAL
- ▥ SWAN VALLEY RURAL

OTHER

- R20 R CODES
- A1 ADDITIONAL USES
- SU2 SPECIAL USE AREA (SEE SCHEME TEXT)
- DCA 1 DEVELOPMENT CONTRIBUTION AREA BOUNDARY (SEE SCHEME TEXT)
- ▲ ▲ ▲ ▲ ▲ FLOOD PRONE AREA
- ▲ ▲ ▲ ▲ ▲ AIRCRAFT NOISE EXPOSURE
- — — — STRATEGIC REGIONAL CENTRE BOUNDARY

FIGURE 4

NORTH

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Planner:	KW
Client:	St Leonards Estate Pty Ltd
Date:	05.02.13
Plan No:	ASP WESLSP2A 7-01a

LOCAL PLANNING SCHEME No17

LSP 2A DAYTON

CITY OF SWAN

TABLE 3: LPS17 SPECIAL USE PROVISIONS

	Objectives of Special Use Site No.11	Structure Plan Achieves Objectives by:
1	To ensure that development in the estate achieves optimal integration with development in surrounding area;	The LSP connects to the approved LSP 1 and significantly progressed LSP2B and consequently to the broader locality
2	To provide for the development of a functional and cohesive community consistent with the orderly and proper planning and in the interest of the amenity of the Estate;	The LSP has been prepared based on a legible movement network and landuse mix with connectivity to the surrounding Cells
3	To develop the Estate in a manner that protects, conserves and enhances the natural environment and cultural assets and to investigate and manage impacts upon the natural environment;	There are limited natural assets within the LSP, rather the LSP recognises the existing topography and ensure a more manageable approach to development and fill levels
4	To encourage variety in the range of lot sizes and dwelling types within the Estate but consistent with cohesiveness;	The LSP identifies a broad category of low, medium and high density residential land uses ranging from R20 to R60, within which a wide spectrum of dwellings, including retirement village, single residential dwellings, grouped housing and multiple dwellings may be accommodated.
5	To enhance the Estate with the provision of open space and recreation networks and facilities with particular attention being given to the timely provision of appropriate community services;	Three parcels of public open space are nominated within LSP. The two larger of these POS areas have previously been identified in the District Structure Plan and also reflects the location of the Aboriginal Heritage Site. The centrally located POS provides a large recreation area for the community. The variety of public open space will facilitate drainage and natural infiltration in a responsible manner whilst also offering a recreation amenity to future residents.
6	To make provision for school sites and other appropriate education facilities within the Estate in a manner that facilitates their management and use as a resource for local communities;	A large primary school is nominated within the Sub Regional and District Structure Plans and is reflected in LSP 2B to the north of LSP2A.
7	To provide appropriate retail and commercial facilities to service the needs of residents of the Estate and with a view to the integration of retail areas with other commercial and business areas and with social services so as to maximise convenience;	A local centre is identified in the DSP within the LSP2A area. This will cater for the local shopping and business needs of the future residents. The Sub Regional Structure Plan identifies the larger district centre within Albion to the north.
8	To provide retail and commercial centres, business parks and service areas to satisfy the need for such services within the Estate and to provide local employment opportunities; and,	The DSP centrally located the local centre and ‘Activity Corridor’ to maximise accessibility and encourage walkable catchments, supported by adjoining medium densities. The LSP2A proposes

		some medium density residential uses in the north-western corner near the local centre.
9	To employ strategies and design aimed at optimising accessibility to the local centre and future public transport node(s) by the use of comprehensive movement networks and by other means which will facilitate connection with public transport and arterial road links to Midland, Perth and other parts of the Metropolitan Region.	The road and dual use path network, including the adjoining Activity Corridor along Arthur Street, shall be used to encourage connections towards this local centre and destinations further afield.

The Dayton district is also included within 'Development Contribution Area 2' (DCA 2) of LPS 17 which requires a 'Development Contribution Plan' to be prepared in accordance with Schedule 13 of the Scheme. A draft Development Contribution Plan has been prepared and is discussed in section 6.1 of this report.

1.3.2 Regional and Sub-Regional Structure Plan

Sub-Regional Structure Plan for the Swan Urban Growth Corridor

The City of Swan and the Department of Planning, in consultation with key landowners and other government agencies, prepared the Sub-Regional Structure Plan for the Swan Urban Growth Corridor, being land located generally between Midland and Ellenbrook in the suburbs of West Swan (including Dayton within which LSP2A is located), Caversham and Albion.

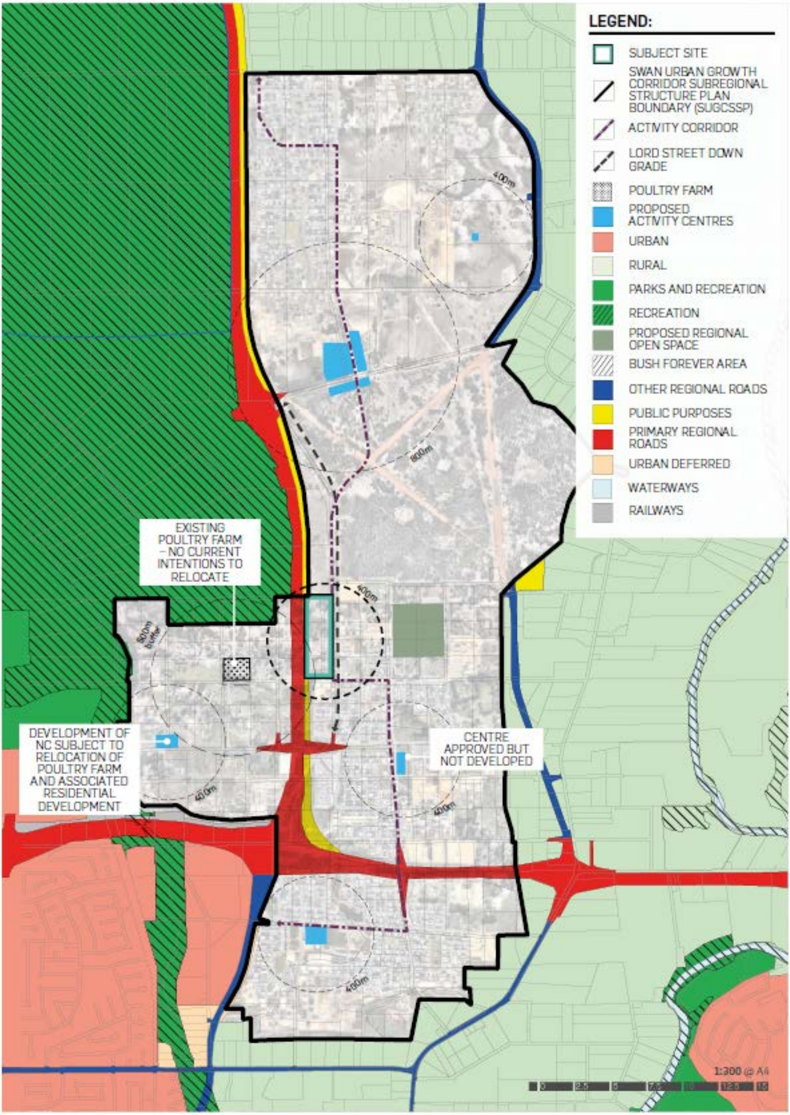
The Sub-Regional Plan is a strategic planning document designed to guide the coordinated growth and development of the Swan Urban Growth Corridor to ultimately accommodate over 30,000 new residents plus associated community, commercial, open space and infrastructure land uses, refer Figure 5.

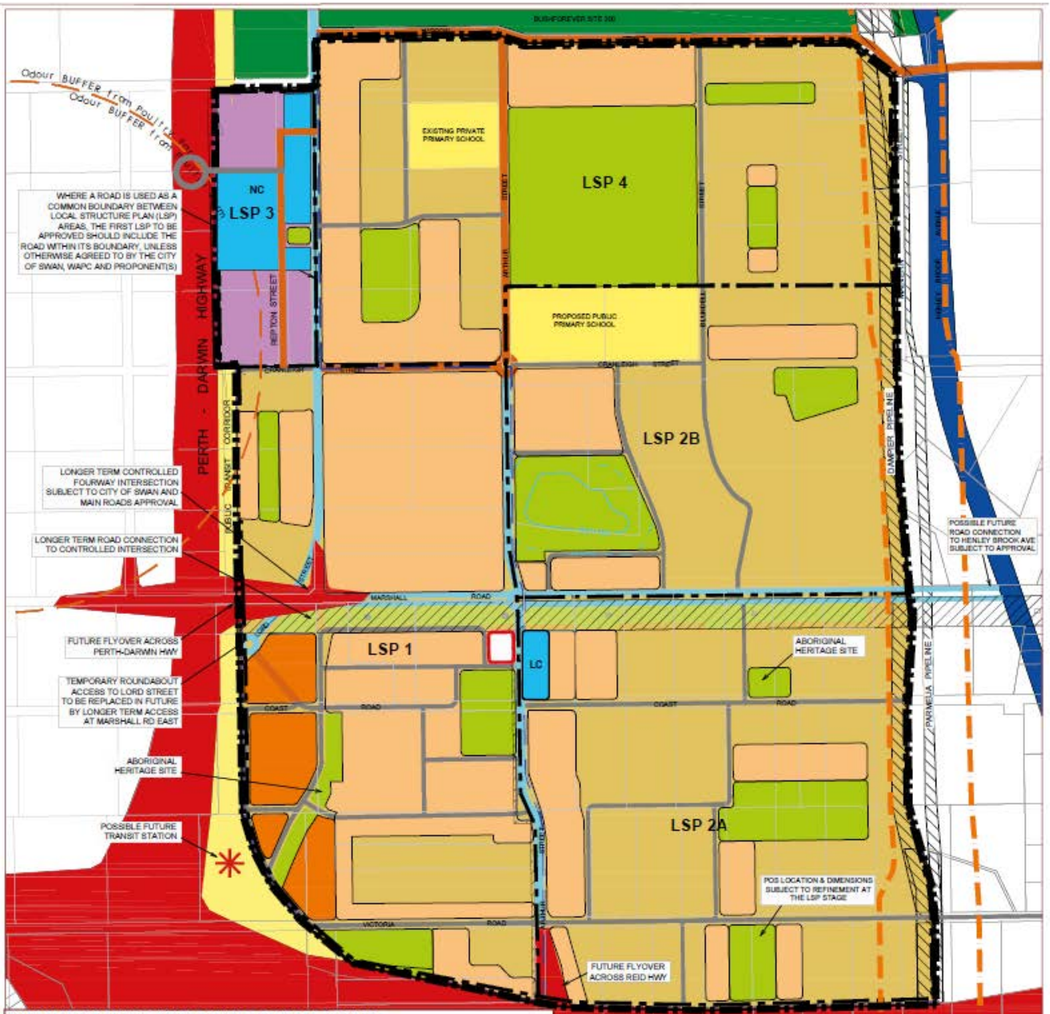
District Structure Plan

A District Structure Plan (DSP) for Dayton was endorsed by the WAPC in March 2012. The DSP broadly guides the land uses across all of Dayton, ensuring coordination of district matters such as drainage, road connections, schools and employment opportunities.

The DSP also nominates local structure plan cells, predominantly based upon drainage catchments, existing street networks and logical boundaries for ease of future planning. LSP2A is one such cell and within which the broad land uses including; public open space, key road networks and infrastructure corridors are identified, refer Figure 6.

Table 2 below summarises the Sub-Regional Plan and District Structure Plan key features of relevance to the LSP2A area:

LEGEND:
SUBJECT SITE
SWAN URBAN GROWTH CORRIDOR SUBREGIONAL STRUCTURE PLAN BOUNDARY (SUGCSSP)
ACTIVITY CORRIDOR
LORD STREET DOWN GRADE
POULTRY FARM
PROPOSED ACTIVITY CENTRES
URBAN
RURAL
PARKS AND RECREATION
RECREATION
PROPOSED REGIONAL OPEN SPACE
BUSH FOREVER AREA
OTHER REGIONAL ROADS
PUBLIC PURPOSES
PRIMARY REGIONAL ROADS
URBAN DEFERRED
WATERWAYS
RAILWAYS
EXISTING POULTRY FARM – NO CURRENT INTENTIONS TO RELOCATE
DEVELOPMENT OF NC SUBJECT TO RELOCATION OF POULTRY FARM AND ASSOCIATED RESIDENTIAL DEVELOPMENT
CENTRE APPROVED BUT NOT DEVELOPED
400m
800m
400m
500m buffer
400m
400m
400m
1:300 @ A4
0
2.5
5
7.5
10
12.5
15



ESTIMATED RESIDENTIAL YIELDS & PUBLIC OPEN SPACE PER LSP.

LSP	Gross Area	Gross Subdivisible Area[1]	Gross Residential Area[1]	Nett Residential Area[1]	Low Density	Medium Density	High Density	Total Dwelling Yield[2]	Gross POS	POS Credit[3]
1	65.27	61.87ha	56.87ha	41ha	100	690	300	1090	5.59ha	4.71ha
2A	67.2	60.4ha	55ha	38ha	530	200	0	730	5.37ha	4.1ha
2B	48.8	42.9ha	36.25ha	24ha	360	160	0	520	6.52ha	2.7ha
3	10.83	3.57ha	0ha	0ha	0	0	0	0	0.11ha	0ha
4	63.9	63.7ha	43.63ha	31ha	290	464	0	754	17.85ha	14.7ha
Total	**256ha**	**232.44ha**	**191.75ha**	**134ha**	**1280**	**1514**	**300**	**3094**	**35.44ha**	**28.21ha (11.3%)**

All figures are estimates only & subject to refinement at the local structure planning stages.

NOTES

PUBLIC OPEN SPACE AND DRAINAGE
Public Open Space and Drainage areas are indicative and subject to detailed design and modelling at the Local Structure Plan stage.

DISTRICT OPEN SPACE FACILITIES
13ha of District Open Space Facilities are to be located within a minimum of 13ha of public open space, adjacent to the Public Primary School along Arthur street.

SERVICE COMMERCIAL
Uses within the site are as per the Service Commercial Use class table listed in the District Structure Plan with emphasis on creating a Mixed Business/Service Commercial development site, and an activity core (local centre) with a maximum NLA of 1500m².

LOCAL NEIGHBOURHOOD CENTRE
Uses within the local neighbourhood centre site are as per the City of Swan General Commercial use class with emphasis on encouraging a main street style local neighbourhood centre.

SPECIAL USE - COMMUNITY SITE
Uses within the site are generally intended for civic and community purposes, with emphasis on a design complementary to the Activity corridor and public open space.

HERITAGE
The identified heritage sites are to be protected within public open space or alternative, subject to detailed design at the Local Structure Plan stage.

RESIDENTIAL
Uses within the Residential areas are as per the City of Swan Residential Zone use class. Residential densities are indicative only and shall be confirmed at the local structure plan stage, aiming to achieve a minimum of 22 dwelling units per hectare across the structure plan area with higher/medium densities concentrated along the Activity Corridor, Commercial centre and areas of POS.

ACTIVITY CORRIDOR
The Activity Corridor is intended as the central spine for movement and activity connecting Albion with Caversham through West Swan and shall provide the function of a frequent public transport route with higher residential densities, home based businesses and some commercial and community uses encouraged alongside it.

INFRASTRUCTURE CORRIDOR & EASEMENT
Use, development and ownership of the infrastructure corridor & easement are to be to the satisfaction of the City of Swan and Western Power and is subject to more detailed design at the Local Structure Plan stage.

GAS PIPELINE SETBACK
Use and development within the gas pipeline setback area is restricted and subject to futher refinement at the Local Structure Plan Stage.

LOCAL STRUCTURE PLANS
Subdivision and development of the subject area is to be in accordance with an endorsed applicable Local Structure Plan unless otherwise approved by the City of Swan and/or Western Australia Planning Commission.

Table 4: Sub Regional and District Structure Plan Compliance

Sub-Regional Plan Requirements	District Structure Plan Requirements	LSP Compliance
An 'Activity Corridor' connecting Albion district centre in the north to Caversham in the south via the Arthur Street flyover across the Reid Highway -	Provision and access to an adjoining 'Activity Corridor'	Located on the western edge of the LSP along Arthur Street
One local neighbourhood centre centrally located along the Activity Corridor;		Proposed in the north-west corner of LSP2A with no further commercial requirements within LSP2A
A predominance of residential land uses across the LSP2A area which assists in the broader District achieving an overall of net residential density target of 22 dwelling units per hectare;	Allocation of nominated residential densities and density targets; Location and areas for public open space and drainage; and External and internal road network	A variety of density of development is provided within the LSP achieving a net residential density of 27 dwelling units per hectare
Recognition of the operating mushroom farm and associated buffer which has since then been confirmed as currently preventing subdivision within a 500m buffer;		The buffer to the former mushroom farm is not provided within the LSP, as per 1.2.2
The existence of the Dampier to Bunbury and the Parmelia gas pipeline easements along the LSP2A eastern boundary and their associated buffer requirements to sensitive land uses;	Recognition of adjoining gas pipeline easements and their setback requirements;	Provision is made for the exclusion of the easement from development, and recognition of constraints within the buffer. No risk assessment report associated with the gas pipelines is included given that no departure from established easement and setback requirements are proposed.
An integrated traffic management study across the Sub-Region, confirming road networks and hierarchy as proposed, including an upgraded intersection in the interim for Marshall Road (north-west) and Lord Street, also acting as the entry to the adjoining LSP 1 area from off Lord Street.	Inclusion of supporting management plans as required by the DSP, specifically a wetland management plan and a cultural heritage management plan.	Facilitates a range of permeable transport movements (car, bus and possible future rail) through appropriate road widths, gridlike street networks, appropriate road hierarchy, provision for future public transport, and regular cell blocks ultimately allowing for a well connected and surveilled local street network;

The above has formed the basis for progressing the planning, traffic management, infrastructure provision and land use allocation within LSP2A and across the greater district, and as such, this structure plan does not compromise the planning objectives for the area.

1.3.3 State Planning Strategies

Directions 2031 and Beyond

This strategic plan recognises the benefits of a more consolidated city and sets realistic goals to promote housing affordability and sustainable urban growth. The LSP is compliant with the key guiding directions and themes of Directions 2031 in the following manner;

- The LSP2A is in an area which is in close proximity to an existing urban area which is currently continuing to grow and shall ultimately provide a range of local and district level facilities such as a secondary education, district shopping, district sporting facilities, and mixed business opportunities.

- Collectively this suggests that the site is well situated for residential land uses which will subsequently then act to improve existing public transport patronage, improve the viability of existing and proposed district and regional centres and in a manner that enhances community and environmental health.

- Directions 2031 sets a minimum target of 15 dwellings per gross urban zoned hectare of land in new development areas, which is achieved via the LSP2A densities proposed.

Draft Outer Metropolitan Perth and Peel Sub-Regional Strategy

Forming part of the Directions 2031 document is the Draft Outer Metropolitan Perth and Peel Sub-Regional Strategy which provides further commentary and guidance specific to the various sub regions, including the north-east corridor within which the subject land is located.

Dayton (including LSP2A) is identified in the draft Strategy as undeveloped urban land intended to accommodate 2800 dwellings. The LSP2A is consistent with the strategy framework and in achieving this target number of dwellings.

1.3.4 Policies

Liveable Neighbourhoods

Liveable Neighbourhoods is a state-wide development control policy that facilitates the development of sustainable communities. It provides an integrated planning and assessment policy for the preparation of Structure Plans and subdivision designs and represents an alternative performance-based approach to conventional subdivision policies.

The Local Structure Plan presented within this report adopts the principles of *Liveable Neighbourhoods* policy and should be assessed against the objectives and requirements of each of the *Liveable Neighbourhoods* design elements.

Swan Urban Growth Corridor – Urban Growth Policy

The City of Swan has prepared and adopted an Urban Growth Policy package, incorporating the ‘Urban Growth Policy’, the ‘Neighbourhood Planning Policy’, the ‘Environmental Planning Policy’ and the ‘Community and Economic Planning Policy’. In summary, these policies contain objectives for Structure Plans within the Swan Urban Growth Corridor (relating to Dayton. These objectives are very similar to the objectives of the Special Use Site No.11 and achieve the objectives as set out in Table 1 above.

In accordance with the ‘Planning for Urban Growth’ requirements of the Policy, LSP2A has been formulated on the engineering, ethnographic, community and economic development, financial reporting commitments, fire and emergency access information and environmental management strategies and plans prepared at the District Structure Plan stage, with additional landscape management, traffic management and refinement of servicing provided within the LSP documentation.

In this regard the Dayton LSP2A is consistent with the suite of Urban Growth Policies and their specific objectives and requirements applicable to structure plan preparation.

1.3.5 Other Approvals and Decisions –Early Release Subdivision

As part of the Sub-Regional Plan preparation process, an agreement was reached to provide for what is known as an ‘early land release program’ as a means of assisting in the timely production of a supply of residential lots to cater for the current population growth of the Perth Metropolitan Region. The Sub-Regional Structure Plan contains criteria for determining the area, extent and planning process of land suitable for the early land release program.

As a result of the Early Release Subdivision application within LSP2A, some lots in the north of LSP2A, accessed from Marshall Road and St Leonards Boulevard were approved comprising a gross area of 2.811ha for new single residential lots, associated subdivisional roads and public open space, plus 2847m^2 was for the ‘Public Utility Reserve’ and one parcel of 3000m^2 was approved as a balance lot. The remainder of the overall application area was located outside of LSP2A. The Early Release Subdivision applicable to LSP2A included a Developer Cost Contribution equivalent to 3.111ha (being the gross approved subdivision plus balance lots).

2. SITE CONDITIONS AND CONTEXT

This section includes an analysis of the context and constraints, refer **Figure 7**, together with the integration of the LSP 2A with the adjoining LSP's.

2.1 Site Analysis

2.1.1 Biodiversity and Natural Area Assets

The LSP2A area has previously been predominantly cleared and grazed and more recently converted to rural residential and rural lifestyle uses with a number of homes and associated outbuildings constructed throughout the subject area. The size and age of these homes varies considerably, with some constructed in recent years and likely to be retained into the short and medium term.

A number of farm dams associated with previous semi-rural activities have also been developed within the subject land as is evident on the aerial photo.

2.1.2 Landform and Soils

RPS conducted an Environmental Assessment Report as part of the preparation of the District Structure Plan. The report confirmed that the subject land located within LSP2A is generally flat and about 14m – 18m above Australian height datum (AHD). The site comprises alluvial soils of silty clay to pebbly silt, with an overlying veneer of Bassendean sands on elevated sections. The soil is generally low lying and poorly drained, allowing for little infiltration (see section 2.1.3 for management measures).

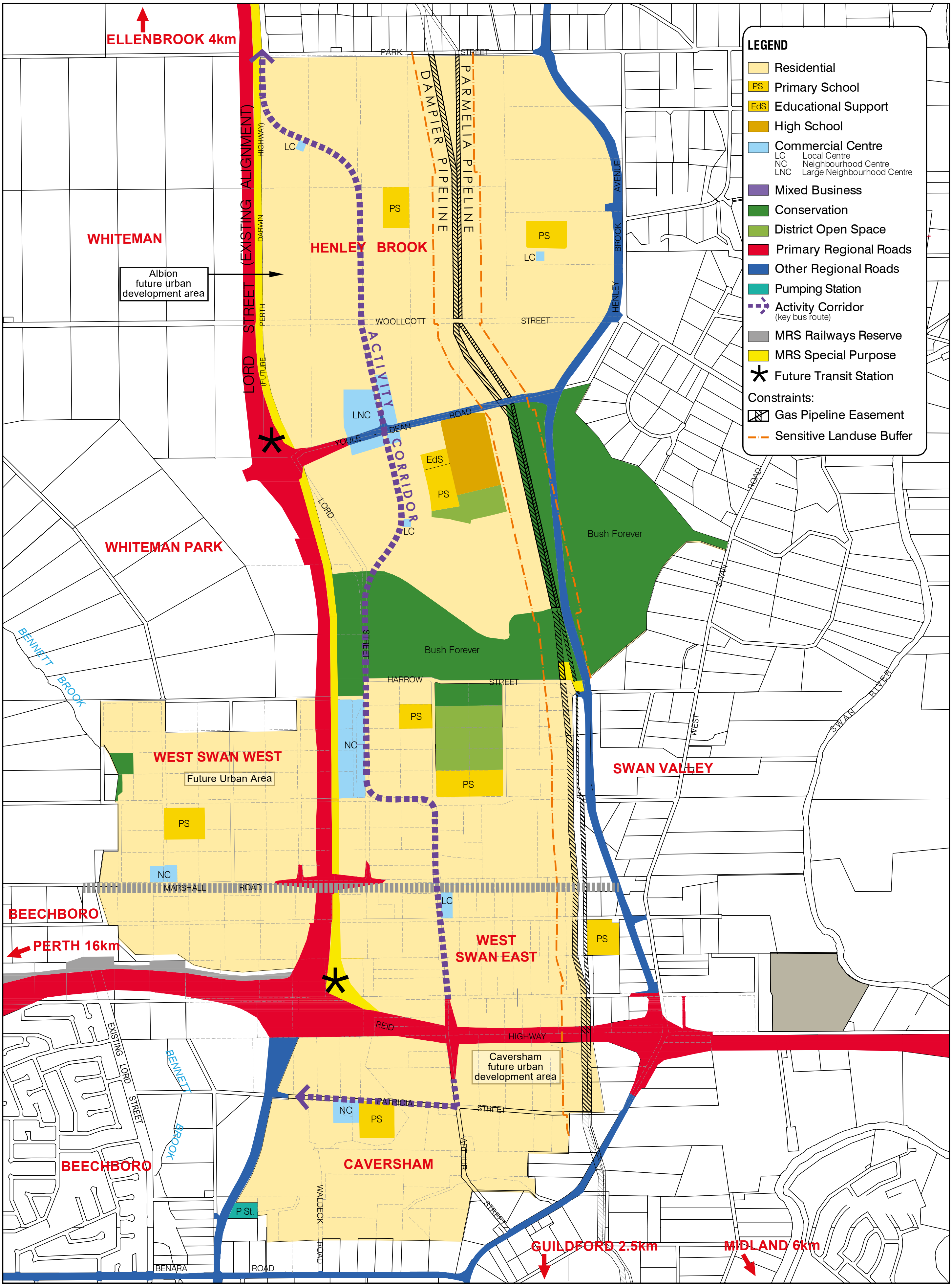
A preliminary Acid Sulfate Soil (ASS) Investigation was undertaken by RPS in April 2007. It found that the land within LSP2A has very low risk of ASS occurring within the first 3 metres of the soil surface. However, there is a moderate risk of ASS occurring at depths greater than 3 metres. It should be noted that any urban development must meet the requirements of the Western Australian Planning Commission's *Acid Sulfate Soils Planning Guidelines* of September 2010.

2.1.3 Groundwater and Surface Water

The LWMS (Appendix 8) compiled by JDA has found that the site comprises Guildford clays, with a thin overlay veneer of Bassendean sands at high-points, with existing drainage being a combination of natural drainage lines and excavated drains (extended or deepened) to enhance the drainage of the area. Floodplain mapping indicates a 100 year flood level of 7.77m above the Australian Height Datum (AHD), well below the minimum surface level of 14m AHD, and a maximum of 18m AHD in the subject area. There are currently no Environmental Water Requirements or Environmental Water Provisions.

In relation to surface water quality, the LWMS found that pH levels were generally neutral and within the ANZECC guideline values, whilst Conductivity and Nitrogen concentrations exceeded ANZECC guidelines.

In relation to groundwater quality, the LWMS found that pH levels were generally neutral and within the ANZECC guidelines. Conductivity, concentrations of Total Dissolved Solids and Phosphorus levels were beyond ANZECC guideline values. Additionally, Nitrogen levels varied



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DATE : 16.09.08
SCALE : N.T.S

NORTH

SITE CONTEXT PLAN

WEST SWAN (EAST)

considerably across the site, owing to the conditions of land use, soils and local hydrological regimes. A mean and median level of 9.6 mg/L and 5.1 mg/L, respectively, is beyond the Swan River Trust Swan River Trust (1999) and ANZECC (2000) guideline nitrogen values of 1 mg/L and 1.2 mg/L, respectively.

The major hydro-geological groundwater formations, in descending order of depth, are as follows:

- Superficial aquifer;
- Mirrabooka aquifer (semi-confined);
- Leederville aquifer (confined); and
- Yarragadee aquifer (confined).

The LWMS identified that whilst low groundwater levels (relative to ground level) reduces the need for fill, the clayey soils present potential for inadequate infiltration in the event of storms. Furthermore, historical rural land uses, coupled with a lack of groundwater quality controls, has negatively impacted groundwater quality. The utilisation of controlled groundwater levels (filling of house pads and subsoil drainage) along with water sensitive urban design will alleviate drainage concerns and maintain or improve surface and groundwater quality. The key urban water management aspects employed by LSP2A protect and rehabilitate existing waterways, utilising linear and localised POS for the detention, retention, conveyance and treatment of stormwater.

2.1.4 Heritage

An Aboriginal Heritage Survey undertaken by R & E O'Connor in 2007 revealed one Aboriginal heritage site within LSP2A. This site, designated "Site 3417" in the Department of Indigenous Affairs (DIA) Register of Aboriginal Sites, acted as a camp and water source and is known as "Coast Road Well." The site has been included as part of the public open space provision in LSP2A, as outlined in section 4.4, and will not be negatively impacted upon by development works.

Subsequent to the DIA's request, a Cultural Heritage Management Plan (CHMP) was completed by R & E O'Conner in 2010 to supplement the original 2007 report (refer **Appendix 1)**. The CHMP aims to ensure that any future development works protect and preserve known Aboriginal heritage sites, and when protection and preservation is not viable, guides actions that uphold the relevant statutory requirements. St Leonards Estate Pty Ltd have committed to the CHMP's recommendation that they nominate a heritage officer that is familiar with the requirements of the CHMP, to help ensure the protection of any objects or skeletal remains, should they be uncovered in the development works, and to assist in any liaising during the construction process.

2.1.5 Fire Management

A Bushfire Management Plan (BMP) has been prepared by Bushfire Safety and is included within Appendix 7. The BMP includes an assessment of the Dayton LSP 2A. The development site has been assessed for vegetation class and bushfire hazard rating levels. It has been determined that the proposed development will fall within the acceptable level of risk. Areas of classified vegetation have been clearly identified on and surrounding the site, which require AS3959 construction standards for residential dwellings.

In accordance with the recommendation of the Bushfire Management Plan, refer Appendix 7 two areas are identified on the Structure Plan requiring bushfire considerations, staging of development will also require consideration of Bushfire Management as required below;

AS 3959 Construction Zone – Within the AS 3959 Construction Zone building materials used in the construction of dwellings must be in accordance with Australian Standard 3959 to the Bushfire Attack Level (BAL) 12.5.

Building Protection Zone – No dwellings are permitted within the Building Protection Zone unless it can be demonstrated that the fire risk has varied since the preparation of this Structure Plan.

Staging considerations - Each development stage will require a 100 metre cleared zone surrounding the perimeter and located within the lot boundary. This will be achieved by clearing vegetation in this zone as stages are developed. It is the responsibility of the developer to establish the temporary staging and perimeter BPZ including landscaping in the power line easement.

2.1.6 Noise Attenuation

A Noise Impact Assessment was undertaken as part of the West Swan East (Dayton) District Structure Plan to address EPA and WAPC requirements to consider the control of noise and vibration associated with existing and proposed major roads, highways and railways. The Noise Study addressed these requirements by examining the potential noise impacts from Reid Highway, the future Perth-Darwin National Highway (PDNH), the future rapid transit rail line (located in the PDNH road reserve) and the potential vibration impacts from the proposed rail line. This data would then be used to identify land potentially affected by (day) noise levels less of than 55 dB(A), between 55- 60 dB(A) and areas greater than 60 dB(A) which would then identify whether there is a need for noise attenuation measures.

State Planning Policy 5.4 'Road and Rail Transport Noise and Freight Considerations in Land Use Planning' establishes a standardised set of criteria for acceptable noise levels to be used in the assessment of planning proposals, such as Structure Plans. The objective of this Policy being to achieve acceptable indoor noise levels in noise-sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms) and a reasonable degree of acoustic amenity in at least one outdoor living area on each residential lot.

The minimum goal set by the DSP Noise Study was to provide attenuation as necessary to ensure a level of outdoor noise exposure that would be acceptable for residential and other noise-sensitive development. If there are proposed residences where the external noise level does not meet the outdoor noise criteria target, external noise levels need to be reduced through acceptable noise management measures, including new infrastructure and the use of quiet house design principles, in order to achieve the internal noise levels of Australian Standard (AS) 2107:2000.

The noise modelling carried out identified the noise impact on the southern end of the site as being the most affected, as identified by night-time noise levels from Reid Highway. A small portion along the western side of the subject site is also affected by the railway. The Noise Study report further identifies the need for noise attenuation methods to be implemented in order to achieve acceptable noise exposure levels for future dwellings. This includes the need for a 2.7m high noise wall on the southern boundary and part of the western boundary, higher dwelling construction standards to achieve quiet house design and notifications being placed on Certificates of Title for any lots potentially impacted by noise.

Conditions addressing the above have already been imposed on the subdivision approval of land adjoining the Reid Highway and the future Perth-Darwin Highway and the expectation is that a similar condition will be applied to future subdivision approval where also affected by noise associated with the highway as depicted by the noise line reflected on the Context & Constraints Plan at Figure 8.

2.2 Context Analysis

LSP2A has evolved from higher level structure planning including; the Sub-Regional Structure Plan for the Swan Urban Growth Corridor that was endorsed by the Western Australian Planning Commission (WAPC) in 2009 and the West Swan East (Dayton) District Structure Plan that was endorsed by the WAPC in early 2012.

Many of the context issues, opportunities and constraints affecting the broader planning for Dayton have been addressed via the District Structure Plan. The LSP for 2A has then been refined taking into consideration the immediately abutting Structure Plans; LSP1 to the west, that was endorsed on 8 October, 2012, and LSP2B to the north, which has been adopted by the City and is currently before the Commission for endorsement. This has dictated matters such as;

- Connections to Marshall Road and Arthur Street, which are therefore largely dictated by approved linkages;

- The distribution of open space, which must take into consideration the approved locations within the adjoining Structure Plans, and has resulted in open space pushing towards the east and north within LSP 2A;

- The street layout, being predominantly north south and east west in terms of layout within LSP1 as well as the shape of the existing lots being long and narrow extending north south;

- The interface with the Dampier – Bunbury Gas Pipeline easement to the east, and the buffer to the Parmelia Gas Pipeline that extends into the Structure Plan area. This is reflective of, and consistent with, the agreements reached with the Department of Regional Development and Lands and the WAPC in relation to LSP 2B.

- The southern interface with Reid Highway, and noise attenuation measures regarding thereto, being consistent with those as agreed to in LSP 1.

- Service commercial uses proposed within LSP 3; and

- A primary school is proposed within LSP 2B.

3. OPPORTUNITIES AND CONSTRAINTS

The opportunities and constraints within LSP2A have been broadly defined in the Context and Constraints Plan (refer **Figure 8**) and are summarised below.

A full Environmental Assessment Report applicable to the subject land and extending to the full district was included within the appendices of the associated West Swan East District Structure Plan and should be read in conjunction with this report.

In addition to the environmental report mentioned above, engineering, traffic and landscape management studies have been conducted for the subject site. These respective reports can be found in the appendix and should be read in conjunction with this structure plan.

These environmental reports and management plans more accurately identify key land capability opportunities and constraints within the subject land, the features of which then impact on the LSP2A planning are identified on the Context and Constraints Plan contained at **Figure 8** and summarised below:

3.1 Summary of Opportunities and Constraints

Table 5: Opportunities and Constraints

	Opportunities	Constraints
Environment	A Local Water Management Strategy has been prepared and endorsed over the greater district, identifying drainage catchment areas, drainage requirements (volumes and general locations) required for accommodating the intended urban development. The endorsed LWMS has therefore guided both the extent of the LSP2A and the general location, distribution and use within the nominated public open space areas.	A former mushroom farm, with an associated 500m odour buffer precluding residential development, and 1000m title notification area, was located at Lot 52 Victoria Road. This site has since ceased operation and the buffers have been removed as per 1.2.2.
	No significant remnant vegetation or rare or threatened species of flora or fauna requiring protection were identified within the LSP2A area with remaining native vegetation considered for inclusion in POS.	Noise exposure Level 2 associated with the adjoining Reid Highway impact the southern portion of LSP2A, refer **Appendix 2**. A noise wall will be required to be constructed to attenuate noise from Reid Highway.
		Previous uses, generally agricultural and storage in nature, may have resulted in some evidence of contamination on properties which will require further investigation or some level of remediation at the more detailed subdivision stage but nothing that prevents structure planning from progressing.
		Preliminary Acid Sulphate Soil investigations have revealed there is the potential for Acid Sulphate Soils to exist within locations across the LSP2A area at a low to moderate level. This require further

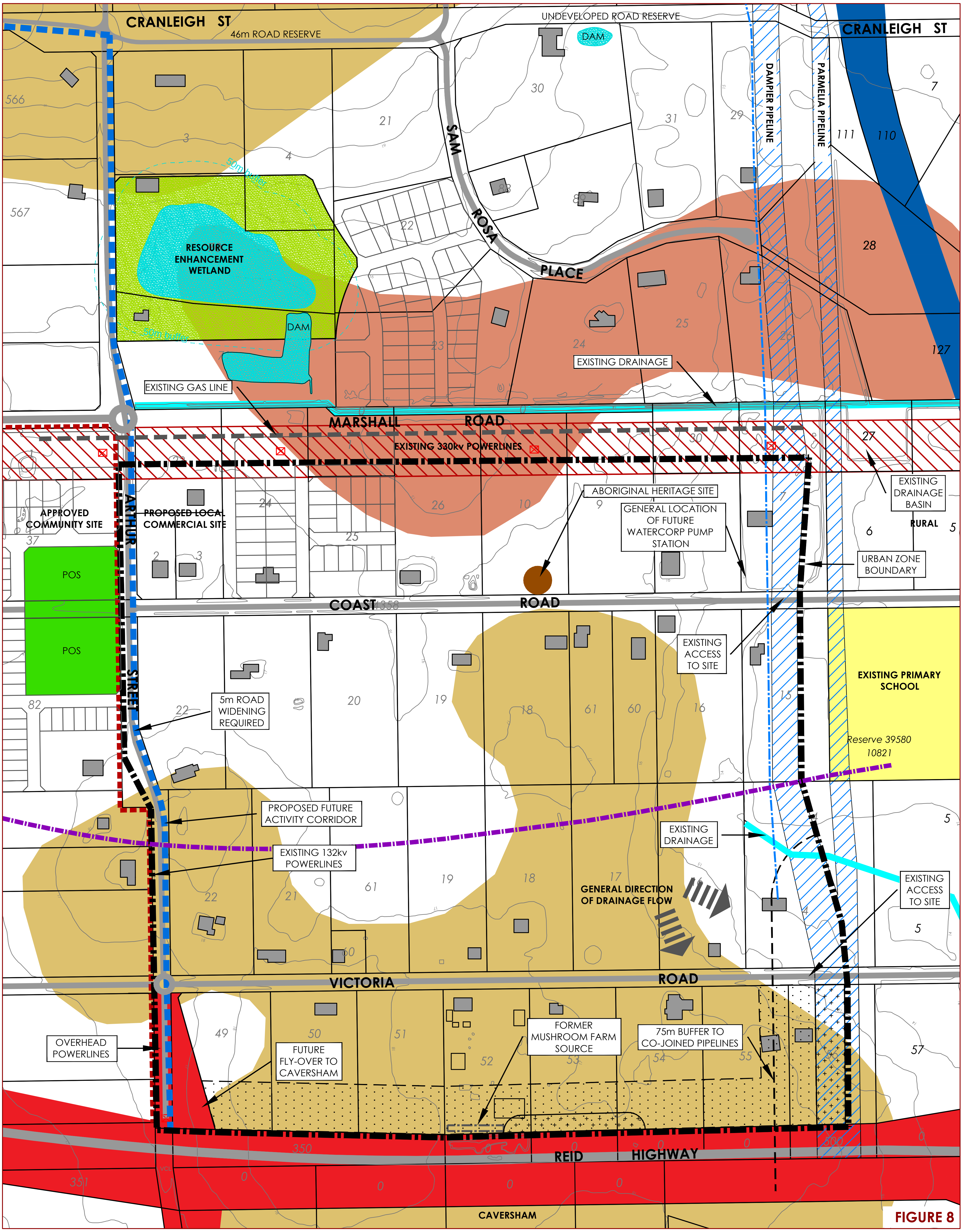

FIGURE 8

LEGEND:

- LSP2A
- Existing houses
- Activity Corridor
- Existing Streets
- Existing Drainage
- ☒ Power Line Poles
- Proposed Public Open Space
- Approved Public Open Space
- 330kv Power Easement
- 132kv Powerline
- Gas Pipeline Easements
- Noise Attenuation Measures
- 70m Setback to Parmelia Pipeline
- Moderate to High Acid Sulphate Soil Risk (DEC)
- Low to Moderate Acid Sulfate Soil Risk (DEC)
- Primary Regional Road
- Other Regional Road
- 100m AS 3959 Construction Zone
- Building Protection Zone

NORTH

CONTEXT & CONSTRAINTS PLAN
LSP2A DAYTON
CITY OF SWAN

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Plan No: ASP WES LSP2A 4-01b
Planner: KM
Date: 01.05.13
Client: St Leonards Estate Pty Ltd

0 20 40 60 80 100 120m
SCALE 1: 4000 (A3)

		investigation or the preparation of management plans at the subdivision stage(s);
		Recognition that mosquito's and midges associated with the wetland found to the north of LSP2A (in LSP2B) may pose a nuisance to future residents and that an appropriate management plan should be prepared accordingly;
		The presence of the Dampier to Bunbury Natural Gas Pipeline along the eastern boundary of the subject land, contained within its own easement and having no additional buffering requirements as it relates to the subject land;
		The presence of the Parmelia Natural Gas Pipeline along the eastern boundary of the subject land, with an easement that extends into the subject site;
		Preliminary investigations have shown that there is an Aboriginal Heritage site within LSP2A. This is detailed further within the Cultural Heritage Management Plan for the whole district area.
		The need to provide for the recommendations of the Bushfire Management Plan, refer **Appendix 7** including the AS 3959 Construction Zone; the Building Protection Zone and staging considerations.
Movement Networks	The proposed road network is based upon integration with the existing roads within and adjoining LSP2A	Access to the nearby Reid Highway abutting the southern border of the subject land is not available other than via the current intersection at Lord Street or at West Swan Road to the south-east
	Access to the LSP2A area is currently available via the existing roads of Arthur Street, St Leonards Boulevard and Victoria Road, all of which are proposed for retention in a modified form (some road reserves widened and some reserves deleted) but all upgraded from their previous rural status	There is a general lack of footpaths and dual use paths within and adjoining the subject area other than those already approved as part of the subdivision works for the 'Early Release' subdivision within LSP 1 and 2B
	Arthur Road, forming the western boundary of the site, is an activity corridor that extends throughout the Swan Growth Corridor. The Swan Sub-Regional Structure Plan and West Swan East District Structure Plan both designate an 'Activity Corridor' leading from Albion in the north, down Lord Street to Cranleigh Street and	

	then running down Arthur Street to Caversham in the south;	
	Reid Highway provides good regional linkages	
Infrastructure	The LSP2B area is already serviced by a normal telecommunications network with extensions readily capable of being achieved as part of any future subdivision works	Existing 330kV powerlines abut the northern section of LSP2A, and marginally extend into the structure plan area.
	Reticulated water is available to the area with extensions and upgrades already occurring as part of the current subdivision construction works	Existing 132kV powerlines abut the western portion of the site, along Arthur Street, and are outside of the site area
	The LWMS identifies existing drainage within LPS2A, along Victoria Road to the east, draining south under Reid Highway discharging to a drain along West Swan Road	Gas Pipelines: • Parmelia Pipeline -The Parmelia Pipeline easement is outside of the LSP2A boundary and no change of ownership or land use is proposed within the easement. In accordance with State Planning Policy, the Parmelia Pipeline has a 70m setback from the pipeline to residential uses and is identified as a 70 meter buffer on the face of the LSP. • Dampier to Bunbury Natural Gas Pipelines (DBNGP) - To appropriately manage the DBNGP pipeline easement, forming the eastern boundary of the LSP, it is the preference of the state to exclude the land, the subject of the DBNGP easement from residential development.
		The subject land is not historically connected to reticulated sewer, as such the initial Early Release subdivision works has had to extend and upgrade services from the south, with a current limit of 500 lots (the majority of which are contained within LSP1) capable of being serviced without further upgrades

Community Infrastructure	A Local Centre, identified by the West Swan East District Structure Plan, is located in the north-west corner of LSP2A. This centre provides opportunity for employment creation and day-to-day shopping and business needs totalling 1500m2 of retail and non-retail uses across the 2ha site. This will also allow for land within the adjacent 330kV powerline easement to be partially utilised for acceptable low key landscaping, pedestrian connection and possible overflow car parking	
	An Aboriginal heritage site, Coast Road Well, identified by the DIA is located within LSP2A, to the north of St Leonards Boulevard, requiring protection and preservation wherever viable	
	There is an over provision of POS identified in the DSP, providing scope for further rationalisation	

4. LOCAL STRUCTURE PLAN

4.1 Land Use

The proposed land uses within LSP2A consist of predominately medium density residential uses, with a local centre located in the north-west corner and an activity corridor that extends along Arthur Street. The land uses proposed are in accordance with those outlined in the West Swan East District Structure Plan and the Swan Corridor Urban Growth Sub-Regional Structure Plan, with the local centre located adjacent to, and residential densities concentrated along, the aforementioned activity corridor identified therein.

The Local Structure Plan for 2A, including a summary of the proposed land uses, can be found at **Plan 1**.

4.2 Residential

The Structure Plan comprises of a range of residential densities ranging from low density (R20) single residential through to medium-high density (R60), with an average density of R30. Overall Lots have been orientated such that they would provide effective surveillance of (and achieve an effective relationship with) the public domain, such as the streets, future bus routes, and local parks, and are preferably in an east-west alignment for maximum solar access along the northern boundary.

The total area available for residential development is just over 35 hectares and will accommodate an estimated minimum of 1096 lots. It is anticipated that those lots will provide for an approximate range of 1096 to 1250 dwellings. The proposed number of lots and dwellings represent a minimum nett yield of 31 dwellings per hectare. It is estimated that this will allow for a population of approximately 2,850 people within LSP2A, based upon an average dwelling size 2.6 people per household (ABS 2011).

The lot pattern is generally based on attempting to achieve a permeable gridlike network, whilst utilising the existing road alignments. The overall design rationale facilitates a highly permeable and legible street layout. High density development is proposed adjacent to the Activity Corridor and the Local Centre whilst recognising that this may occur in a staged manner and that some landowners may seek to retain their existing homes. A range of route alternatives are therefore presented to residents as a result of the lot pattern and street network.

The LSP primarily intends to provide the opportunity for R30 densities. There are a number of strategically placed R40 and R60 sites, suited to smaller families or single person households, in the form of smaller single residential cottage lots and a grouped housing opportunity next to the Activity Corridor and Public Open Space. A small amount of R20 sized lots have been provided as part of the early release programme.

Also aimed at achieving variety in housing form is the inclusion of a provision on the LSP which allows for R20 coded corner lots to be developed at an R30 density, and R30 coded corner lots to be developed/subdivided at an R40 density if desired. The intention being to allow landowners to consider developing their low density corner lots as duplex developments, with each dwelling then expected to achieve street frontage, thereby increasing the variety of housing options whilst improving the streetscape and passive surveillance.

4.3 Activity Centres and Employment

A Local Centre is proposed at the corner of Arthur Street and Marshall Road.

The Local Centre is intended to provide for local convenience needs with pedestrian and cycle connections to the surrounding community, and a total retail floorspace allocation of 1500m2. The Local Centre is located opposite a proposed 7000m2 Special Use community site, located in LSP1, providing a strong community focus and allowing for recreation and special events to occur within the one node. Furthermore, this Local Centre abuts Arthur Street, identified as an activity corridor by the West Swan East District Structure Plan, connecting to Albion and Caversham through West Swan, and providing a frequent public transport route for the future community.

In accordance with Local Planning Scheme No.17, Residential land use is not contemplated within the 'General Commercial' zone.

Council may require the preparation of a Local Development Plan to provide guidance to the future development.

4.4 Open Space

The proposed POS area within LSP2A generally reflects that originally proposed under the adopted regional and district structure plans. Additional smaller areas of local POS accommodate drainage (through live streams), and provide maximum convenience for local residents.

To date, open space within Dayton has been distributed in relation to the whole of the District Structure Plan area, rather than on a cell by call basis, however, what is most critical is the open space within the whole of Dayton. Consequently, in addition to the open space schedule prepared for LSP2A, an open space schedule has been prepared for the whole of Dayton in accordance with Liveable Neighbourhoods, both of which are included within Appendix 3. These schedules demonstrate that the broader Dayton area provides over 10% POS, well in excess of what is required. Furthermore, as shown in Figure 10, all lots within LSP2A are located in close proximity to open space either within LSP2A, or adjoining structure plan areas.

Given that Dayton has a surplus of POS, there is no requirement for the provision of additional open space.

The City of Swan should be consulted in relation to Public Open Space calculations applying to the Dayton area.

4.4.1 Distribution

The open space provision must also be considered in the context of the surrounding LSP's. Figure 10 illustrates that all lots within LSP2A are located primarily within 200m of open space and all lots are within 400m of open space. In this regard the structure plan complies with the requirements of the DSP.

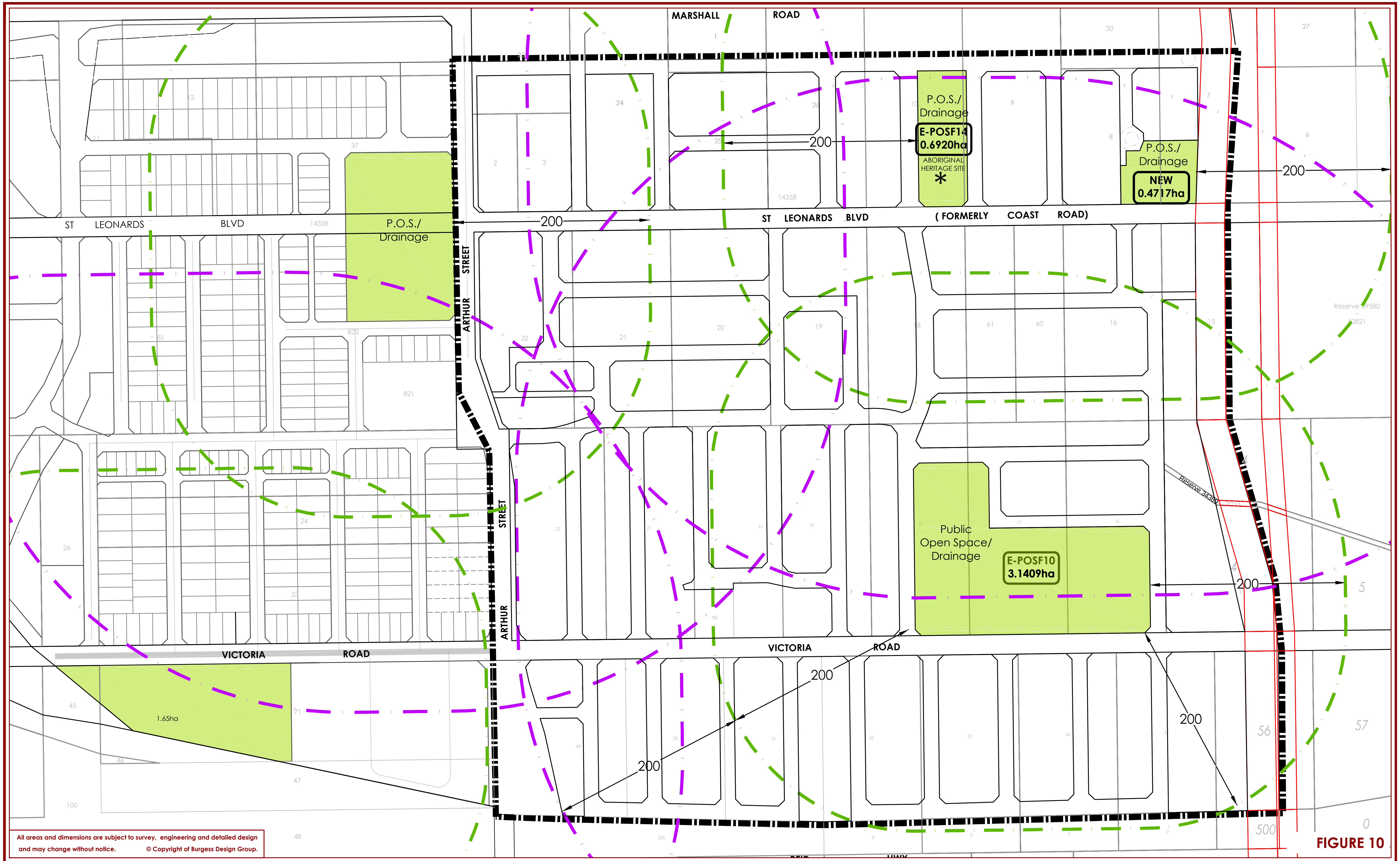

FIGURE 10

LEGEND

🟩 Public Open Space

- - 200m POS Ped Shed

- - 400m POS Ped Shed

NORTH

PUBLIC OPEN SPACE
LSP2A DAYTON
CITY OF SWAN

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Plan No: ASP WES 2A 3-02Zc_10
Client: St Leonards Estate Pty Ltd
Date: 13.06.14
Planner: MS

0 25 50 75 100m
SCALE 1:4,000 (A3)

New - 4,717m^2

This new area of local open space provides an informal open space with a large active turf area for the broader community. Additionally, this POS will include shaded BBQ facilities and possibly public art (at the south east corner). Lots fronting the northern and eastern boundaries will have informal access to the POS, helping to provide a safe space through passive surveillance.

Drainage is to be integrated in the POS through stormwater and biofiltration basins. This area of POS will also contain a Type 40 pumping station, to service the drainage requirements of the eastern third of the LSP2A area.

EPOS F14 - 7,624m^2

EPOS F14 is a passive local park that caters for nearby residents who are within 200-400m walking distance, and abuts the Western Power high voltage powerline easement to the north. This park is to contain planted areas to create shade, BBQ and picnic facilities, with an informal space to allow for both active and passive recreation. Furthermore, pedestrian and cycle paths are provided to create linkages to the broader path network, both within LSP2A, and the wider Dayton area. This POS also has cultural significance, as it contains an Aboriginal heritage site, with appropriate interpretation signage. This POS area will contain waterwise planting, dry gardens and integrated stormwater/biofiltration basins to assist in drainage and minimise water use.

EPOS F10 – 3.1409ha

EPOS F10 provides a local park for residents within 200-400m walking distance, with numerous pockets of turf and nooks for play, gatherings and informal recreation. Picnic facilities, play equipment and a connected path network are proposed to accommodate for the recreational needs of the community. The shape of the open space allows for drainage to be integrated through a vegetated drainage basin, with waterwise planting and dry gardens to be planted so as to minimise irrigation requirements, whilst having sufficient separation to informal passive open spaces.

The detailed design and landscape principles have been prepared by Emerge and Associates and are detailed within the report contained within **Appendix 4**. The siting of these areas of POS have been carefully considered in the context of the wider Dayton District Structure Plan area, so as to provide all future residents with easy access to open space.

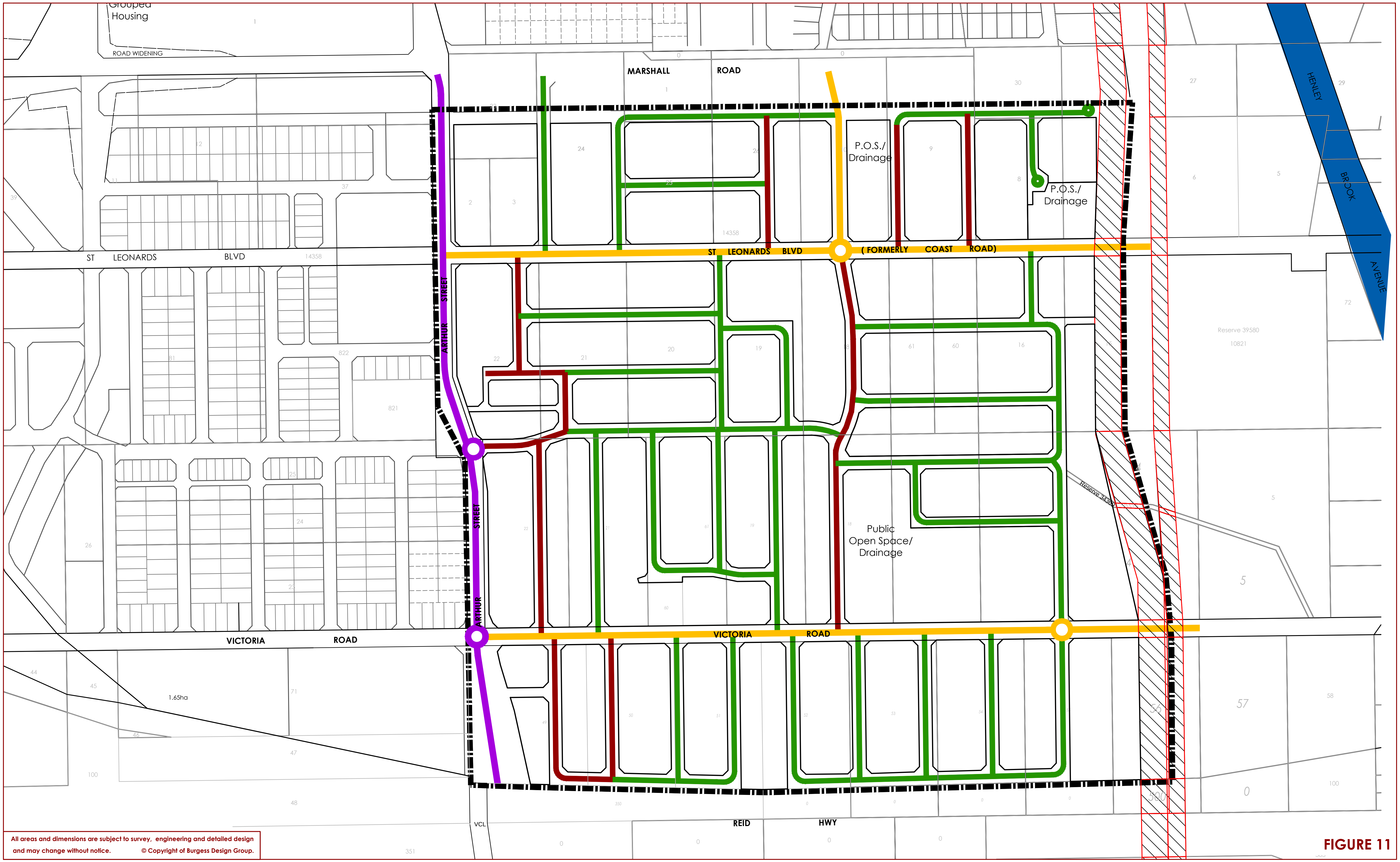
4.5 Movement Network

Transcore has prepared a Transport Assessment, refer **Appendix 5**. A summary of the key findings is included below.

Proposed Road Network

The proposed road network is based upon integration with the existing roads within and adjoining LSP2A (particularly given that a number of established homes are reliant upon the existing road network for access), those incorporated into the LSP2B and LSP1 subdivision design as well as with those future roads identified in previously agreed structure planning documents.

The Transcore report examines the daily traffic volumes and the anticipated function of the existing and proposed roads to determine the resultant proposed road classifications for the structure plan road network, refer **Figure 11**. The road hierarchy has been determined based on the principles of Liveable Neighbourhoods.



All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

FIGURE 11

LEGEND

🟦	Other Regional Road	🟥	Access Street B
🟪	District Distributor Integrator B	🟩	Access Street C
🟨	Neighbourhood Connector B	⬜	Access Street D

NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

MOVEMENT NETWORK
LSP2A DAYTON
CITY OF SWAN

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Plan No: ASP WES 2A 3-02ZcClient: St Leonards Estate Pty Ltd
Date: 13.06.14 Planner: MS

From the framework illustrated in **Figure 11**, a series of local access streets are proposed to extend through the LSP2A cell, connecting the existing roads to create a legible and permeable grid-like pattern, with viewscapes towards the public open space areas (where practical) and Activity Corridor, whilst attempting to minimise the impact on existing homes, particularly those homes which landowners have previously expressed a desire to retain. Such an outcome encourages efficiency for vehicles, cyclists and pedestrians as well as for the future lot yields of individual landowners.

The proposed LSP2A road network also links with the road network proposed as part of the broader District Structure Plan and the public transport routes within or adjoining, and hence, the associated West Swan East DSP should be read in conjunction with this LSP.

It should also be noted that in designing the road network, consideration was also given to road widths, noting in particular that the existing Arthur Street reserve need to be adjusted as part of the structure planning, with widening to occur relevant to the anticipated traffic volumes and road pavement design.

Similarly, the road network reflects the ideal access scenarios. Residential driveways directly accessing Arthur Street was deemed undesirable, and as such, the use of rear access streets is proposed. These design elements will maintain attractive streetscapes whilst reducing opportunities for traffic conflict.

4.5.1 Public Transport

Existing public transport services in the area consist of a bus service (Route 956: Ellenbrook North-Bassendean Station) along Lord Street, the to the west of the LSP area with 10 to 15 minute services during the weekday peak periods, 15 minute services during the midday off-peak period and hourly services in the evenings. Weekend services consist of 30 minute service frequencies on Saturday and hourly services on Sundays and public holidays.

Proposed public transport services in the broader area within the West Swan East DSP area include a dedicated bus rapid transit facility running along a new transit way between Morley and Ellenbrook. This has been identified as a key project within the Public Transport for Perth 2031, released for draft comment by the Public Transport Authority in 2011. The MRS has reserved an alignment for a transit way along the east side of the Perth Darwin Highway and north of Reid Highway.

4.5.2 Pedestrian and Bicycle Network

LSP2A proposes to provide a dual use path/shared path on the east side of Arthur Street, the dual use path then links with proposed paths in the adjoining Structure Plans, north side of Cranleigh Street, west side of Blundell Street, south side of Harrow Street and east side of Lord Street with footpaths on the other side of the road. The balance of the local roads within LSP2A will only require footpaths on one side of the road.

All of the roads abutting public open space and the primary schools in the area have therefore taken this into consideration with regard to the siting of the shared path network.

4.6 Gas Pipelines

The Dampier to Bunbury Gas Pipeline and the Parmelia Gas Pipeline are existing pipelines traversing the Perth metropolitan region. The Dampier to Bunbury Gas Pipeline straddles the eastern boundary of LSP2A, whilst the Parmelia Gas Pipeline is further east and falls outside of the Structure Plan boundary to the north, before amalgamating with the Dampier to Bunbury Gas Pipeline to the south. Both are proposed to be retained in an unaltered fashion within their current trenches and respective easements, as outlined below.

4.6.1 Parmelia Pipelines

As mentioned, the western extent of the Parmelia pipeline easement forms the northern 220 metres of the LSP2A boundary (outside of the subject area), and continues south, forming a common easement with the Dampier to Bunbury Gas Pipeline within the subject area. In accordance with State Planning Policy, the Parmelia Pipeline has a 70m setback from the pipeline to residential uses and is identified as a 70 metre buffer on the face of the LSP. The impact of the buffer from the Parmelia Pipeline extends very marginally along portion of length of the eastern extremity of the Structure Plan. No dwellings are proposed to be located within the buffer.

4.6.2 Dampier to Bunbury Natural Gas Pipelines (DBNGP)

To appropriately manage the DBNGP pipeline easement, forming the eastern boundary of the LSP2A area, it is the preference of the state to exclude the land subject of the DBNGP easement from residential development.

To ensure appropriate management of the DBNGP easement, no residential lot or development is to extend into or over the DBNGP easement. Rather it is proposed that at the time of subdivision of properties containing the pipeline easement, a condition of subdivision approval will be imposed requiring that the land containing the easement will be ceded free of cost to the crown, vested in the Department of Regional Development and Lands with a Management Order to the Dampier to Bunbury Natural Gas Pipeline.

This arrangement is currently being worked through by the various agencies and stakeholders that are involved in this process.

5. INFRASTRUCTURE COORDINATION, SERVICING AND STAGING

TABEC Civil Engineering Consultants prepared a Civil Infrastructure and Servicing Strategy; with 3E Consulting Engineers completing Electrical and Communication Servicing reports as appendices, to support the preparation of LSP2A (refer **Appendix 6**). These reports confirm that there are no identified servicing constraints that prevent the land from being developed for urban purposes. The site is capable of being provided with all essential services and infrastructure. A summary of the report is provided below.

5.1 Power

With the exception of the 330kV and 132kV powerlines abutting Marshall Road and Arthur Street (respectively), existing above ground services will be required to be removed and replaced with underground infrastructure upon development of lots fronting those roads. Existing underground services are available in the vicinity of Arthur Street (for stages 1A and 1B), Grandis Street (formerly Victoria Road) near the intersection of Arthur Street, and St Leonards Boulevard in the vicinity of Stage 1J. It is anticipated that LSP2A (along with LSP2B) will initially be fed by the BCH518 High Voltage Feeder to the east of the subject site. Due to the limited capacity of the existing HV feeders, LSP2A will require the construction of a new dedicated feeder from a Zone Substation to the development site to service the ultimate load of 1.2MVA for the subject site.

5.2 Telecommunications

Current Telstra telecommunications infrastructure is provided through both fibre-optic and local cable along Arthur Street, and local cable along Victoria Road and St Leonards Boulevard. Telecommunications services are planned through the National Broadband Network system (NBN). Current plans propose the construction of five Fibre Distribution Hubs (FDH's) to provide NBN access to LSP2A through Retail Service Providers' voice, data, video and TV services. In accordance with Government Policy, the Developer is to provide pit and pipe, at their expense, when electing to service with NBN fibre.

As outlined by 3E's Communication report, plans should be submitted to NBN once the electrical layout for the development has been prepared. The network and system upgrades will then be determined, with plans produced by NBN and a construction programme agreed upon to suit the development works. All system upgrade costs and external reticulation requirements will be paid for in-full by the developer. This is to be completed at subdivision stage.

5.3 Water

The Water Corporation has installed a DN600 and DN250 water main to the south and south-east of the subject site, respectively, improving the initial water supply for the Dayton Structure Plan Area.

Future development will require the extension of a 600mm-diameter water distribution main near the intersection of Marshall Road and Lord Street (located south of the Dayton DSP area), the timing of which will be confirmed with the Water Corporation.

A 250mm water ring main will also be required along Victoria Road, the future most eastern roads of LSP2A and along Arthur Street, ensuring all lots are provided with connections in accordance with the Water Corporations requirements.

5.4 Sewer

In addition to the existing initial capacity expansion Type 40 pump station, wastewater management in the West Swan East Structure plan area will require the construction of a Type 180 pump station. This is to be located on the intersection of Benara Road and Bennett Street, with the associated infrastructure works including the construction of a rising main connecting to infrastructure at the intersection of Benara Road and Tonkin Highway. The Type 180 is planned to be constructed by Water Corporation this calendar year.

The LSP2A area comprises one of two sewerage catchment areas for the West Swan East Structure Plan area. This catchment area, contained entirely within the subject site, requires the construction of a Type 40 pumping station (Eden Hill F) to be located along the eastern boundary of the subject site, near the intersection of St Leonards Boulevard and the Dampier to Bunbury Natural Gas and Parmelia Gas Pipeline Corridor (confirm location on map). Additionally, a sewer pressure main, that will run parallel to the Dampier to Bunbury Natural Gas and Parmelia Gas Pipeline Corridor from St Leonards Boulevard to Reid Highway, and a DN225 gravity sewer main continuing southward to Suffolk Street will also be required.

5.5 Gas

A Pressure reduction valve, provided by St Leonards Estates, on the existing high pressure gas main in Marshall Road will provide the local point of connection for all future services within Dayton.

5.6 Water Management

In the absence of a district water management strategy, a Local Water Management Strategy (LWMS) has previously been developed by JDA Consultant Hydrologists on behalf of West Swan Estate Pty Ltd for the West Swan East District Structure Plan Area. At The request of the City of Swan a revision to the LWMS was completed by JDA, this can be found in Appendix 8. Favourable comments have been received from the City of Swan, Department of Water, and Swan River Trust and the report will shortly be consolidated and submitted to the City.

The LWMS is consistent with the North East Corridor Urban Water Management Strategy (GHD 2006), and the Swan Urban Growth Corridor Drainage and Water Management Plan (DoW, 2009). The LWMS has been prepared with sufficient detail to bridge the gap between the previously mentioned regional drainage strategies, supporting both the District Structure Plan, and individual Local Structure Plans.

In accordance with the Water Management Strategy flow criteria, the developable area north of St Leonards Boulevard will be graded north-east, with the Marshall Road drain upgrade to be completed in conjunction with development in the catchment area.

Development areas south of St Leonards Boulevard will be graded south-east towards the allocated POS/Drainage Reserve area, where stormwater will be retained prior to being conveyed to Bennet Brook via Victoria Street.

5.7 IMPLEMENTATION

5.8 Developer Contribution Arrangements

West Swan East District Structure Plan area, which includes the LSP 2A, is identified as ‘Developer Contribution Area 2’ (DCA 2) within Schedule 13 of LPS 17. DCA 2 in Schedule 13 gives effect to the Dayton Development Contribution Plan ('DCP').

The objective of the DCP is to ensure equitable distribution of development costs between stakeholders and is the mechanism that delivers the Swan Urban Corridor Sub Regional Structure Plan, the Urban Growth Corridor – Sub Regional Planning Community Facilities Analysis and the West Swan East District Structure Plan outcomes.

The DCP applicable to DCA2 identifies a number of infrastructure items within or immediately adjoining the LSP 2A area, as well as throughout the wider District, which are required to be ceded, resumed or constructed as part of the process of converting Dayton from a predominantly rural use to an urban use consistent with the structure planning outcomes. The ‘Infrastructure Demand’ is apportioned across the development in order to derive Infrastructure Contribution Rates for each network of Infrastructure. Each developer will be required to make Cost Contribution payment based on the area that they develop and the applicable Contribution Rate for DCA 2.

Table 6 below lists:

a) The DCP items that are within or borders the LSP2A area or are works/arrangements that need to commence as part of the development of LSP2A, and;

b) The triggers for the completion of these DCP items before or at the subdivision clearance of deposited plan that generates the lot (or its unit of equivalent demand) that meets or exceed the trigger specified in that table.

This is not a comprehensive listing of works and land identified in the endorsed Development Contribution Plan for DCA 2, so where a DCP item is not listed in the table below, the trigger for the acquisition and/or construction of the DCP item is addressed in its relevant Local Structure Plan and the 'Capital Expenditure Plan for the Urban Growth Corridor' ('CEP'). In the absence of an endorsed LSP or CEP, the CEP advertised by City of Swan applies.

The construction of DCP items will be guided by subdivision and the CEP, which will give due regard to the triggers in the endorsed LSP2A and availability of funds.

Any developers seeking subdivision within LSP2A must contribute to the endorsed DCP applicable to DCA 2 as contemplated by Clause 5A.2.5.2 of the City of Swan Local Planning Scheme No.17. If however subdivision is sought prior to the final endorsement of the DCP and its incorporation into Schedule 13 of LPS17, the owner/developer shall first enter into a deed with the City of Swan that requires the owners/developers to make an appropriate cost contribution upon notification by Council that payment is required and securing in the form of either payment or caveat of any balance that might be due on gazettal of the DCP for DCA 2.

Table 6: Triggers for DCP Works

DCP Code	Description of DCP item	Description if the DCP item needs to be acquired and/or constructed in stages	Trigger (dwelling units or equivalent)****
E-IRF01	Roundabout Cnr Marshall Road and Arthur Street	Construct roundabout	1200 du
E-TRF01 & E-TRF02	Upgrade Arthur Street (Marshall Rd to Coast Rd)	1. Widen and kerb west side	With abutting development in LSP1
		2. Upgrade to integrator B standard	With abutting development in LSP2A or with Arthur St flyover (long term)*
E-ITF01	Priority T intersection at Arthur Street and St Leonards Boulevard	Construct T-junction (done)	With abutting development in LSP1
E-TRF36	Upgrade Arthur Street (Coast Rd to Victoria Rd)	1. Widen and kerb west side	With abutting development in LSP1
		2. Upgrade to integrator B standard	With abutting development in LSP2A or with Arthur St flyover (long term)*
E-IRF06	Roundabout Cnr Victoria Road and Arthur Street	Construct roundabout	With Arthur St flyover across Reid Hwy (long term)
E-TRF37	Upgrade Arthur Street (south of Victoria Rd)	Connect to future flyover across Reid Hwy	With Arthur St flyover across Reid Hwy (long term)
E-TRF05 **E-TRF04**	Upgrade Marshall Road (Lord St to Arthur St)	Upgrade to integrator B standard	1200 du
E-TRF32	Construct Marshall Road (east of Arthur Street)	Construct to integrator B standard	1200 du
E-IRF05	Roundabout Cnr Marshall Road and link to Sam Rosa Place	Construct roundabout	1200 du
E-TRF38	Construct Marshall Road (eastern section of LSP2A)	Construct to integrator B standard	1200 du**
E-ITF02	Intersection of Marshall Road and LSP2A eastern access street	Construct priority controlled intersection	1200 du**
E-TRF39	Construct Marshall Road (west of Henley Brook Ave)	Construct to integrator B standard	1200 du**
E-ISE01	Roundabout cnr Marshall Road and Henley Brook Ave	Construct roundabout	1200 du**
*****	Upgrade to Coast Road between Arthur Street and West Swan Road	Localised widening and enhanced street lighting	1200 du
*****	Intersection of Coast Road and West Swan Road	Construct priority controlled intersection	1200 du
E-TRF25 to 29, 33, 34 &	Construct Henley Brook Avenue (Marshall Road to	Land acquisition and construct first carriageway.	1200 du**

35, E-ACQ07 to 13	Reid Highway)	Construct second carriageway	Year 2019
E-ITF04	Intersection of Henley Brook Ave and Victoria Rd	Construct priority controlled intersection	1200 du**

Given Henley Brook Avenue depends on land acquisitions and Marshall Rd depends on the willingness of multiple affected landowners to subdivide, these roads may not be available by the time the 1200 dwelling unit trigger is reached. If Marshall Rd and Henley Brook Ave are not available, then Coast Rd (notated *** on* ***Table 6*) is presented as an interim arrangement that a subdivider (or the City and WAPC through a condition of subdivision) can implement until the ultimate access arrangement (Marshall Road & Henley Brook Avenue) or an alternative access strategy is agreed upon & implemented. See Appendix C of the Transport Assessment for these alternative access strategies.*

*****The dwelling units triggers nominated in the table above may vary in consultation with the City of Swan.*

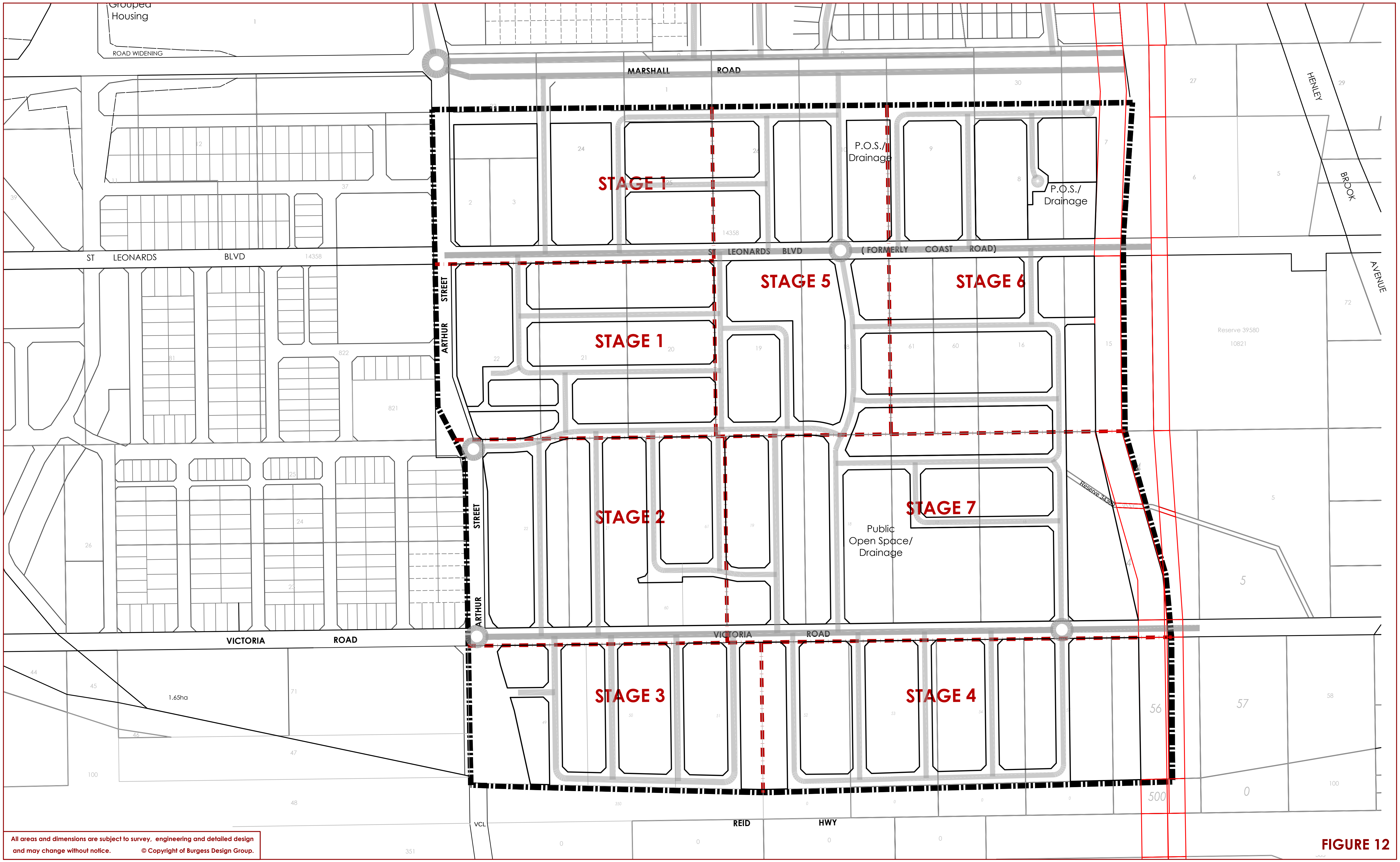
5.9 Staging

Upon successful advertising, adoption and endorsement of the LSP, landowners within the LSP2A area may progress to subdivision and/or development. It is likely that the first stages of development will commence on St Leonards Estate Pty Ltd owned land. Extending in a southerly direction from Marshall Road, and within the western half of the Structure Plan area. The timing of other subdivisions is dependent upon individual landowner intentions and is therefore indicatively nominated as further stages.

An indicative staging plan is included at **Figure 12** to assist in illustrating the likely order of staging and subdivision construction works within the LSP area but is simply a guide to likely logical progression partially based on proponents aspirations and partially on proximity to servicing extensions, noting that the 500 lot sewer allocation provides an initial hurdle for release of lots until additional extensions are realised.

It is also important to note that each development stage will require a 100 metre cleared zone surrounding the perimeter and located within the lot boundary. This will be achieved by clearing vegetation in this zone as stages are developed. It is the responsibility of the developer to establish the temporary staging and perimeter BPZ including landscaping in the power line easement.

In relation to the infrastructure items and the triggers mentioned in **Table 6** above, it is intended that the completion of these upgrades will be constructed before or at subdivision clearance of deposited plan that generates the lot (unit of equivalent demand) that meets or exceeds the triggers.



All areas and dimensions are subject to survey, engineering and detailed design and may change without notice. © Copyright of Burgess Design Group.

FIGURE 12

INDICATIVE STAGING PLAN
LSP2A DAYTON
CITY OF SWAN

NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

burgess design group
TOWN PLANNING + URBAN DESIGN

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Plan No: ASP WES 2A 3-02Zc Client: St Leonards Estate Pty Ltd
Date: 13.06.14 Planner: MS

6. CONCLUSION

The Dayton Local Structure Plan 2A report, accompanying plans and appendices satisfy Council's Scheme requirements with respect to a District Structure Plan being in place prior to the more detailed Local Structure Plan endorsement and substantive subdivision and development of the land.

The Local Structure Plan as described in this report satisfies the planning frameworks adopted by the City of Swan and the Western Australian Planning Commission and the advice received during consultation with other agencies. The Plan should ultimately assist in achieving a contemporary and well integrated suburb that provides the foundation for a strong and cohesive community.

In light of the above, the Local Structure Plan as submitted represents a logical, well planned and timely addition to the ongoing development of the City of Swan's Urban Growth Corridor and the next stage of implementing the Dayton District Structure Plan.

APPENDIX 1

CULTURAL HERITAGE MANAGEMENT PLAN

WEST SWAN (EAST) DISTRICT STRUCTURE PLAN

DEVELOPMENT AREA ABORIGINAL CULTURAL HERITAGE

MANAGEMENT PLAN

Prepared by R. & E.O'Connor Pty. Ltd.
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For St. Leonard's Estate Pty. Ltd.
And Aspen Development Services,
P.O. Box 3442,
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August 2010

ABSTRACT

In July 2010, St. Leonard's Estate Pty. Ltd. commissioned R. & E.O'Connor Pty. Ltd. to prepare an Aboriginal Cultural Heritage Management Plan for the proposed West Swan (East) District Structure Plan Development Area. This document is Draft Number One (Draft #2) of that ACHMP. It contains eight sections, as follows.

Section One, which details the background to the ACHMP and discusses proposed development at the SPDA.

Section Two, which details the relevant legislation.

Section Three, which details the scope and purpose of the ACHMP.

Section Four, which details and analyses previous Aboriginal heritage studies and surveys at the SPDA and their findings.

Section Five, which discusses the potential effects of development on Aboriginal sites at the SPDA and possible mitigative management strategies.

Section Six, which outlines suggested management commitments.

Section Seven, which deals with logistics for heritage management, including Aboriginal monitoring programmes.

Section Eight, which details contingency plans that can be activated in the event of previously unidentified Aboriginal sites or objects being discovered during ground disturbance.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

In January 2007 R. & E.O'Connor Pty. Ltd. carried out an ethnographic survey of the West Swan East District Structure Plan Development Area ("the SPDA"). A desk-top archaeological study of the same project area was also carried out by Quartermaine Consultants. The ethnographic survey reached the following conclusions and made the following recommendations.

Two Aboriginal sites, namely registered Aboriginal sites numbers 3417 and 22159 are located within the Project area. In addition, registered Aboriginal site number 20030 is located close to the southern perimeter of the Project area.

The four sub-groups of the Region Six Single Noongar Claim native title holders, namely the Garlett family, Headland-Corunna family, Wilkes family and the Swan Valley Circle of Elders sub-groups were consulted in regard to the Project, as also were the Ballaruk group and the Jacobs clan. All have given approval for the Project to proceed. Four of the groups attached a condition of preservation of the registered Aboriginal sites within the Project to their approvals. The Wilkes group attached a condition of having Aboriginal monitors on site when earthworks are taking place to their approval. All signed approvals are included in this report.

This report recommends that the Project should proceed, as the relevant Aboriginal groups have approved it, subject to certain conditions. It is also recommended that registered Aboriginal sites numbers 3417 and 22159 should be preserved undisturbed by the Project through inclusion in Public Open Space. It should be noted that disturbance of these sites is an offence under the Aboriginal Heritage Act 1972, unless Ministerial consent pursuant to Section 18 of that Act has been obtained in their regard. It is also recommended that, in recognition of the concerns of the Wilkes family in regard to possible disturbance of skeletal remains or Aboriginal cultural material, an Aboriginal monitoring programme should be established during initial ground surface disturbance.

In July 2010, as planning for development of the SPDA progressed, and following receipt of comments on the Plan from the City of Swan on 18 March 2010, St. Leonard's

Estate Pty. Ltd. commissioned R. & E.O'Connor Pty. Ltd. to prepare an Aboriginal Cultural Heritage Management Plan ("ACHMP") for the SPDA. This document is a First Draft of that ACHMP.

1.2 The Land

Figure One shows the SPDA, Figure Two shows the site layout, and Figure Three shows the District Structure Plan. The SPDA is bounded to the north by Harrow Street, to the east by the Dampier to Bunbury Natural Gas Pipeline, to the south by Reid Highway and to the west by the future Perth-Darwin National Highway. As detailed in Figure Three, it comprises five Local Structure Plan ("LSP") areas, numbered 1, 2A, 2B, 3 and 4 respectively. This ACHMP considers all five LSP areas. It is the author's understanding that the SPDA is freehold land.

1.3 The ACHMP

In preparation of the ACHMP the following documents were taken into consideration:

- Aboriginal Cultural Heritage Management Plan Template 2008. A Guide for Local Governments. Prepared by Cheryl-Anne McCann, Swan Catchment Council.

- Aboriginal Heritage Management Plans, as described and detailed under *Heritage Management* in the Department of Indigenous Affairs website.
- Aboriginal Cultural Heritage Management Plans previously prepared by R. & E.O'Connor Pty. Ltd.

Specifically, the ACHMP addresses the following matters under separate rubrics:

1. Summary of Project area and proposed developments.
2. Relevant legislation.
3. Scope and purpose of ACHMP.
4. Previous studies and findings, including listing of registered Aboriginal sites.
5. Summary of potential effects of development on Aboriginal sites and possible management responses.
6. Suggested management commitments.
7. Logistics for heritage protection.
8. Monitoring, reporting and notification.
9. Contingency plans.

2.0 RELEVANT LEGISLATION

2.1 The *Aboriginal Heritage Act 1972*

The Western Australian *Aboriginal Heritage Act* ("AHA"), whose short title is *an Act to make 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 purposes incidental thereto*, came into operation on 15 December 1972. It has been amended substantially since then. Initially, the AHA was administered by the Department of Aboriginal Sites at the Western Australian Museum. Following a series of changes, it is now administered by the Department of Indigenous Affairs. The AHA defines Aboriginal sites as follows:

> *(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.*

Over time there has developed in this State an understanding that collections of refuse from the manufacture of stone implements (referred to as "debitage" by archaeologists) constitute "Aboriginal sites" within the meaning(s) of the above definitions. Section 6 of the AHA defines "Aboriginal objects" as follows.

> *(1) Subject to subsection (2a), this Act applies to all objects, whether natural or artificial and irrespective of where found or situated in the State, which are or have been of sacred, ritual or ceremonial significance to persons of Aboriginal descent, or which are or were used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people past or present.*
>
> *(2) Subject to subsection (2a), this Act applies to objects so nearly resembling an object of sacred significance to persons of Aboriginal descent as to be likely to deceive or be capable of being mistaken for such an object.*
>
> *(2a) This Act does not apply to a collection, held by the Museum under section 9 of the Museum Act 1969 , which is under the management and control of the Trustees under that Act.*
>
> *(3) The provisions of Part VI do not apply to an object made for the purpose of sale and which —*

(a) is not an object that is or has been of sacred significance to persons of Aboriginal descent, or an object so nearly resembling such an object as to be likely to deceive or be capable of being mistaken for the same; or

(b) is an object of the kind referred to in paragraph (a) that is disposed of or dealt with by or with the consent of the Minister.

The Committee referred to is the Aboriginal Cultural Material Committee, which was established by Amendment No. 8 of 1980. Its functions are as follows:

(a) To evaluate on behalf of the community the importance of places and objects alleged to be associated with Aboriginal persons;

(b) Where appropriate, to record and preserve the traditional Aboriginal lore related to such places and objects;

(c) To recommend to the Minister places and objects which, in the opinion of the Committee, are, or have been, of special significance to persons of Aboriginal descent and should be preserved, acquired and managed by the Minister;

(d) Deleted by No. 8 of 1980, s. 10.

(e) To advise the Minister on any question referred to the Committee, and generally on any matter related to the objects and purposes of the Act;

(ea) to perform the functions allocated to the Committee by this Act;

(f) To advise the Minister when requested to do so as to the apportionment and application of moneys available for the administration of this Act.

Once again, over time there has developed a situation where the main, and at times sole, role of the Committee at its monthly meetings is to work through a series of applications pursuant to Section 18 of the AHA (see Appendix One) and make recommendations to the Minister in their regard.

The AHA makes it an offence for any person to carry out the following actions within an Aboriginal site:

(a) Excavate, destroy, damage, conceal or in any way alter any Aboriginal site; or

(b) In any way alter, damage, remove, destroy, conceal, or deal with in a manner not sanctioned by relevant custom, or assume the possession, custody or control of, any object on or under an Aboriginal site.

Again, over time there has developed in this State an understanding that removal, or alteration, etc. of the material referred to above, constitutes an offence against the AHA, unless the requisite Ministerial consent for such actions has been obtained, as detailed in Section 18 (see Appendix One).

2.2 The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*

The Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* ("ATSIHPA") takes precedence over the State legislation if successfully invoked. Unlike the State legislation, this Act does not make provision for the orderly destruction of Aboriginal sites. Also, unlike the State legislation, it can be invoked only by or on behalf of an Aboriginal person or persons. The purposes of this Act are *the preservation and protection from injury or desecration of areas and objects in Australia and in Australian waters being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition.* The ATSIHPA makes provision for Emergency and Permanent Declarations in respect of significant Aboriginal areas. Significant Aboriginal areas and objects are defined as follows.

***"significant Aboriginal area"** means:*

(a) an area of land in Australia or in or beneath Australian waters;

(b) an area of water in Australia; or

(c) an area of Australian waters;

being an area of particular significance to Aboriginals in accordance with Aboriginal tradition.

***"significant Aboriginal object"** means an object (including Aboriginal remains) of particular significance to Aboriginals in accordance with Aboriginal tradition.*

(2) For the purposes of this Act, an area or object shall be taken to be injured or desecrated if:

(a) in the case of an area:

(i) it is used or treated in a manner inconsistent with Aboriginal tradition;

(ii) by reason of anything done in, on or near the area, the use or significance of the area in accordance with Aboriginal tradition is adversely affected; or

(iii) passage through or over, or entry upon, the area by any person occurs in a manner inconsistent with Aboriginal tradition; or

(b) in the case of an object, it is used or treated in a manner inconsistent with Aboriginal tradition;

and references in this Act to injury or desecration shall be construed accordingly.

(3) For the purposes of this Act, an area or object shall be taken to be under threat of injury or desecration if it is, or is likely to be, injured or desecrated.

In the case of an Emergency Declaration, the Act reads as follows.

(1) Where the Minister:

(a) receives an application made orally or in writing by or on behalf of an Aboriginal or a group of Aboriginals seeking the preservation or protection of a specified area from injury or desecration; and

(b) is satisfied:

(i) that the area is a significant Aboriginal area; and

(ii) that it is under serious and immediate threat of injury or desecration;

he or she may, by legislative instrument, make a declaration in relation to the area.

(2) Subject to this Part, a declaration under subsection (1) has effect for such period, not exceeding 30 days, as is specified in the declaration.

(3) The Minister may, if he or she is satisfied that it is necessary to do so, declare by legislative instrument that a declaration made under subsection (1) shall remain in effect for such further period as is specified in the declaration made under this subsection, not being a period extending beyond the expiration of 60 days after the day on which the declaration under subsection (1) came into effect.

The ATSIHPA also makes provision in Section 10 for extended or Permanent Declarations to be made in respect of Aboriginal Places or Objects. Although the Commonwealth Minister has shown himself or herself unwilling to make Declarations pursuant to Sections 9 and 10 of the ATSIPHA in the past, the Act remains on the statute books and should be regarded by developers as a potential constraint. It should also be noted that the majority of listings in the Register of Aboriginal Sites (more than 75%) are for archaeologists' sites rather than sites of spiritual or other significance to Aboriginal people. As noted above, non-Aboriginal people cannot make an application pursuant to the ATSIHPA, unless they do so on behalf of an Aboriginal person or Aboriginal people.

2.3 The *Native Title Act 1993*

This Commonwealth Act *recognises and protects native title (and) provides that native title cannot be extinguished contrary to the Act.* As noted in 1.2 above, the SPDA is freehold land. Native title has therefore been extinguished there. However, the Act has two implications for proposed developments there, both of which are relevant to this ACHMP, as follows.

- Native title claimants, whose applications cover lands including the SPDA assert the right to protect areas and places of significance to them in accordance with their laws and customs. Although native title may be extinguished within the SPDA, that assertion is relevant to both the ATSIHPA (see 2.2 above) and to the AHA.
- In regard to the operation of the AHA, should a developer of land within the SPDA make an application pursuant to Section 18 of the Act, the ACMC will require that applicant to show that they have consulted, *inter alia*, the relevant native title claimant groups.

3.0 SCOPE AND PURPOSE OF THE ACHMP

The scope of this document comprises the formulation of plans, procedures and work methods that together will satisfy the requirements of the AHA (see 2.1 above) and the aspirations vis-à-vis protection of their heritage of the relevant Aboriginal groups.

The purpose of this document is to ensure that works associated with development of the SPDA will, wherever possible, protect and preserve existing known Aboriginal heritage sites and possible yet to be identified sites. In cases where such protection and preservation are not feasible, a secondary purpose is to ensure that all actions in respect of those sites are in accordance with the relevant legislation, as outlined in 2.1, 2.2 and 2.3 above.

4.0 PREVIOUS STUDIES AND FINDINGS

4.1 Sources – DIA Register

The electronic Register of Aboriginal Sites was consulted for the polygon described by the following coordinate sets: (MGA Zone 50): 402000E 6476250N; 404000E 6476250N; 404000E 6474000N; 402000E 6474000N. The Register contains 8 listings for this polygon (see Appendix Three). Site 3692 (Bennett Brook *in toto)* is to the west of the SPDA; Site 3744 (Marshall's Paddock Burial) is to the south of Reid Highway and, by extension, of the SPDA, as also is Site 3746 (West Swan Road Camp – Moore's Camp); Site 3840 (Bennett Brook Camp Area) is to the west of the SPDA, as also is Site 22643 (West Swan Isolated Artefacts). The remaining two listings, relevant to the SPDA, are as follows.

- Site Number 3417. "Coast Road Well", a "camp and water source" site located at 403409E 6474899N. This site was recorded by Robert Bropho on 3 June 1993. It is located in a paddock on the northern side of Coast Road at a point four hundred meters (400m) east of the Coast Road/Arthur Street junction. The well was utilized by persons residing at Jack and Mabel Moore's camp, which was itself situated between Reid Highway and Patricia Street and therefore outside the Project area. The site has not been placed on the Permanent Register and is, at this stage, listed as "Insufficient Information". However, the provisions of the AHA apply to such a listing. Location details for this site, extracted from the Aboriginal

Site File at the Department of Indigenous Affairs, are included in this report as Appendix Four.

- Site Number 22159. "Little Creek/One Hundred Year Creek", a "mythological and camping" site. 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 listed as "Stored Data". Such a listing is not covered by the provisions of the AHA. However, the fact that it is claimed as a mythological site by the Nyungars is of relevance to the SPDA. Maps of the waterway extracted from the Aboriginal Site File at the Department of Indigenous Affairs are included in this report as Appendix Five. 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. The author discussed this waterway with local landowner Mr Stephen Gregg of Coast Road in West Swan on 23 October 2007. Mr Gregg advised that the Little Creek was in fact a man-made drain rather than a natural waterway, which has been piped underground through his property. Certainly, sections of the creek do appear to have been realigned and straightened in the past. However, other sections, including that to the immediate north of Reid Highway give the impression of being a natural ephemeral and seasonal waterway.

4.2 Sources - Previous Reports

Four reports on Aboriginal heritage surveys carried out in the SPDA contain relevant information, as follows.

- R.O'Connor, November 2005. Report on a Preliminary Ethnographic Investigation of the West Swan Project Area, prepared for 360 Environmental Pty. Ltd. This report was a desk-top analysis of the then current ethnographic database and did not involve Aboriginal consultation or field inspections.
- R. O'Connor. January 2007. Report on an Aboriginal Heritage survey of the West Swan Project, prepared for RPS Bowman Bishaw Gorham. This report identified the two Aboriginal sites discussed in 4.1 above. It also identified the relevant Aboriginal stakeholders reviewed below. It included the following recommendations. *This report recommends that the Project should proceed, as the relevant Aboriginal groups have approved it, subject to certain conditions. It is also recommended that registered Aboriginal sites numbers 3417 and 22159 should be preserved undisturbed by the Project through inclusion in Public Open Space. It should be noted that disturbance of these sites is an offence under the Aboriginal Heritage Act 1972, unless Ministerial consent pursuant to Section 18 of that Act has been obtained in their regard. It is also recommended that, in recognition of the concerns of the Wilkes family in regard to possible disturbance of skeletal remains or Aboriginal cultural material, an Aboriginal monitoring programme should be established during initial ground surface disturbance.* It should be noted that the recommendation in respect of Site Number 22159 is no

longer valid, as this Register listing is now "Stored Data", and therefore not covered by the provisions of the AHA.

- G.Quartermaine, November 2005. Report on a Preliminary Archaeological Investigation for Aboriginal Sites – West Swan Project Area, prepared for 360 Environmental Pty. Ltd.. This report is a desk-top study only, which reviews the then current archaeological record for the SPDA. As such, it did not involve a field inspection and did not result in the reporting of any newly discovered archaeological sites.
- G.Quartermaine, July 2008. Report on an Archaeological Investigation for Aboriginal Sites – Stage One, St. Leonard's Estate, West Swan, prepared fro St. Leonard's Estate Pty. Ltd. This report details the results of a field archaeological survey of Local Structure Plan Area 1, as shown in Figure Four. No archaeological sites were identified as a result of the field survey.

5.0 POTENTIAL EFFECTS OF DEVELOPMENT AND POSSIBLE MANAGEMENT STRATEGIES

5.1 Effects of Development

As noted in 4.1 above, there are two listings in the Register of Aboriginal Sites relevant to the SPDA, namely Coast Road Well and Little Creek. Only Coast Road Well is currently covered by the provisions of the AHA. That site has been located on the ground and is now designated on the SPDA plans as "Public Open Space, Drainage and Conservation Area". As such, the proposed development will not have an impact upon it.

Although Little Creek is not currently covered by the provisions of the AHA, it is of stated significance to Nyungar people. Prudence, therefore, suggests that it should be treated as a *de facto* Aboriginal site – attention is drawn here to the discussion of the implications of the ATSIHPA in 2.2 above. The creek and its immediate surrounds are now designated on the SPDA plans as "Public Open Space, Drainage and Conservation Area". As such, apart from minor landscaping works which have already occurred, the proposed development will not have an impact upon it.

6.0 SUGGESTED MANAGEMENT COMMITMENTS

6.1 Aboriginal Stakeholders

The January 2007 O'Connor ethnographic survey report detailed the Nyungar stakeholders relevant to the SPDA. These can be summarised as follows.

- The Combined Metropolitan Working Group of Native Title Claimants, being four sub-groups: the Bropho family group with the Swan Valley Circle of Elders; the Garlett family; the Headland-Corunna family group; and the Wilkes-Warrell family group. Current spokespersons for the four groups are as follows: Ms. Bella Bropho, Mr Greg Garlett, Mr Stan Headland, and Mr Richard Wilkes. The native title claim is administered by a Working Group and by the South West Aboriginal Land and Sea Council, which is the primary formal point of contact for the groups. The Council can advise regarding changes to the spokespersons for the groups which take place from time to time.
- The Ballaruk Group and Bodney family group. The primary point of contact for this group is Mr Corrie Bodney or Ms. Violet Bodney.
- Mr Iva Hayward-Jackson.
- The Independent Aboriginal Environmental Group, for which the primary contact person is Mr Patrick Hume.
- The Jacobs Clan, for which the primary contact person is Rev. Cedric Jacobs.
- The Bibulmun Group, for which the primary contact person is Ms. Esandra

Colbung.

6.2 Aboriginal Involvement

It is essential for management and developers at the SPDA to understand that the heritage under consideration is, first and foremost, the heritage of local indigenous people. Bureaucratic procedures for management of that heritage must always take second place to the wishes and aspirations of those indigenous people (see Section 7, AHA). Accordingly, it is important that the relevant Aboriginal people should at all times be consulted in regard to heritage management decisions and be involved in any re-location of archaeological material which may be discovered in the future or in any fencing of heritage sites which may occur. To this end, the first draft of this ACHMP should be submitted to the South West Aboriginal Land and Sea Council and the Council's input sought for amendments and additions, as appropriate.

6.3 Suggested Management Commitments

This ACHMP suggests that the West Swan (East) developers should make the following commitments.

- Ongoing Aboriginal consultation, as outlined in 6.2 above;
- Aboriginal monitoring of initial ground disturbance in the vicinity of areas of

Aboriginal significance, as recommended in the January 2007 O'Connor ethnographic survey report (this report notes that earthworks have already taken place in the vicinity of Little Creek);

- Strict adherence at all times to the requirements of the AHA;
- Where feasible, preservation *in situ* of Aboriginal heritage sites;
- Where the above is not feasible, and following consultations with the indigenous people listed above, making timely and appropriate application(s) pursuant to Section 18 of the AHA in respect of any such sites that require disturbance;
- Salvaging of archaeological material, should such material be discovered in the future, where required by the indigenous representatives and ACMC, in accordance with archaeological best practice, under the supervision of appropriate Aboriginal monitors;
- Where such surveys have not already been executed, carrying out archaeological surveys of all areas of proposed infrastructure and other development before ground disturbance takes place It is noted in 4.2 above that only Local Structure Plan Area 1 has been the subject of an archaeological field survey;
- Dealing with archaeological sites identified by such surveys, if any, in accordance with the requirements of the AHA (see 2.1 above);
- Whilst development proceeds, dealing with discovery of Aboriginal sites not previously recorded in accordance with the suggested logistics below;
- Whilst development proceeds, dealing with the discovery of skeletal material, should such occur, in accordance with the suggested logistics below.

7.0 LOGISTICS FOR HERITAGE MANAGEMENT, INLCUDING ABORIGINAL MONITORING PROGRAMMES

7.1 Background

This ACHMP will be the controlling document for all Aboriginal heritage management and for all proposed Aboriginal heritage surveys within the SPDA. Accordingly, West Swan (East) Developers should ensure that all direct employees and consultants involved in planning and contractors engaged to execute such plans are made aware of its contents. Persons engaged to oversee development of the SPDA should also be responsible for the monitoring of those developments to ensure compliance with the ACHMP.

7.2 Senior Heritage Officer

It is proposed that West Swan (East) Developers should nominate a senior person who will have overall responsibility for implementation of the ACHMP - a "Senior Heritage Officer" (SHO). Pursuant to 7.1 above, persons responsible for the monitoring of developments at the SPDA should report where appropriate to the SHO. The SHO will also be the primary point of contact for the indigenous groups should their involvement become necessary. The SHO will also be the main point of contact in the event that human skeletal remains, Aboriginal cultural material, or any other object or place to which Sections 5 or 6 of the AHA (see 2.1 above) may apply are discovered in the course of development at the SPDA.

7.3 Previously Identified Aboriginal Sites

The two areas of Aboriginal significance described in 4.1 above, have been identified on the ground and are now protected from future disturbance by inclusion in Public Open Space (see 5.1 above). Local Structure Plan Area 1 has also been the subject of an archaeological field survey which did not identify any previously unknown archaeological sites. Nonetheless, when any further ground disturbance is taking place in the vicinity of the two areas of significance, Aboriginal monitors should be on site to oversee ground disturbance. The normal procedure in the Perth Metropolitan Area is for two monitors to be on site each day, as required. The two monitors should be drawn from the groups listed in 6.1 above, on a rotational basis. The SHO should oversee the monitoring programme and should ensure that adequate records of attendance are kept. The duties of the monitors will be as follows.

- To convey back to their groups details of the progress of development at the SPDA;
- To notify their groups of any discoveries of Aboriginal cultural material made during works at the SPDA;
- To notify their groups of any discoveries of Aboriginal skeletal material made

during works at the SPDA; and

- To notify their groups of any discoveries of other Aboriginal objects or sites made during works at the SPDA.

8.0 CONTINGENCY PLANS

8.1 Skeletal Material

It is important that all parties involved in the development of the SPDA be made aware of the possibility of human skeletal material being unearthed and that special provisions under law apply when such skeletal material is uncovered in the course of developments in Western Australia. To comply with those provisions, the following management steps are suggested.

- In the event of discovery of verified, or possible, human skeletal material, all ground disturbance in the vicinity of the discovery must stop immediately;
- The discoverer should notify immediately the Works Supervisor or other senior person on site as appropriate;
- All contractors or employees of West Swan (East) Developers carrying out ground disturbing activities in the general vicinity of the discovery should be notified by that senior person and instructed not to carry out any ground disturbance within twenty metres of the skeletal material;
- Aboriginal monitors, if not already aware of the discovery, should be notified;
- The SHO should be notified of the discovery;
- The SHO should notify the WA Police at the nearest Police Station and should request the attendance of an Officer at the site of the discovery;
- The SHO should notify the Registrar of Aboriginal Sites at the DIA of the

discovery;

- If the skeletal material is identified by the Police as Aboriginal and as being sufficiently old to suggest pre-contact interment, then the SHO should confer with the Registrar or Registrar's Delegate and with the Aboriginal groups listed in 6.1 above in regard to management options including, if appropriate, exhumation and reburial away from areas of ground disturbance.

8.2 Other Aboriginal Objects or Sites

If, during ground disturbance, identifiable Aboriginal cultural material or other Aboriginal objects (other than skeletal material) are uncovered, or if the monitors identify any object or place which they believe to be an Aboriginal site or object as defined by Section 5 and 6 of the AHA (see 2.1 above), then the following steps should be taken.

- All ground disturbance in the vicinity of the discovered or identified place or object must stop immediately;
- The discoverer or identifier should notify immediately the Works Supervisor or other senior person on site as appropriate;
- All contractors or employees of West Swan (East) Developers carrying out ground disturbing activities in the general vicinity of the discovered or identified place or object should be notified by that senior person and instructed not to carry out any ground disturbance within an appropriate distance of the place or object; that distance to be agreed with the monitors on site;

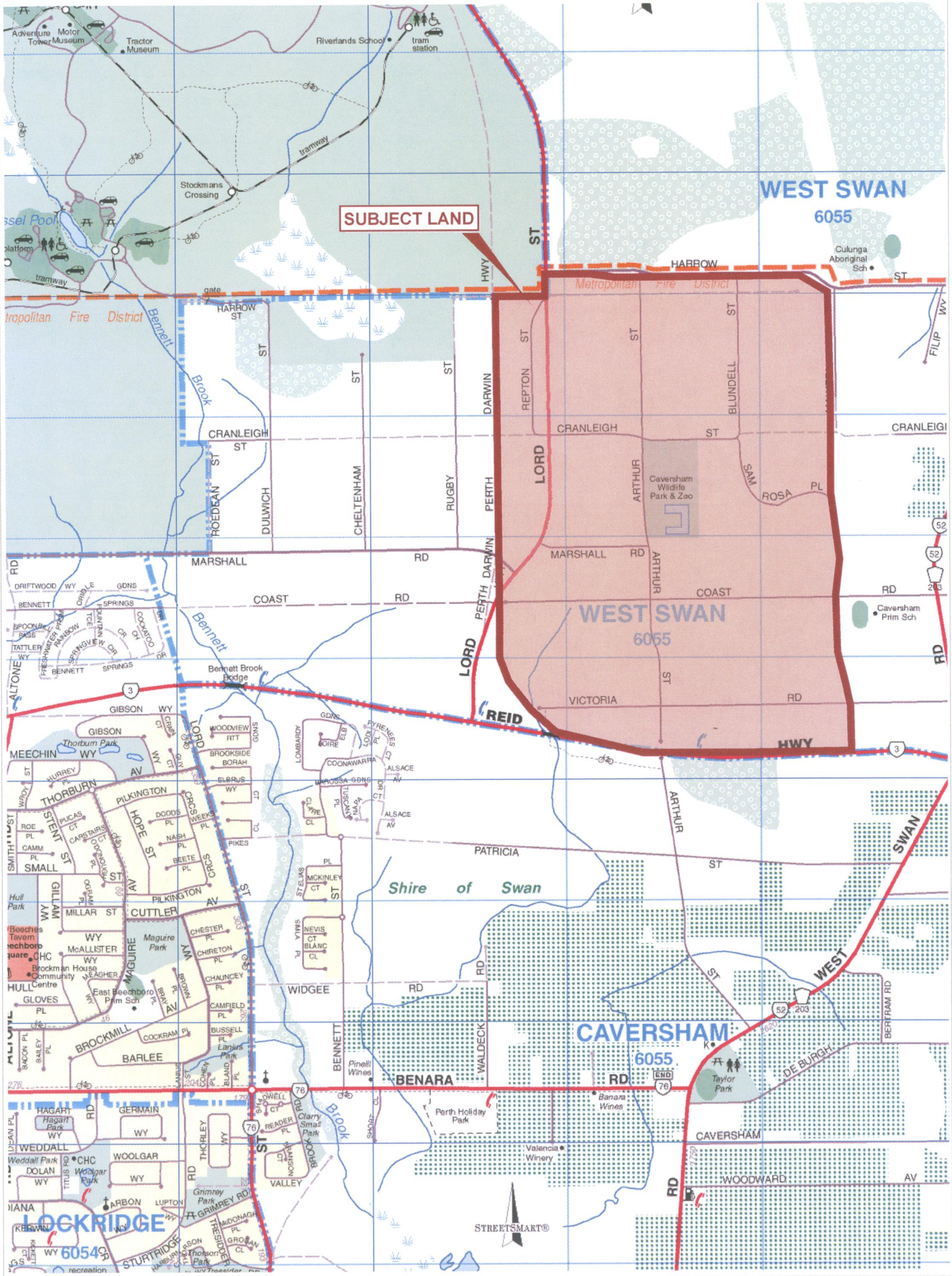
- The SHO should be notified of the discovery;
- The SHO, if appropriate, should notify the Registrar of Aboriginal Sites at the DIA of the discovery or identification;
- The SHO should confer with the Registrar and the Aboriginal monitors in regard to steps to be taken to deal with the discovery or notification.

8.3 Complaints

The SHO should institute and maintain a Complaints Register (CR). In the event of a complaint regarding the implementation of this ACHMP, or regarding any other issue relevant to Aboriginal heritage within the SPDA, the complaint or issue should be entered formally in the CR and signed by the complainant(s) and SHO. The SHO should then liaise with the complainant(s) and raise the matter at the first available general group meeting (see 6.1 above). Upon resolution of the complaint or issue, the manner of resolution should be entered in the CR and again signed by the complainant and SHO.

Figure One:

Location of SPDA



![burgess design group logo]

burgess design group

DWG No : ASP WES-9-03
DATE : 04.11.09
SCALE : N.T.S

LEGEND:
Subject Land........... ▨

SOURCE: Street Smart 2008

NORTH

LOCATION PLAN
WEST SWAN (EAST)

Figure Two:

Details of SPDA

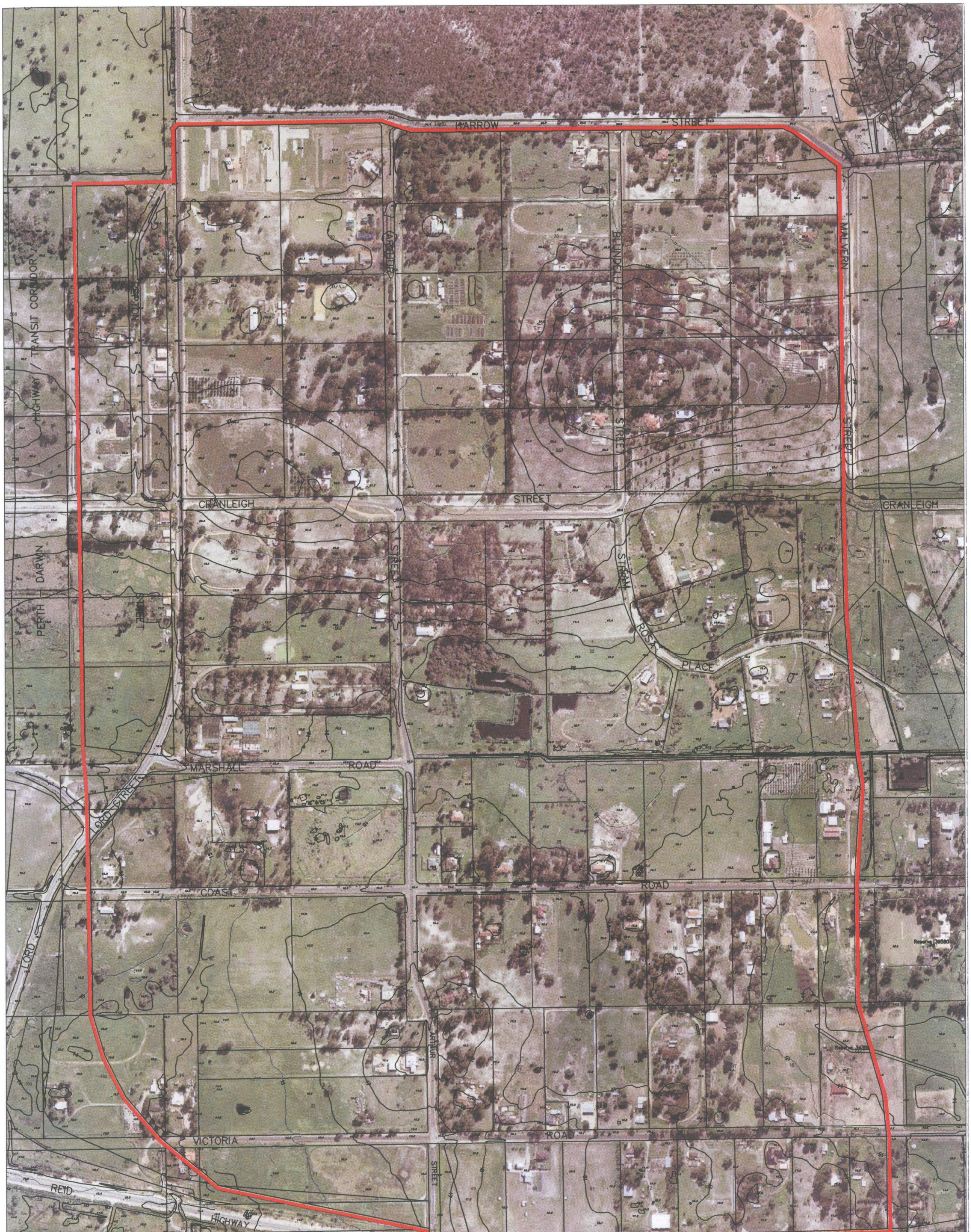

HARROW STREET
MALVERN STREET
BLUNDELL STREET
ARTHUR STREET
HIGHWAY / TRANSIT CORRIDOR
PERTH - DARWIN
CRANLEIGH STREET
CRANLEIGH
STREAM
ROSA PLACE
MARSHALL ROAD
LORD STREET
LORD
COAST ROAD
ARTHUR
VICTORIA ROAD
STREET
REID HIGHWAY

Figure Three:

SPDA Overall Plan, Showing Local Structure Plan Areas

ESTIMATED RESIDENTIAL YIELDS & PUBLIC OPEN SPACE

LSP	Gross Area	Gross Subdivisible Area[1]	Gross Residential Area[2]	Nett Residential Area[3]	Low Density	Medium Density	High Density	Total Dwelling Yield[4]	Gross POS	POS Credit[5]
1	58.5	55.1ha	50.4ha	36ha	80	640	300	1020	4.6ha	4.4ha
2A	67.2	60.4ha	55ha	38ha	530	200	0	730	5.3ha	4.1ha
2B	48.8	42.9ha	36.25ha	24ha	360	160	0	520	6.5ha	3.5ha
3	17.6	8.7ha	6.47ha	5ha	20	50	0	70	1.7ha	1.1ha
4	63.9	61.6ha	39.5ha	28ha	290	260	0	550	19.8ha	18.5ha
Total	**256ha**	**228.7ha**	**187.62ha**	**131ha**	**1280**	**1310**	**300**	**2890**	**37.9ha**	**31.6ha (13.8%)**

LEGEND

- ▭ Subject Area
- 🟨 Low Density Residential (R5-R20)
- 🟧 Medium Density Residential (R20-R60)
- 🟧 High Density Residential (R60-R100)
- 🟦 Local Neighbourhood Centre
- 🟪 Service Commercial
- 🟨 Primary Schools
- 🟩 POS/Drainage/Conservation Area
- ▭ Special Use - Community
- ▨ Powerline Easement
- ▨ Gas Pipeline Easement
- 🟩 Infrastructure Corridor
- ▨ Special Use- Infrastructure
- ■■■■ Gas Pipeline Setback
- ━ ━ Noise Attenuation Measures as appropriate
- ■■■■ Interim Odour Buffer
- ✳ Possible Future Transit Station
- ‒ ‒ Activity Corridor
- 🟥 MRS Primary Regional Road
- 🟦 MRS Other Regional Roads
- ━ Integrator B Road
- ━ Neighbourhood Connector Road
- ━ Access Streets
- 🟨 MRS Public Purpose Reserve
- ⌜⌟ Local Structure Plan Boundaries

NOTES

PUBLIC OPEN SPACE AND DRAINAGE

Public Open Space and Drainage areas are indicative and subject to detailed design and modelling at the Local Structure Plan stage.

DISTRICT OPEN SPACE FACILITIES

12ha of District Open Space Facilites are to be located within a minimum of 15ha of public open space, co-located with the Resource Enhancement Wetland and adjacent to the Public Primary School along Arthur street.

SERVICE COMMERCIAL

Uses within the site are as per the Service Commercial Use class table listed in the District Structure Plan with emphasis on creating a Mixed Business/Service Commercial development site to cater for commercial uses not suitable for the local neighbourhood centre.

LOCAL NEIGHBOURHOOD CENTRE

Uses within the local neighbourhood centre site are as per the City of Swan General Commercial use class with emphasis on encouraging a main street style local neighbourhood centre.

SPECIAL USE - COMMUNITY SITE

Uses within the site are generally intended for civic and community purposes with emphasis on a design complementary to the Activity corridor and public open space.

SPECIAL USE - INFRASTRUCTURE SITE

The Special Use - Infrastructure site may be required for a 2 ha power substation site. In the event agreement is reached for an alternative location, this site is designated for low density residential.

INTERIM ODOUR BUFFER

Subdivision within the designated interim odour buffer is not permitted until the satisfactory removal or reduction of the interim buffer in accordance with section 4.4.1 of report

HERITAGE

The identified heritage sites are to be protected within public open space or alternative, subject to detailed design at the Local Structure Plan stage.

RESIDENTIAL

Uses within the Residential areas are as per the City of Swan Residential Zone use class. Residential densities are indicative only and shall be confirmed at the local structure plan stage, aiming to achieve a minimum of 22 dwelling units per hectare across the structure plan area with higher/medium densities concentrated along the Activity Corridor, Commercial centre and areas of POS.

ACTIVITY CORRIDOR

The Activity Corridor is intended as the central spine for movement and activity connecting Albion with Caversham through West Swan and shall provide the function of a frequent public transport route with higher residential densities, home based businesses and some commercial and community uses encouraged alongside it.

INFRASTRUCTURE CORRIDOR & EASEMENT

Use, development and ownership of the infrastructure corridor & easement are to be to the satisfaction of the City of Swan and Western Power and is subject to more detailed design at the Local Structure Plan stage.

GAS PIPELINE SETBACK

Use and development within the gas pipeline setback area is restricted and subject to futher refinement at the Local Structure Plan Stage.

LOCAL STRUCTURE PLANS

Subdivision and development of the subject area is to be in accordance with an endorsed applicable Local Structure Plan unless otherwise approved by the City of Swan and/or Western Australia Planning Commission

burgess design group
town planning | urban design

SCALE 1:2500
ORIGINAL PLAN SIZE: A1

DRAWING NUMBER: ASP WES-2-03f

DATE: 30.06.2010

JOB CODE: ASP WES ST

351 Newcastle Street, Northbridge W.A. 6003
PO Box 374 Northbridge W.A. 6865
PH: (08) 9328 6411 FAX: (08) 9328 6511

NORTH

ASPEN LIVING

WEST SWAN (EAST) DISTRICT STRUCTURE PLAN

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:

Register of Aboriginal Sites Extract

Government of **Western Australia**
Department of **Indigenous Affairs**

Aboriginal Heritage Inquiry System

Register of Aboriginal Sites

Search Criteria

8 sites in a search polygon. The polygon is formed by these points (in order):

MGA Zone 50	
Northing	Easting
6476250	402000
6476250	404000
6474000	404000
6474000	402000

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, 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.

Copyright

Copyright in the information contained herein is and shall remain the property of the State of Western Australia. All rights reserved. This includes, but is not limited to, information from the Register of Aboriginal Sites established and maintained under the Aboriginal Heritage Act 1972 (AHA).

Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

[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.

Status

L	Lodged
I	Insufficient Information
P	Permanent register
S	Stored data

IR	Insufficient Information (as assessed by Site Assessment Group)
PR	Permanent register (as assessed by Site Assessment Group)
SR	Stored data (as assessed by Site Assessment Group)

Site Assessment Group (SAG)

Sites lodged with the Department are assessed under the direction of the Registrar of Aboriginal Sites. These are not to be considered the final assessment.

Final assessment will be determined by the Aboriginal Cultural Material Committee (ACMC).

Spatial Accuracy

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.

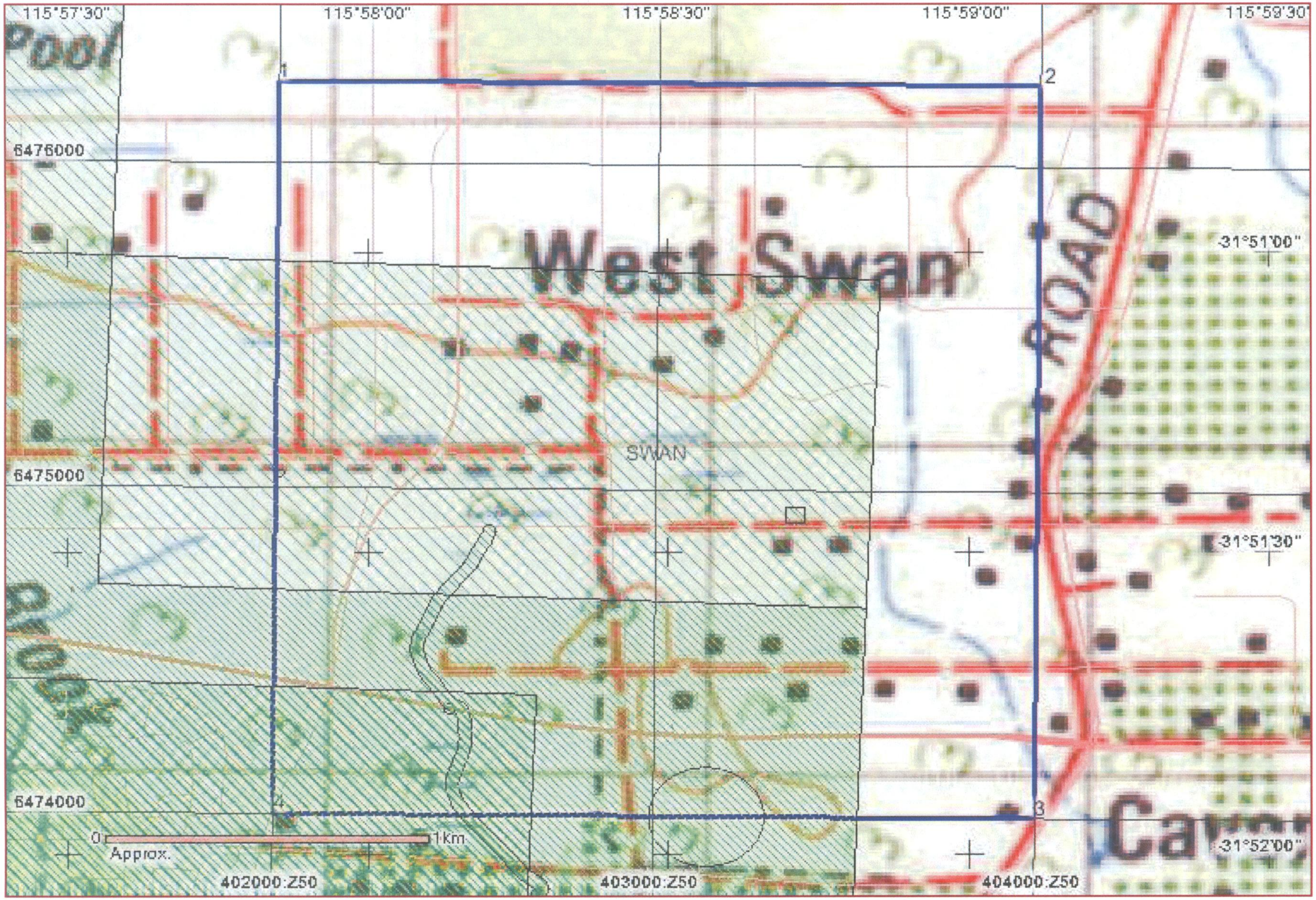
Aboriginal Heritage Inquiry System

Register of Aboriginal Sites

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3417	I	O	N	Coast Road Well.		Camp, Water Source	*Registered Informant names available from DIA.	403367mE 6474925mN Zone 50 [Reliable]	S02818
3692	P	C	N	Bennett Brook: In Toto	Mythological		*Registered Informant names available from DIA.	Not available for closed sites	S02254
3744	P	C	N	Marshalls Paddock	Skeletal material/Burial		*Registered Informant names available from DIA.	Not available for closed sites	S02194
3746	S	O	N	West Swan Road Camp (Moore'S Camp)		Camp	*Registered Informant names available from DIA.	403139mE 6473999mN Zone 50 [Unreliable]	S02196
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.	Not available for closed sites	S01997
20030	IR	O	N	Ancient Well		Water Source	*Registered Informant names available from DIA.	402462mE 6474324mN Zone 50 [Reliable]	
22159	S	O	N	Little Creek / One Hundred Year Creek	Mythological	Camp	*Registered Informant names available from DIA.	402208mE 6473584mN Zone 50 [Reliable]	
22643	L	O	N	West Swan Isolated Artefacts	Artefacts / Scatter		*Registered Informant names available from DIA.	401259mE 6474814mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Register of Aboriginal Sites



Legend

- ▨ Highlighted Area
- ● Town
- ☐ Map Area
- --- Search Area

For further important information on using this information please see the Department of Indigenous Affairs' Terms of Use statement at http://www.dia.wa.gov.au/Terms-Of-Use/

Appendix Four:

Aboriginal Site 3417

3417

Site Description - include ethnographic and archaeological comments.
(See separate Site Recording Aid.)

Well – originally believed to be a natural soak.

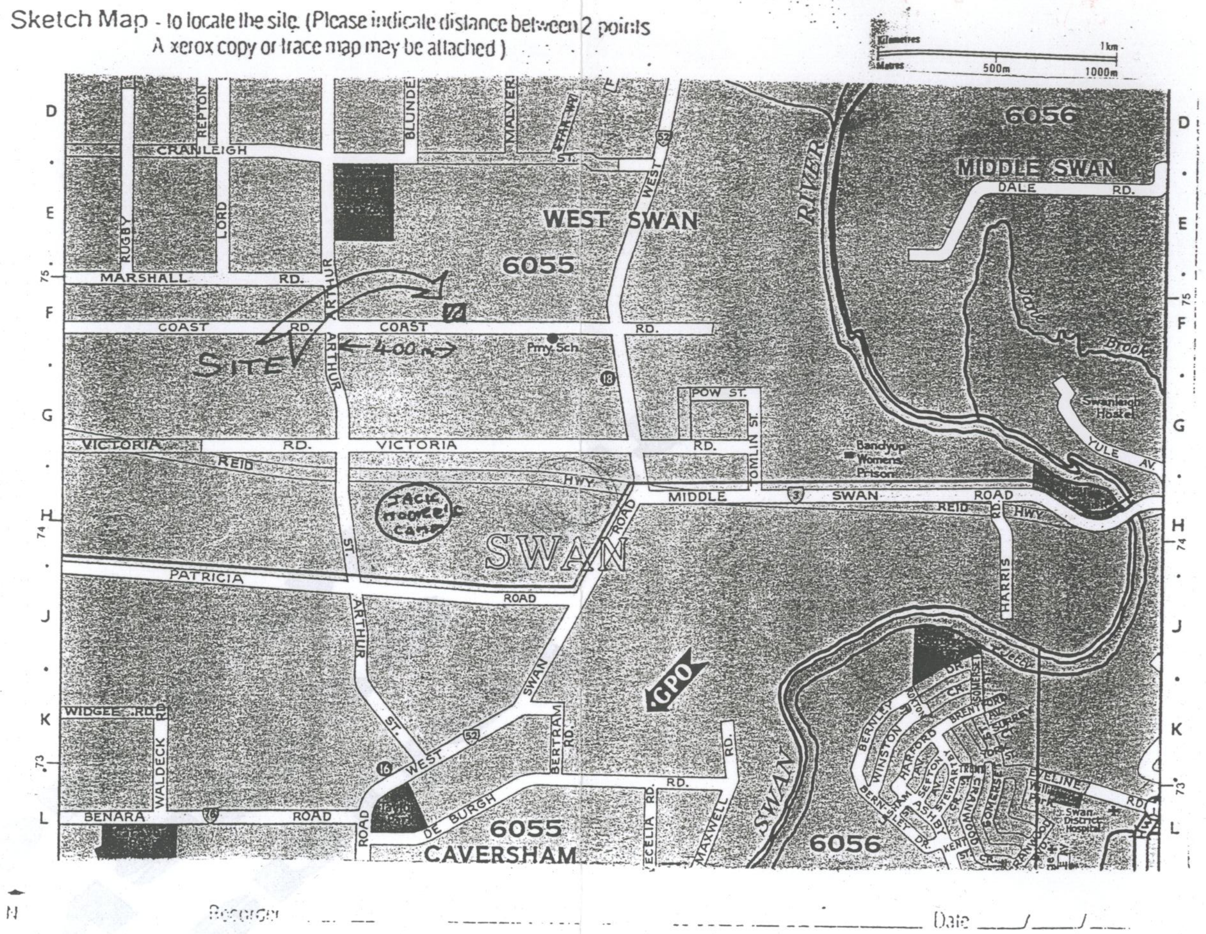
This well was used as a watersource & day camp between the 1930's & 1950's for those living at Jack & Mable Moore's camp south of Victoria road. It is also likely to have been used long before this.

People from the camp ~~here~~ came here to do their washing. Robert remembers coming here when visiting the Moore's camp. The washing was hung on the fence by the road till dry. Kids used to feed from the now dead mulberry tree just to the east of the well.

13 General Remarks:

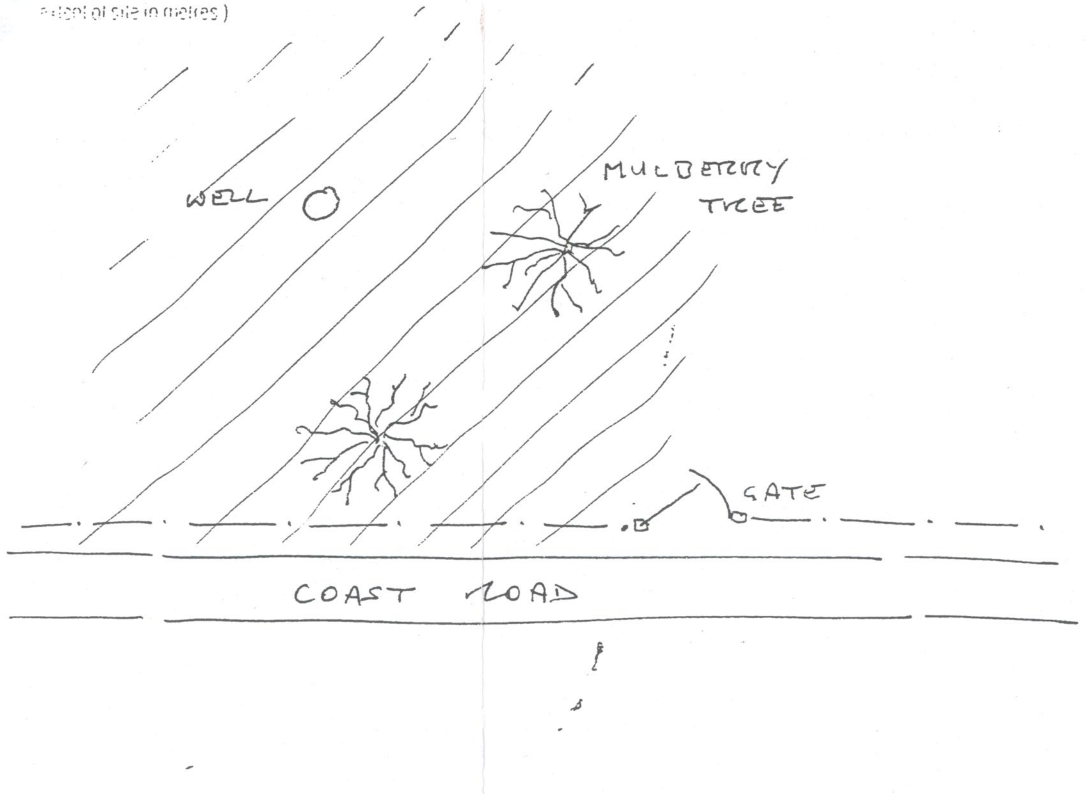
No stone artefacts seen that would indicate prehistoric occupation, however, the dense ground cover, especially the lush grass around the old well is likely to prevent material been seen

14 Sketch Map - to locate the site. (Please indicate distance between 2 points A xerox copy or trace map may be attached)



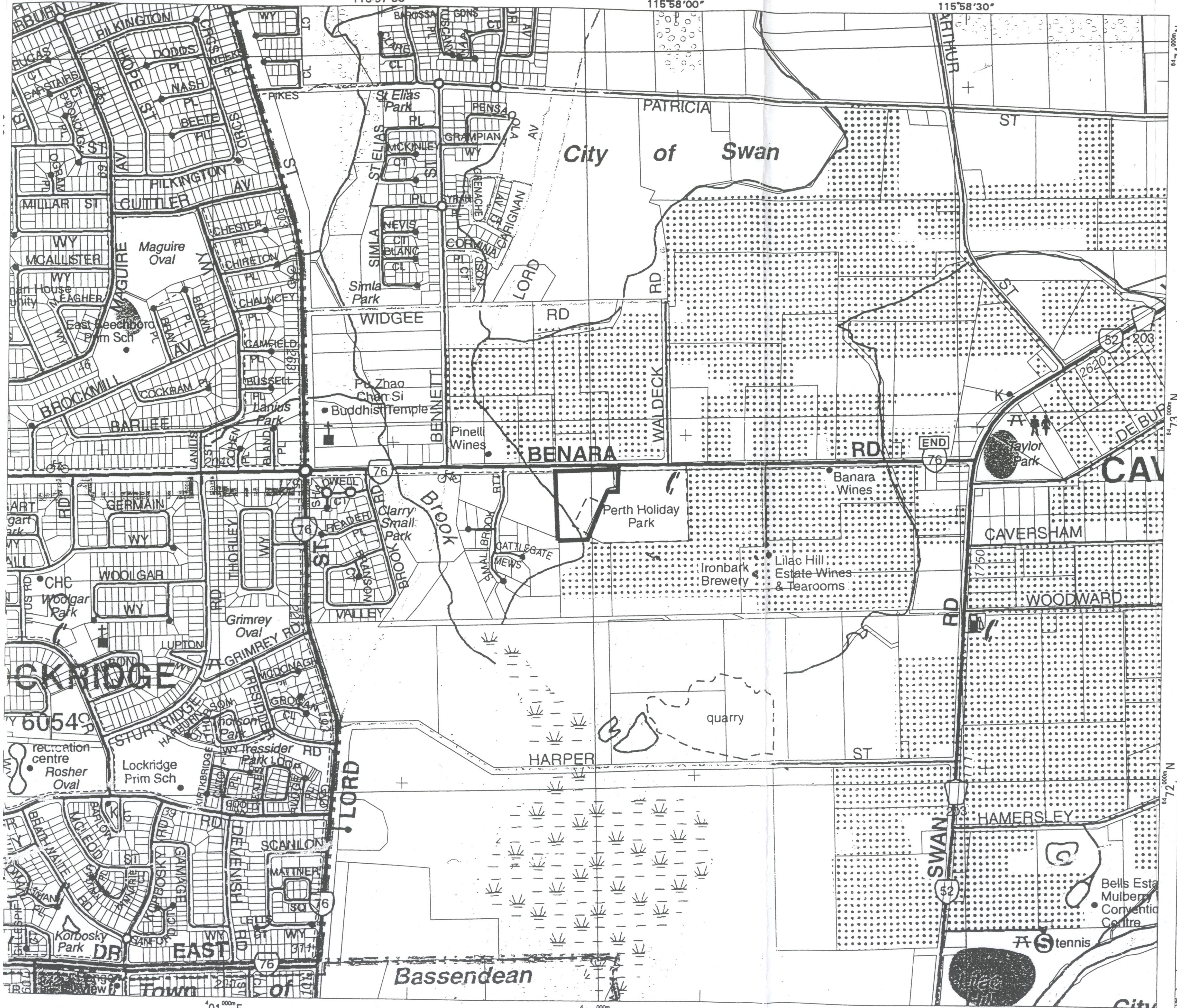
Recorder ______ Date __/__/__

15 Site Plan (Give distance between two points & extent of site in metres)



Site extent: 50 m × 50 m

Recorder R REYNOLDS Date 3/6/92



Site No: 22159

Capture Method: Map

Source date: 15/07/2005

Reliability: Reliable

Circle Radius: N/A

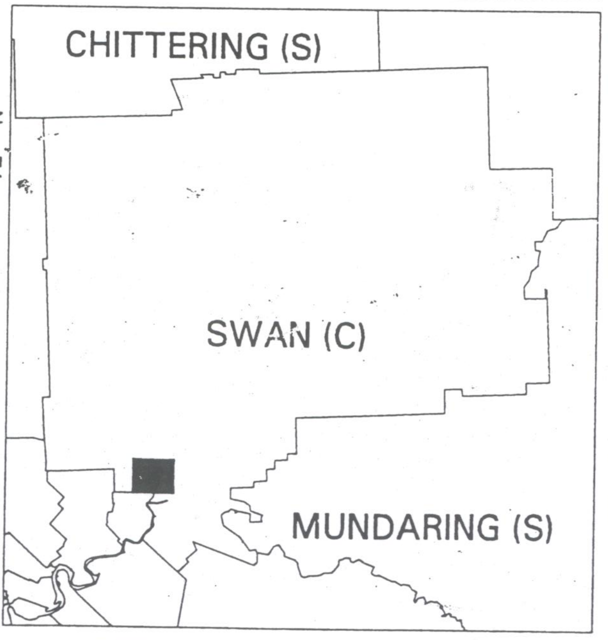
DIA INTERNAL USE ONLY

Captured By:..............................

QA By:..............................

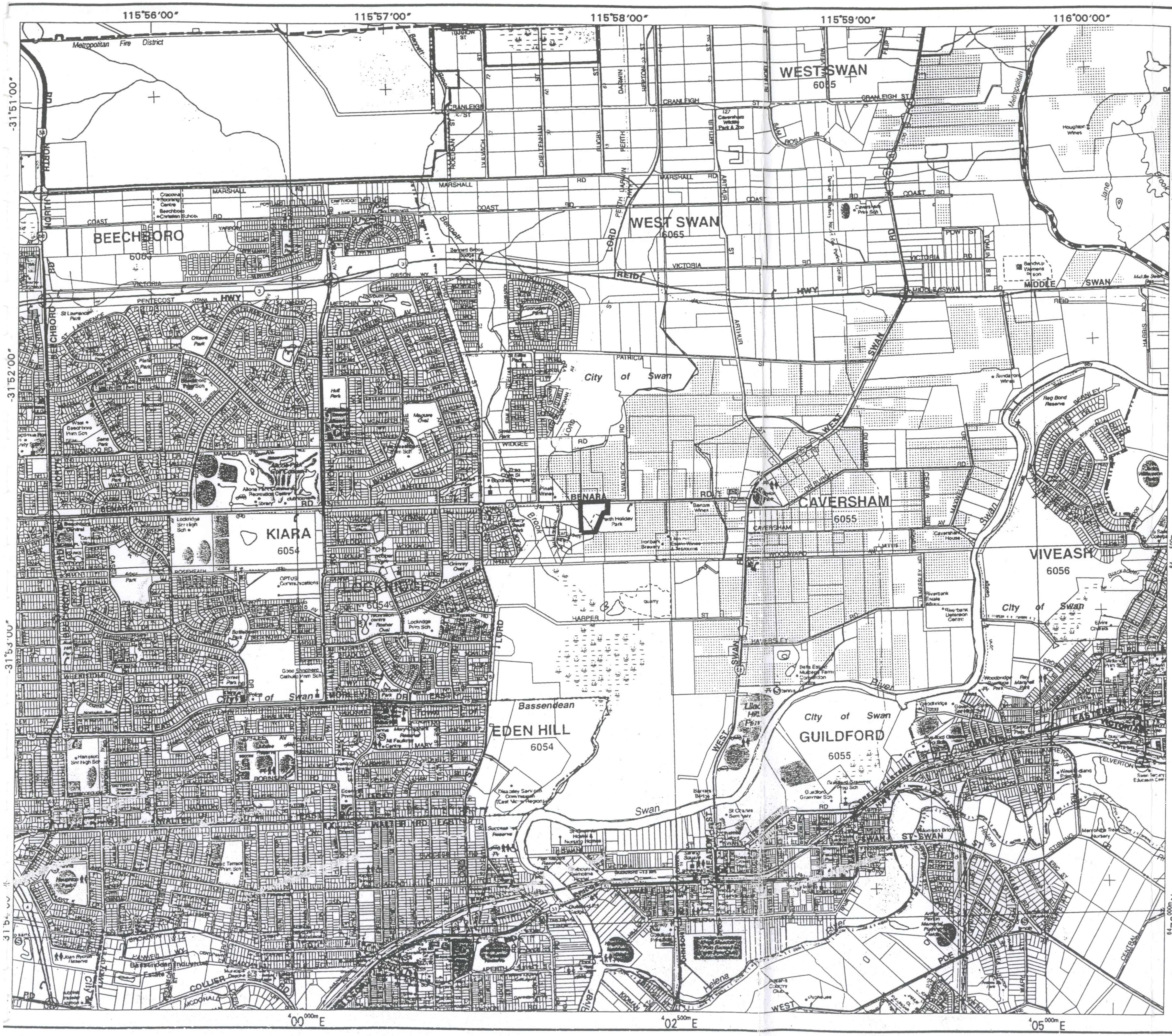
Scale 1:10000

Date: 04 Aug 05



Appendix Five:

Aboriginal Site 22159



Site No: 22159

Capture Method: Map

Source date: 15/07/2005

Reliability: Reliable

Circle Radius: N/A

DIA INTERNAL USE ONLY

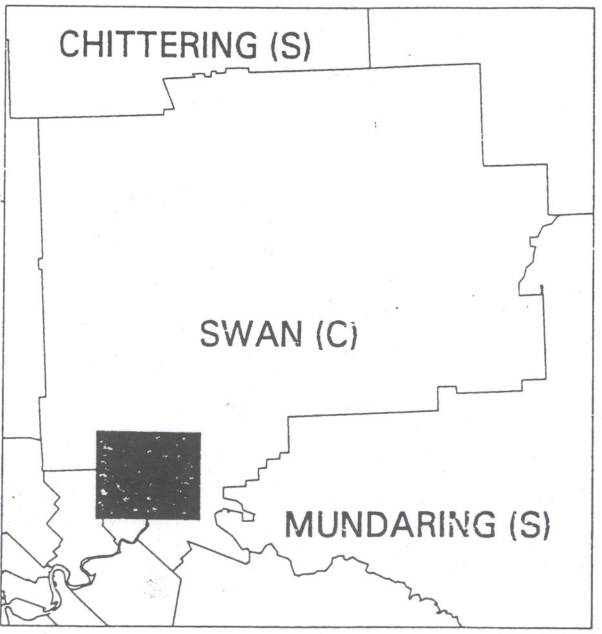
Captured By:................................

QA By:......................................

0 500 m

Scale 1:25000

Date: 04 Aug 05



APPENDIX 2

NOISE ASSESSMENT

Noise Impact Assessment

West Swan Development

Bound by Reid Highway, Lord Street, Harrow Street and the Dampier-Bunbury Natural Gas Pipeline

Prepared For

West Swan Estate Pty Ltd
&
RPS Bowman Bishaw Gorham

September 2009

Reference: 609622-01a

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Lloyd Acoustics

Report: 609622-01a

This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd Acoustics Pty Ltd ACN 097 356 093 and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client, and Lloyd Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Approved for Issue:	Terry George
Position:	Project Director
Date:	30 September 2009

CONTENTS

APPENDICES

1 INTRODUCTION

The subject site is in the Western Australian suburb of West Swan and is bound by Reid Highway to the south, Perth-Darwin National Highway to the west, Harrow Street to the north and the Dampier-Bunbury Natural Gas Pipeline – refer *Figure 1.1*.

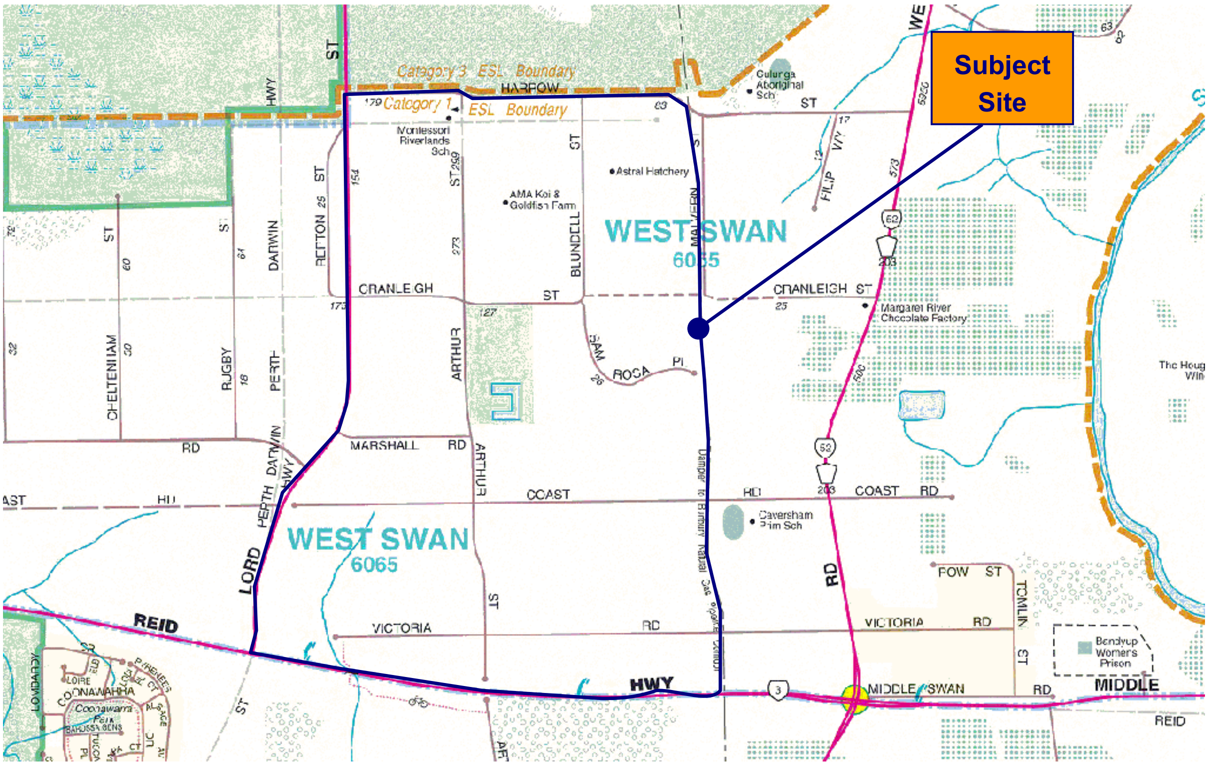


Figure 1.1 – Locality Map

Advice from the Environmental Protection Authority was:

The EPA expects that consideration of the control of noise and vibration associated with the proposed rapid transit rail line and highway and existing major roads and highway will be addressed during Outline Development planning to determine the extent of the affected area, and management measures which can be implemented through development of the site in accordance with the Western Australian Planning Commission's Draft Statement of Planning Policies "Metropolitan Freight Network" and "Road and Rail Transport Noise".

This report address the above EPA requirements by examining the potential noise impacts from Reid Highway, the future Perth-Darwin National Highway (PDNH) the future rapid transit rail line (located in the PDNH road reserve) and the potential vibration impacts from the proposed rail line.

2 DEFINITIONS

The following is an explanation of the terminology used throughout this report.

a Decibel

The decibel (dB) describes the sound pressure level of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

b A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound pressure level is described as L_A dB or dB(A).

c L_{A10}

An L_{A10} level is the A-weighted noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

d L_{Aeq}

The L_{Aeq} level represents the A-weighted average noise energy during a measurement period.

e $L_{A10,18hour}$

The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight.

f $L_{Aeq,8hour}$

The $L_{Aeq,8hour}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day. This value is determined by converting the calculated $L_{A10,18hour}$ value based on equations involving traffic volumes and percentage heavy vehicles within the respective time periods.

g $L_{Aeq,16hour}$

The $L_{Aeq,16hour}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is determined by converting the calculated $L_{A10,18hour}$ value based on equations involving traffic volumes and percentage heavy vehicles within the respective time periods.

h R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB.

3 METHODOLOGY

3.1 Noise Monitoring

Noise level monitoring was undertaken between 7 and 16 December 2006, 40 metres from the south side of Reid Highway for a previous project in this area in order to:

- Quantify existing noise levels from Reid Highway; and
- Determine the relationship between different parameters ($L_{A10,18hour}$, $L_{Aeq,8hour}$, $L_{Aeq16hour}$).

Figure 3.1 below shows the monitoring location.

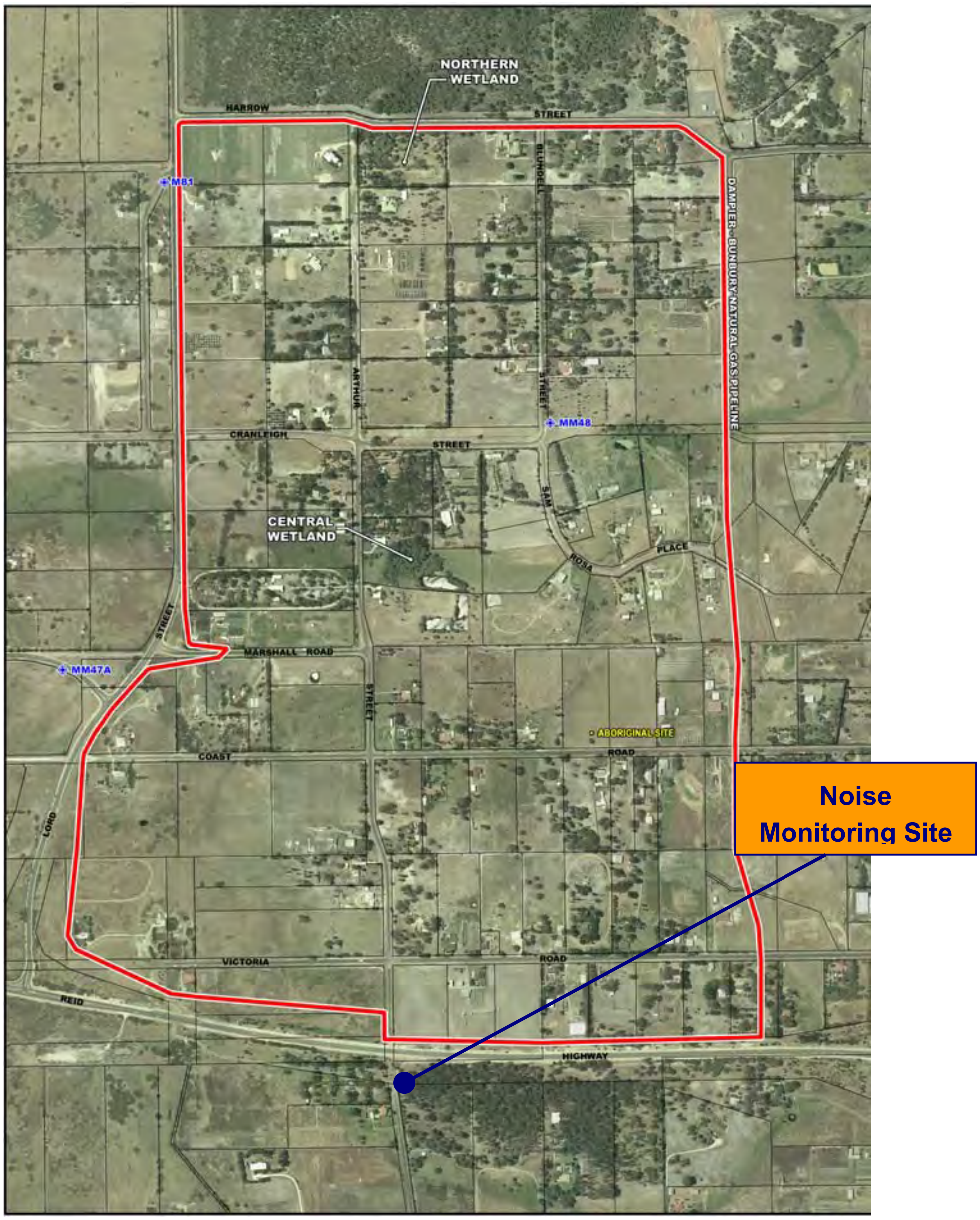


Figure 3.1 – Noise Monitoring Locations

Noise monitoring is undertaken by using an automatic noise data logger (pictured in *Figure 3.2*).

Figure 3.2 – Automatic Noise Data Logger

Sound pressure levels were measured in accordance with Australian Standard 2702-1984: *Acoustics - Method For Measurement of Road Traffic Noise*. The logger was placed on the ground with the microphone height being 1.4 metres above ground level.

The statistical noise data logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. From the hourly measurements, the $L_{A10,18\ hour}$, $L_{Aeq,8hour}$ and $L_{Aeq,16\ hour}$ values were determined for each complete measurement day. These results were averaged and the mean level reported.

The logger was calibrated before and after the measurements. The difference between the before and after calibrated levels was less than 1 dB.

The noise data collected was verified by inspection and professional judgement. Where hourly data was considered atypical, an estimated value was used.

3.2 Noise Modelling

To predict the future road traffic noise levels and determine noise control requirements, the computer programme *SoundPLAN* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- ❑ Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. Splitting the noise source into three allows for the lesser amount of barrier attenuation for higher noise sources. Note that corrections are applied to the exhaust of –8.0 dB (based on *Transportation Noise Reference Book, Paul Nelson, 1987*) and to the engine source of –0.8 dB, required to provide consistent results with the CoRTN algorithms.

- ❑ An adjustment of –1.7 dB has been applied to the predicted levels based on the findings of *An Evaluation of the U.K. DoE Traffic Noise Prediction*; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group 1982.

The same computer package used for road traffic is used for modelling rail traffic, however the *Nordic Rail Prediction Method (Kilde Report 130)* algorithms are utilised, incorporating data from the existing Perth electric passenger trains.

Predictions are made at a height of 1.4 metres above ground floor level and adjusted by + 2.5 dB to allow for the reflected noise when positioned 1.0 metre from a building façade.

Various input data are included in modelling such as ground topography, road/rail design, traffic volumes etc and are discussed below.

In terms of vibration, work on the South West Metropolitan Railway determined that a distance of 44 metres was acceptable for residential use and between 31 and 44 metres conditional.

3.2.1 Ground Topography, Road/Rail Design & Cadastral Data

Noise modelling is 3-dimensional so that landmarks such as hills and cuttings are taken into account. In this instance, the ground, road and rail have all been assumed to be on even ground. The ground in this area is relatively flat, however the approach was taken as no detailed design of the roads or rail is available. Note that the general alignment for the PDNH is based on that in the current *StreetSmart.* This shows the road adjacent the subject site at the southern end and then increases in distance from the site to the north.

3.2.2 Traffic Data

Traffic information used for both the road and rail are discussed below.

- ❑ Road Surface –

  The road surface of the existing Reid Highway is open graded asphalt and it is assumed this will also be the case in the future and for the PDNH.

  The noise relationships between different road surface types are shown below in *Table 3.1*.

Table 3.1 – Noise Relationship Between Different Road Surfaces

Road Surfaces					
Chip Seal			**Asphalt**		
14mm	**10mm**	**5mm**	**Dense Graded**	**Stone Mastic**	**Open Graded**
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-1.5 dB	-2.5 dB

- ☐ Vehicle Speed –

  The current posted speed on Reid Highway is 90km/hr. In the future it is expected this will increase to 100km/hr and the same has been assumed for the PDNH.

- ☐ Traffic Volumes –

  Existing and future road traffic volumes were previously provided by Sinclair Knight Merz and confirmed by the Transcore. These volumes are shown below in *Table 3.2*.

Table 3.2 – Existing and Future Traffic Volumes

Road	Existing / Future	24 hour Volume	16 hour Volume	8 hour Volume
Reid Highway	Existing	19,973	18,823	1,150
	Future (2031)	49,500	46,650	2,850
PDNH	Future (2031)	15,600	14,702	898

Information on the future passenger rail service was unavailable from NewMetro Rail. The existing rail movements on the Armadale line have therefore been used as summarised below in *Table 3.3*.

Table 3.3 – Input Data for Noise Modelling

Parameter	Value	
Northbound Train Movements		
3 Car Set	Daytime = 3.38 per hour	Night-time = 1.38 per hour
4 Car Set	Daytime = 0.32 per hour	Night-time = 0.00 per hour
6 Car Set	Daytime = 0.25 per hour	Night-Time = 0.00 per hour
Southbound Train Movements		
3 Car Set	Daytime = 3.44 per hour	Night-time = 1.13 per hour
4 Car Set	Daytime = 0.32 per hour	Night-time = 0.00 per hour
6 Car Set	Daytime = 0.25 per hour	Night-Time = 0.00 per hour
Train Length (m)		
3 Car Set	75	
4 Car Set	100	
6 Car Set	150	
Train Speed (km/hr)	130	
Maximum Pass by Noise Level at 15 metres (L_{Amax}, dB)	87	

Note that for the purposes of this study, the location of the track was assumed to be in the centre of the PDNH.

A train speed of 130 km/hr is the maximum design speed of the newer trains (known as Type B). If stations are located in the vicinity, noise levels may be slightly lower due to reduced train speeds, although this is often negated by increased noise levels associated with accelerating and decelerating near stations.

3.2.3 Ground Attenuation

The ground attenuation for calibration against the measured noise levels was assumed to be 1.00 (100%). This was reduced to 0.50 (50%) within the subject land for the future scenario to reflect the urbanisation of the land. Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

4 CRITERIA

The criteria contained within the *Statement of Planning Policy: Road and Rail Transportation Noise* are shown below in *Table 4.1*.

Table 4.1 – External Noise Exposure Level Criteria (dB)

Time Period	**Exposure Level 1 (target)**	**Exposure Level 2**	**Exposure Level 3**
Day (16 hour) 6.00 am to 10.00 pm	Less than L_{Aeq} 55	L_{Aeq} 55-60	Above L_{Aeq} 60
Night (8 hour) 10.00 pm to 6.00 am	Less than L_{Aeq} 50	L_{Aeq} 50-55	Above L_{Aeq} 55
Additional criteria for railways	Less than L_{Amax} 55	L_{Amax} 75-80	Above L_{Amax} 80

Exposure Level 1 (Target) refers to a level of outdoor noise that is considered a desirable target for residential and other noise-sensitive development. It will apply primarily to integrated greenfields planning of road or rail infrastructure and adjoining development. In situations where either infrastructure or residential development is already in existence, achievement of this target may not be practicable.

Where residential or other noise-sensitive development is proposed on a site, which is subject to Exposure Level 1, no action is required under this policy in relation to the management or amelioration of transport noise. However, it needs to be recognised that, because some people are more sensitive to noise than others, a proportion of the population may still be affected by noise which falls within Exposure Level 1.

Exposure Level 2 refers to a level of outdoor noise exposure that would be acceptable for residential and other noise-sensitive development, subject to appropriate measures to ameliorate noise impact.

For road or rail infrastructure with a noise exposure level in this range, new noise sensitive development should be designed and constructed so as to comply with:

- The 'target' Exposure Level 1 for required outdoor living areas; and
- The 'satisfactory' criteria under Australian Standard 2107:2000 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors*, for indoor areas.

Exposure Level 2 generally represents the maximum noise exposure for proposed new road or rail infrastructure and noise-sensitive development on land adjoining such infrastructure, but may not be practicable for many of the existing major road and rail corridors.

Exposure Level 3 refers to a level of outdoor noise exposure that is not generally regarded as acceptable for conventional residential or other noise-sensitive development.

For new or upgraded roads and railways where the predicted noise levels are in this range at nearby noise-sensitive sites, noise management measures in conjunction with the new or upgraded infrastructure are mandatory, with the objective of achieving Exposure Level 2 or better.

For existing road or rail infrastructure with a noise exposure level in this range, new noise sensitive development should where practicable, be designed and constructed so as to comply with:

- The 'target' Exposure Level 1 for required outdoor living areas; and
- The 'satisfactory' criteria under Australian Standard 2107:2000 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors*, for indoor areas.

In determining the practicability of compliance with the criteria, it needs to be recognised that a significantly higher level of noise attenuation would generally be required for sites affected by Exposure Level 3 compared to Exposure Level 2. Accordingly, it may not always be practicable to achieve compliance with the criteria, although special attention should be given to meeting the indoor standards.

The implementation of noise control measures is determined to be reasonable and practicable with reference to:

- The effectiveness of the proposed measure(s) including a comparison of predicted noise levels with or without the specified measure(s);
- The estimated cost of the measure(s) and, if applicable, the distribution of such costs between the owner/developer and the agency responsible for the relevant transport infrastructure;
- The amenity impacts of the measure(s) including appearance, access, surveillance and security, landscape/streetscape, vegetation etc;
- Traffic safety; and

- ❑ Community acceptance.
- ❑ Practicability of proposed amelioration measure(s) also requires that there are no unreasonable physical, legal or financial impediments to their implementation.

4.1 CRITERIA SUMMARY

The minimum goal is to provide attenuation as necessary to ensure external nose levels are less than Exposure Level 3. If practicable, external noise levels should be reduced to Exposure Level 1. If there are houses where the external noise level is within Exposure Level 2, these should then be constructed using quiet house design principles, in order to achieve the internal noise levels of AS2107:2000.

5 RESULTS

5.1 Noise Monitoring Results

The results from the noise data logger is summarised below in *Table 5.1* and graphically in *Figure 5.1*.

Table 5.1 – Results of Noise Data Logging, dB

Date	Parameter		
	$L_{A10,18hour}$	$L_{Aeq,Day}$	$L_{Aeq,Night}$
8 December 2005	61.1	58.7	54.4
9 December 2005	60.8	58.4	55.4
12 December 2005	61.1	58.9	54.6
13 December 2005	62.1	59.9	55.5
14 December 2005	61.4	59.4	54.1
15 December 2005	61.0	58.5	54.3
Average	**61.3**	**59.0**	**54.7**

Note that the difference between the $L_{Aeq,Day}$ and $L_{Aeq,Night}$ for road traffic noise is 4.3 dB so that in comparison to the criteria, it is the night-time noise levels that are most stringent.

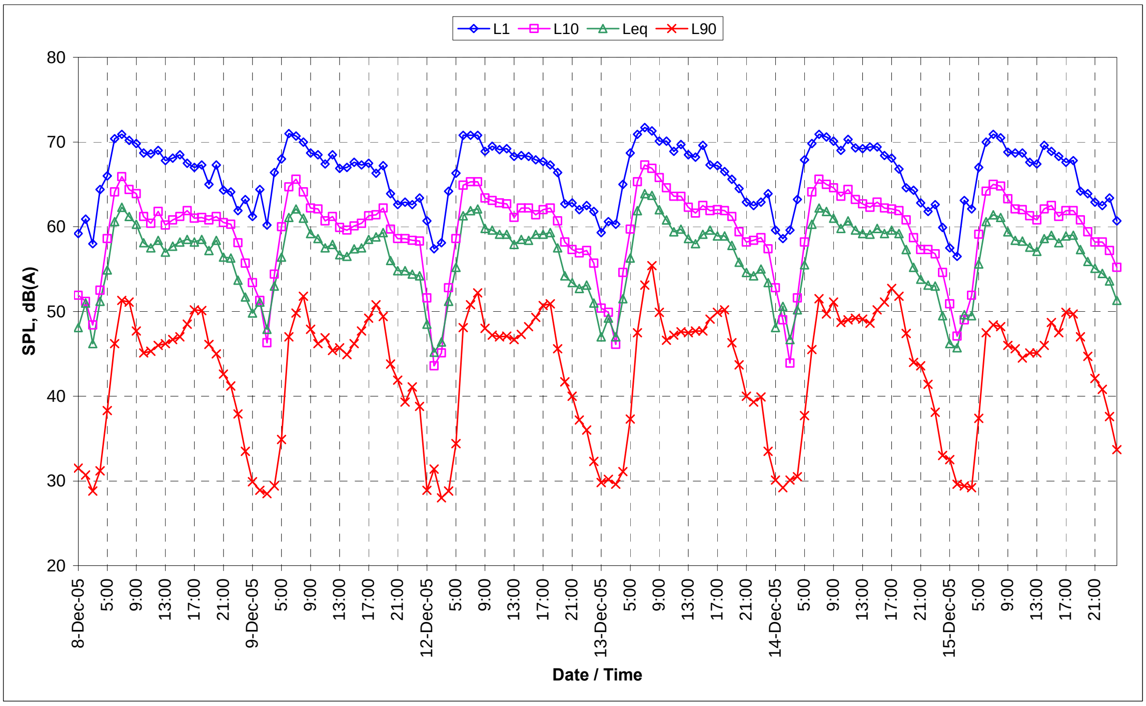


Figure 5.1 – Noise Data Logging 40 Metres from Reid Highway

5.2 Noise Modelling Results

The noise model was initially run for existing road conditions and calibrated against the results of the noise data logger. The following scenarios were then run for future conditions:

- ❑ Future $L_{Aeq,Day}$ Road Traffic Noise Levels;
- ❑ Future $L_{Aeq,Night}$ Road Traffic Noise Levels;
- ❑ Future $L_{Aeq,Day}$ Rail Traffic Noise Levels;
- ❑ Future $L_{Aeq,Night}$ Rail Traffic Noise Levels; and
- ❑ Future L_{Amax} Rail Traffic Noise Levels.

The above are shown in *Figures 5.2 to 5.6*. Also provided in *Figure 5.7* are the vibration buffers from the railway discussed in *Section 3.2*.

Note that the above preliminary contours do not include any attenuation for fencing/walls or for buildings that would screen the noise to houses behind.

FIGURE 5.2

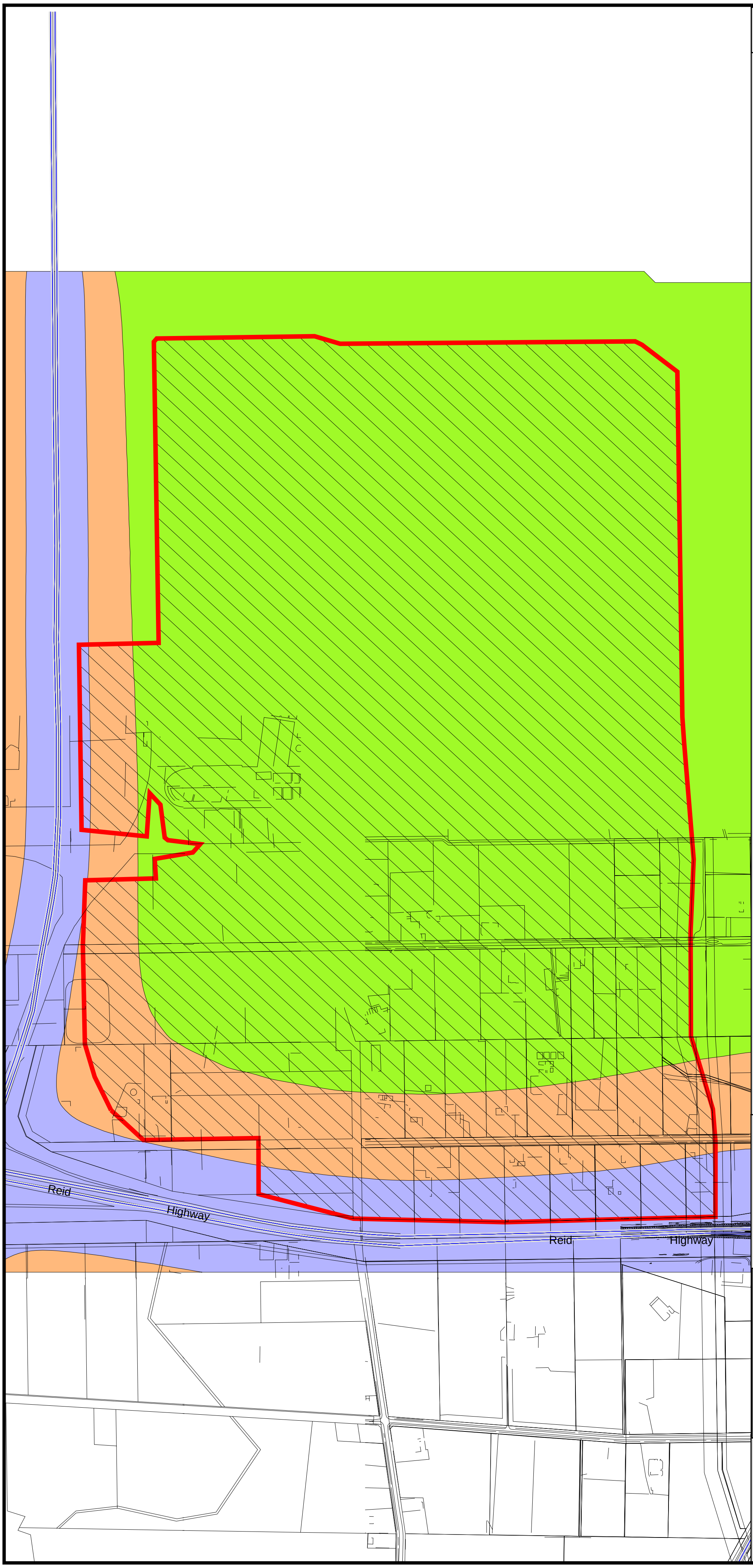
WEST SWAN DEVELOPMENT

Adjacent Reid Hwy & Perth-Darwin National Hwy

PREDICTED NOISE LEVEL CONTOURS Leq(Day)

ROAD TRAFFIC VOLUMES FOR THE YEAR 2031

Open Graded Asphalt 100km/hr



Noise level
Leq(Day)
in dB(A)

🟩 <= 55
55 < 🟧 <= 60
60 < 🟦

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
— Road
— Cadastre
🟥 Subject Site

N

Length scale 1:12500

0 50 100 200 300 400 m

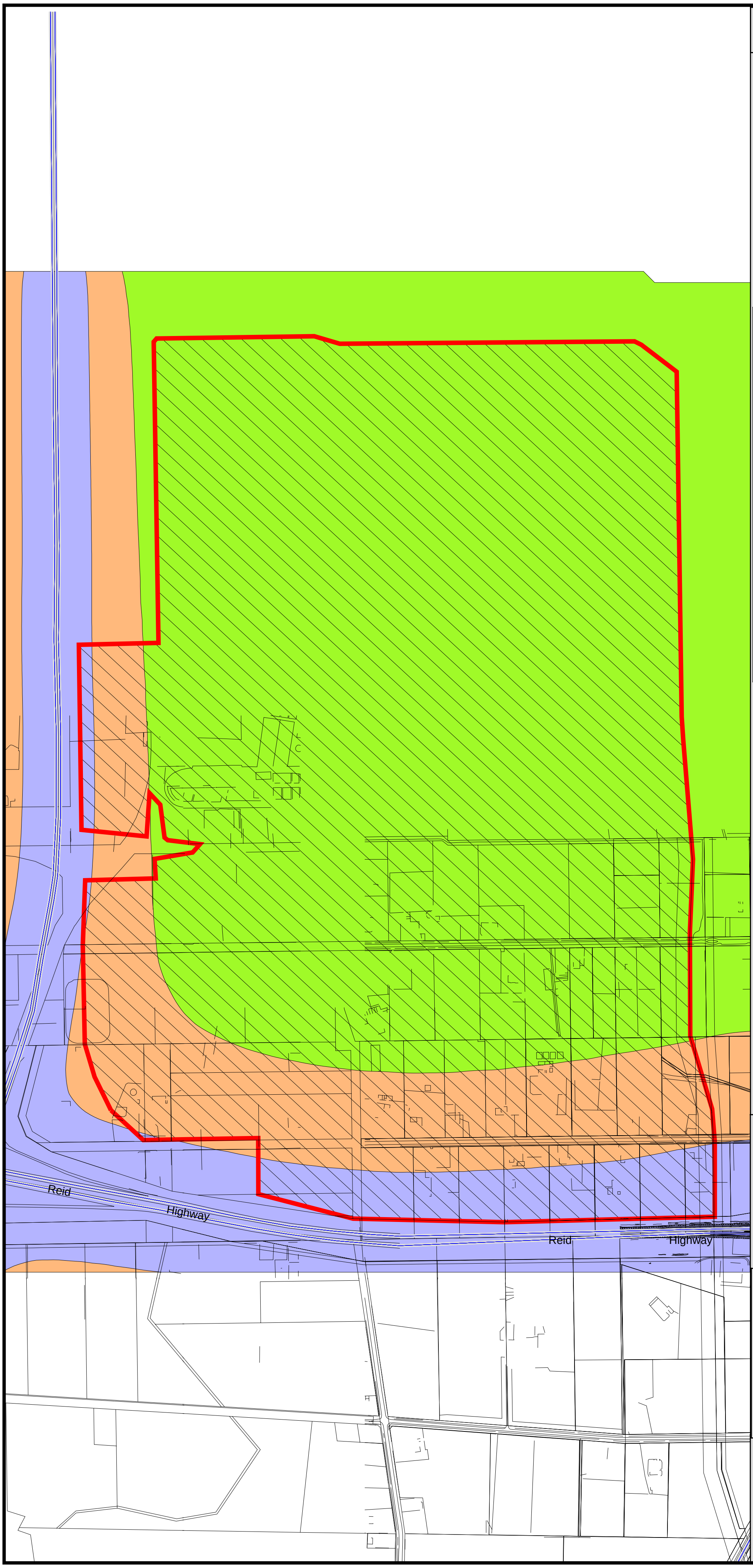


FIGURE 5.3

WEST SWAN DEVELOPMENT

Adjacent Reid Hwy & Perth-Darwin National Hwy

PREDICTED NOISE LEVEL CONTOURS Leq(Night)

ROAD TRAFFIC VOLUMES FOR THE YEAR 2031

Open Graded Asphalt 100km/hr

Noise level
Leq(Night)
in dB(A)

	🟩	<= 50
50 <	🟧	<= 55
55 <	🟦	

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Signs and symbols
— Road
— Cadastre
▭ Subject Site

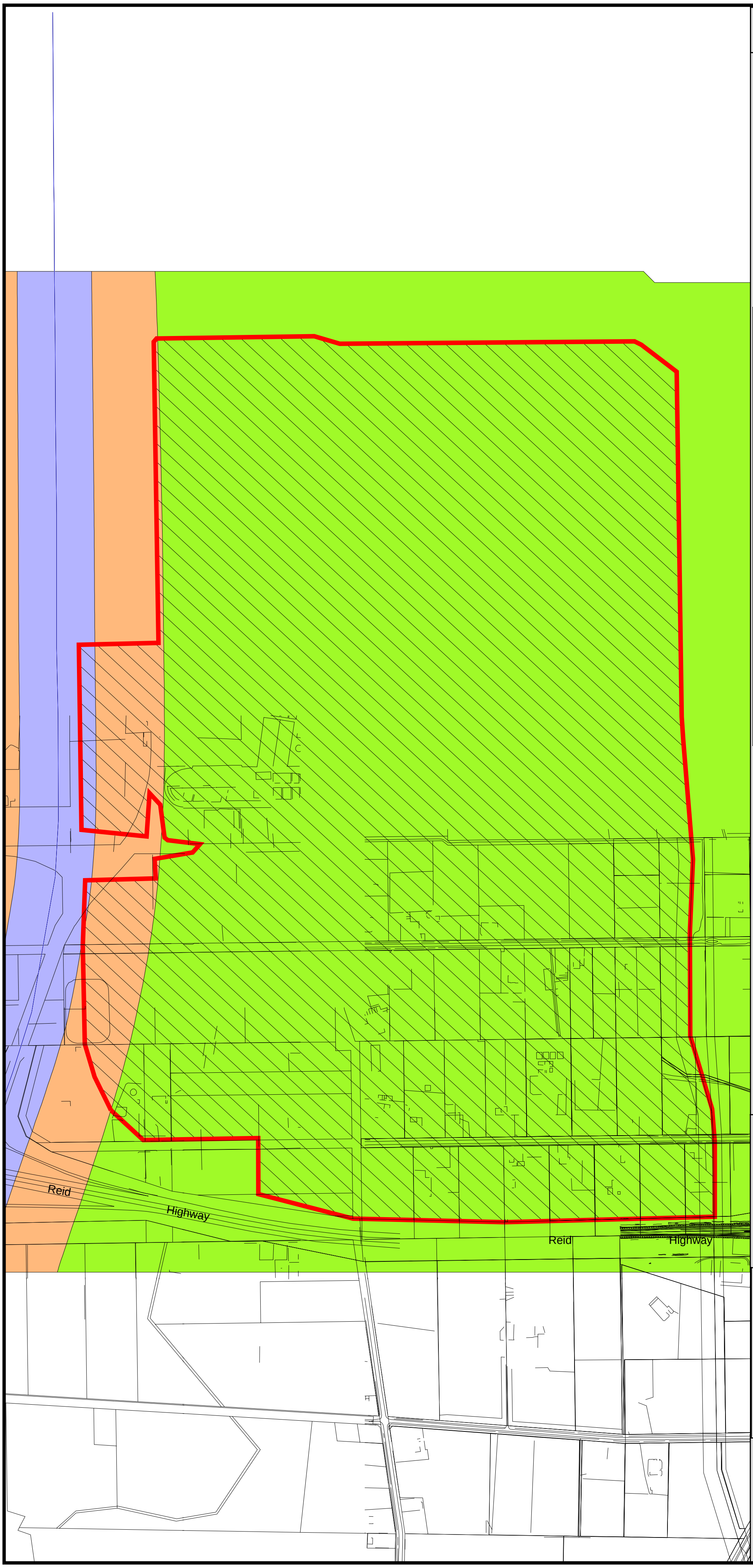
Length scale 1:12500

0 50 100 200 300 400
m

FIGURE 5.4

WEST SWAN DEVELOPMENT

Adjacent Future Electric Passenger Rail



PREDICTED NOISE LEVEL CONTOURS Leq(Day)

FUTURE ELECTRIC PASSENGER RAIL TRAFFIC VOLUMES BASED ON ARMADALE LINE

Existing Perth Trains 130km/hr

Noise level
Leq(Day)
in dB(A)

🟩 <= 55
55 < 🟧 <= 60
60 < 🟦

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
— Rail
— Cadastre
🟥 Subject Site

N

Length scale 1:12500
0 50100 200 300 400
m

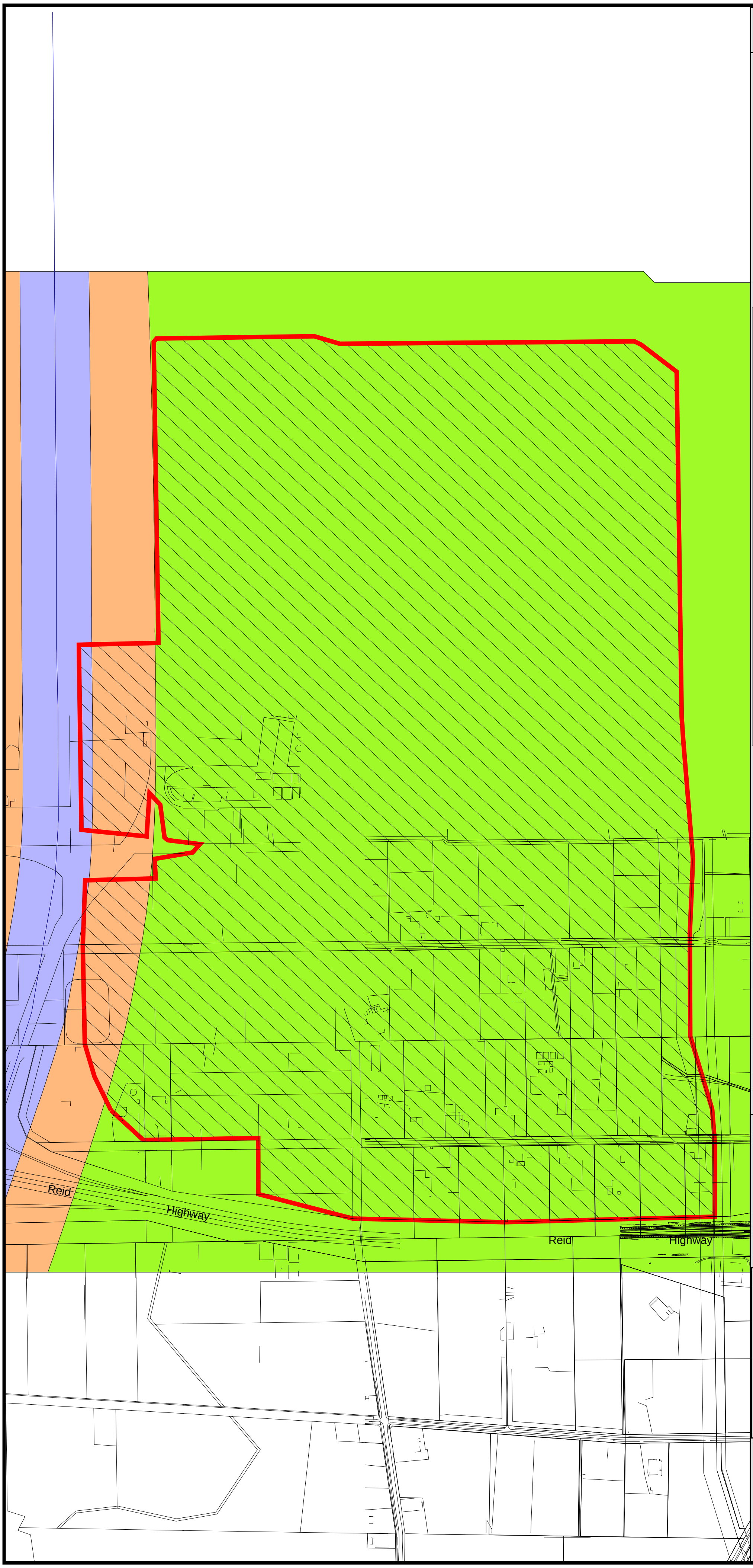


FIGURE 5.5

WEST SWAN DEVELOPMENT

Adjacent Future Electric Passenger Rail

PREDICTED NOISE LEVEL CONTOURS
Leq(Night)

FUTURE ELECTRIC PASSENGER RAIL TRAFFIC VOLUMES BASED ON ARMADALE LINE

Existing Perth Trains
130km/hr

Noise level
Leq(Night)
in dB(A)

	🟩	<= 50
50 <	🟧	<= 55
55 <	🟦	

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
— Rail
— Cadastre
▭ Subject Site

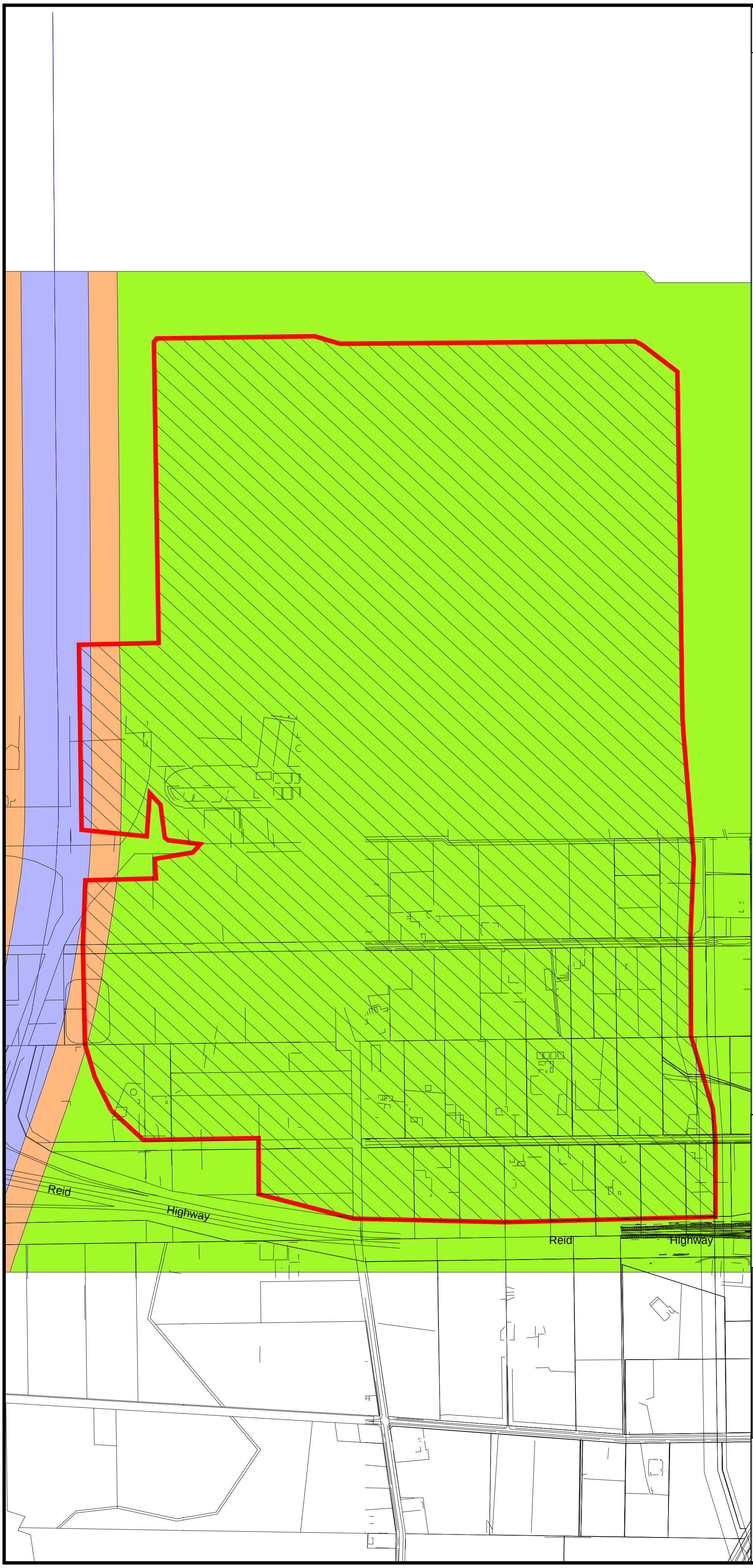
N

Length scale 1:12500
0 50100 200 300 400
m

FIGURE 5.6

WEST SWAN DEVELOPMENT

Adjacent Future Electric Passenger Rail



PREDICTED NOISE LEVEL CONTOURS
Lmax

FUTURE ELECTRIC PASSENGER RAIL TRAFFIC VOLUMES BASED ON ARMADALE LINE

Existing Perth Trains
130km/hr

Noise level
Lmax
in dB(A)

🟩 <= 75
75 < 🟧 <= 80
80 < 🟦

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
Rail
Cadastre
🟥 Subject Site

N

Length scale 1:12500

0 50100 200 300 400
m

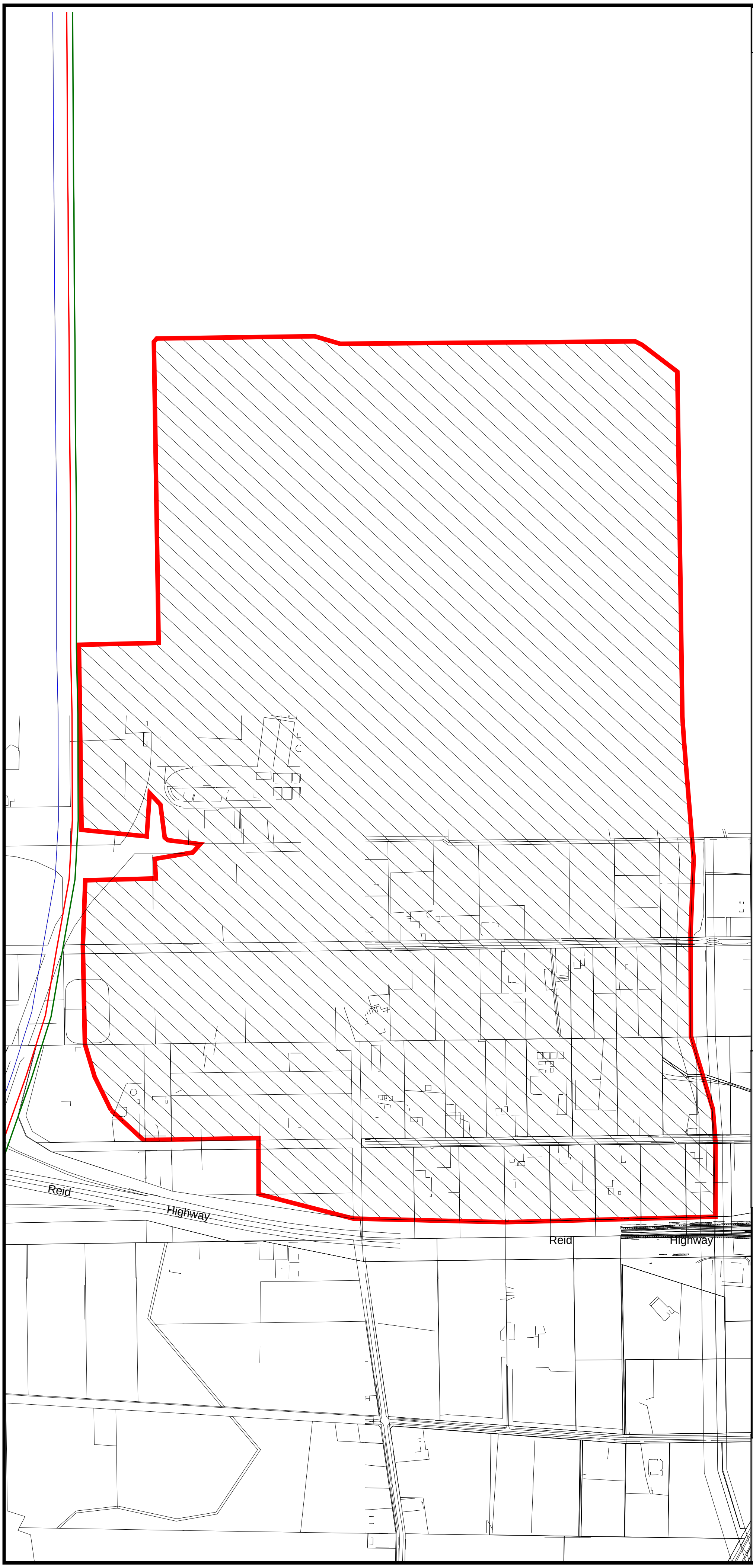


FIGURE 5.7

WEST SWAN DEVELOPMENT

Adjacent Future Electric Passenger Rail

VIBRATION ZONES

FUTURE ELECTRIC PASSENGER RAIL TRAFFIC VOLUMES BASED ON ARMADALE LINE

Existing Perth Trains 130km/hr

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
- Rail
- Cadastre
- 🟥 Subject Site
- Conditional
- Acceptable

Length scale 1:12500

0 50100 200 300 400 m

6 ASSESSMENT

Figures 5.2 to 5.7 were overlayed to establish which noise/vibration source will dictate the affected areas. *Figure 6.1* shows the result of this analysis.

The noise impact on the southern end of the site is determined by night-time noise levels from Reid Highway with areas of land being within Exposure Level 3. Along the western side of the subject site, the railway determines the noise impact, although it should be noted that the input data for this scenario was an estimate, as NewMetro Rail could not provide any information. Nevertheless, the impact is not significantly different from the night-time road traffic and noise levels are partially within Exposure Level 3.

Based on the analysis, it is the southern end of the site that will be most affected, with a small portion of the western side. To minimise the noise impact to noise sensitive dwellings, the following should be considered:

- ❑ Construct a 2.7 metre high noise wall on the southern boundary and part of the western boundary. This will result in noise levels on the subject land being Exposure Level 2 or less – refer *Figure 6.2*;

- ❑ Any residence that is within Exposure Levels 2 or 3 will require notification on their lot titles advising of the possible noise impacts. In addition, the construction of such residences will need to be to a higher acoustic standard, referred to as quiet house design (refer *Section 7*).

Note that the assessment and above recommendations are based on the best available information at the time of the study. Final lot levels within the development, final road and rail design and more accurate volumes for rail traffic may vary the conclusions. As the land development will likely occur first, ultimate responsibility to ensure the WAPC draft Policy is met will fall onto the road and rail builders/authorities.

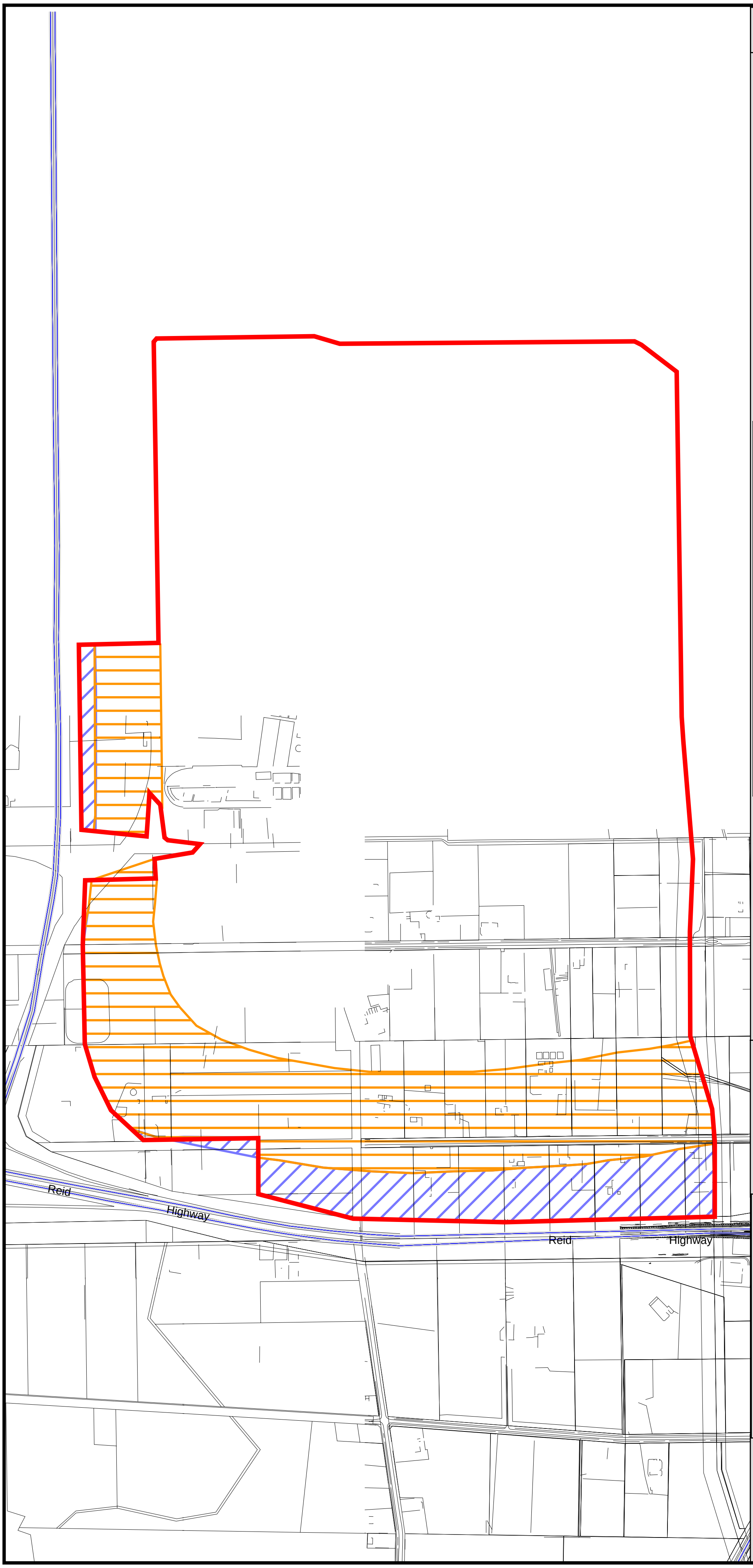


FIGURE 6.1

WEST SWAN DEVELOPMENT

Adjacent Reid Hwy, Perth-Darwin National Hwy & Electric Passenger Rail

MAP SHOWING NOISE AFFECTED AREAS

Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols

—	Road / Rail
—	Cadastre
🟥	Subject Site
▤	Exhibit Level 2
▨	Exposure Level 3

N

Length scale 1:12500

0 50100 200 300 400
m

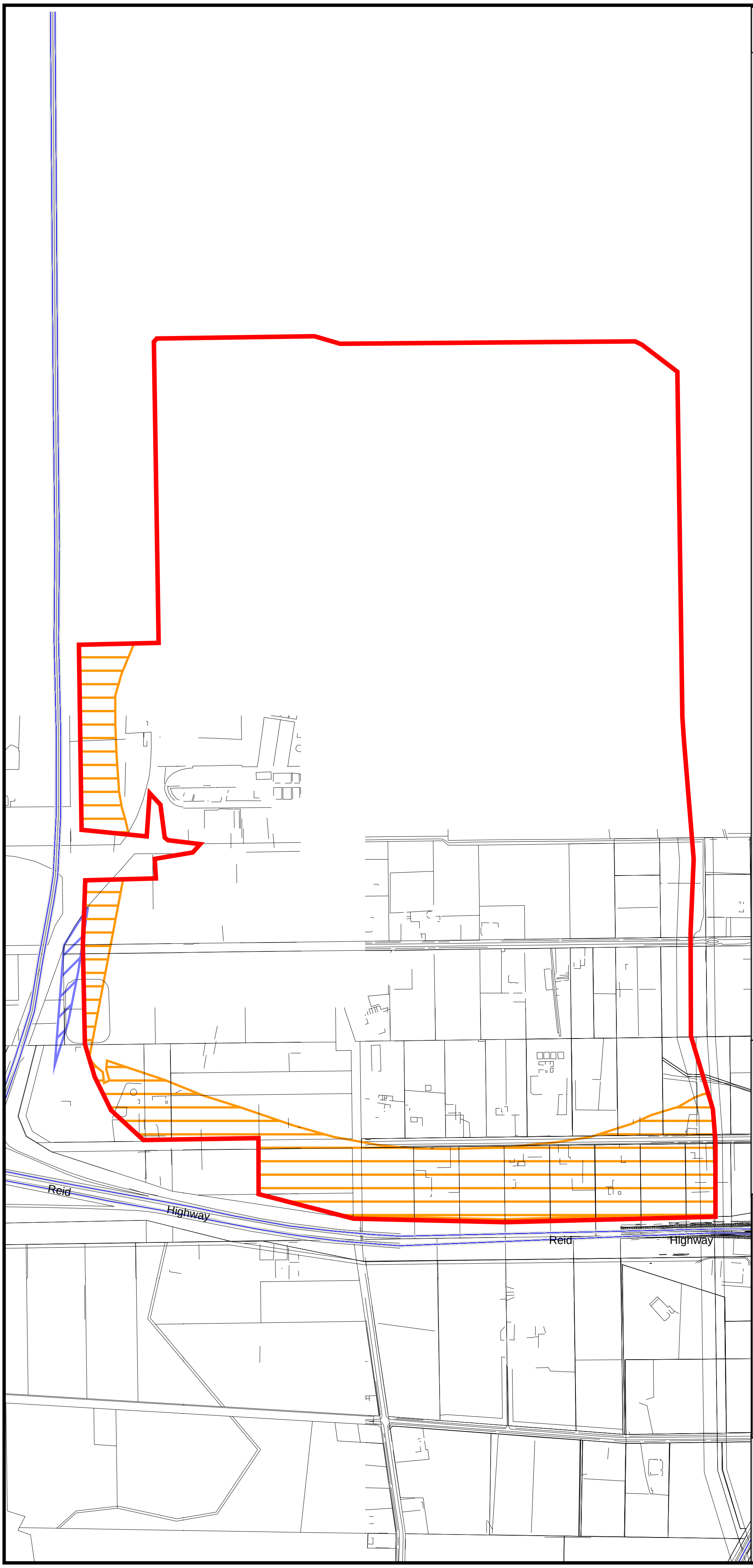
FIGURE 6.2

WEST SWAN DEVELOPMENT

Adjacent Reid Hwy, Perth-Darwin National Hwy & Electric Passenger Rail

with 2.7m High Wall on Southern & Western Boundary

MAP SHOWING NOISE AFFECTED AREAS



Job No. 609622
Client: West Swan Estate
Project Engineer: TG

Lloyd Acoustics

Signs and symbols
- Road / Rail
- Cadastre
- 🟥 Subject Site
- ▤ Exposure Level 2
- ▨ Exposure Level 3

N

Length scale 1:12500

0 50 100 200 300 400 m

7 QUIET HOUSE DESIGN

Typical house construction in Western Australia comprises of double brick cavity walls, 10mm plasterboard ceilings with insulation, sheet metal or clay tiled roof, timber front doors and sliding glass doors and windows with minimum thickness glass (3-4mm) in either sliding or awning style frames. Such construction will typically reduce noise levels by 15-20 dB (assuming windows are closed). Therefore, a normal residence with external noise levels at the top of Exposure Level 1 will have internal noise levels around 30-35 dB(A) during the night and 35-40 dB(A) during the day. Most persons generally consider these noise levels acceptable, however some people more sensitive to noise may still consider these too high.

If a residence is to be constructed within an area having external noise levels at the top of Exposure Level 2, the internal noise levels, assuming standard house construction, would increase by 5 dB, i.e. 35-40 dB(A) during the night and 40-45 dB(A) during the day. These noise levels may be acceptable by some persons, however are generally considered too high.

Where external noise levels are within Exposure Level 3, standard house construction is considered to result in internal noise levels that would be considered unacceptable to the majority of people (greater than 40-45 dB(A) during the night and 45-50 dB(A) during the day).

Any residence within Exposure Level 2 should be constructed to a high acoustic standard generally including:

- ☐ Orient the house in such a way so that any outdoor entertaining area is on the opposite side of the house to the road;
- ☐ Layout of the house to be such that any non-noise sensitive areas are to be located closest to the road. These would include garages, storage rooms, laundries, bathrooms, toilets etc, although there should be no fixed openings such as in toilets. This is particularly important in order to minimise the costs to the home owner;
- ☐ Eaves to be enclosed and ceiling to be 13mm thick plasterboard with any penetrations (mechanical and electrical services) acoustically sealed;
- ☐ Minimise the size of external doors and windows with a view of the road;
- ☐ External hinged doors (except those on the opposite side of the house to the road) to be 40mm thick solid timber with Raven RP10 and RP99 seals or equivalent. If an aluminium door is preferred, this is to be in a high grade residential frame with the aforementioned door seals, with any glass being 6.38mm thick laminated (R_w 30 or more);
- ☐ External windows (except those on the opposite side of the house to the road) to be in awning style frames closing onto compressible seals using mechanical winders with 6.38mm thick laminated glass (R_w 30 or more);

- External sliding doors (except those on the opposite side of the house to the road) to be *Boral Window Systems* 6.38mm laminated glass sliding door fitted with Q-Lon 69650 seals with a D9652 sump sill (R_w 30 or more) or approved equivalent;

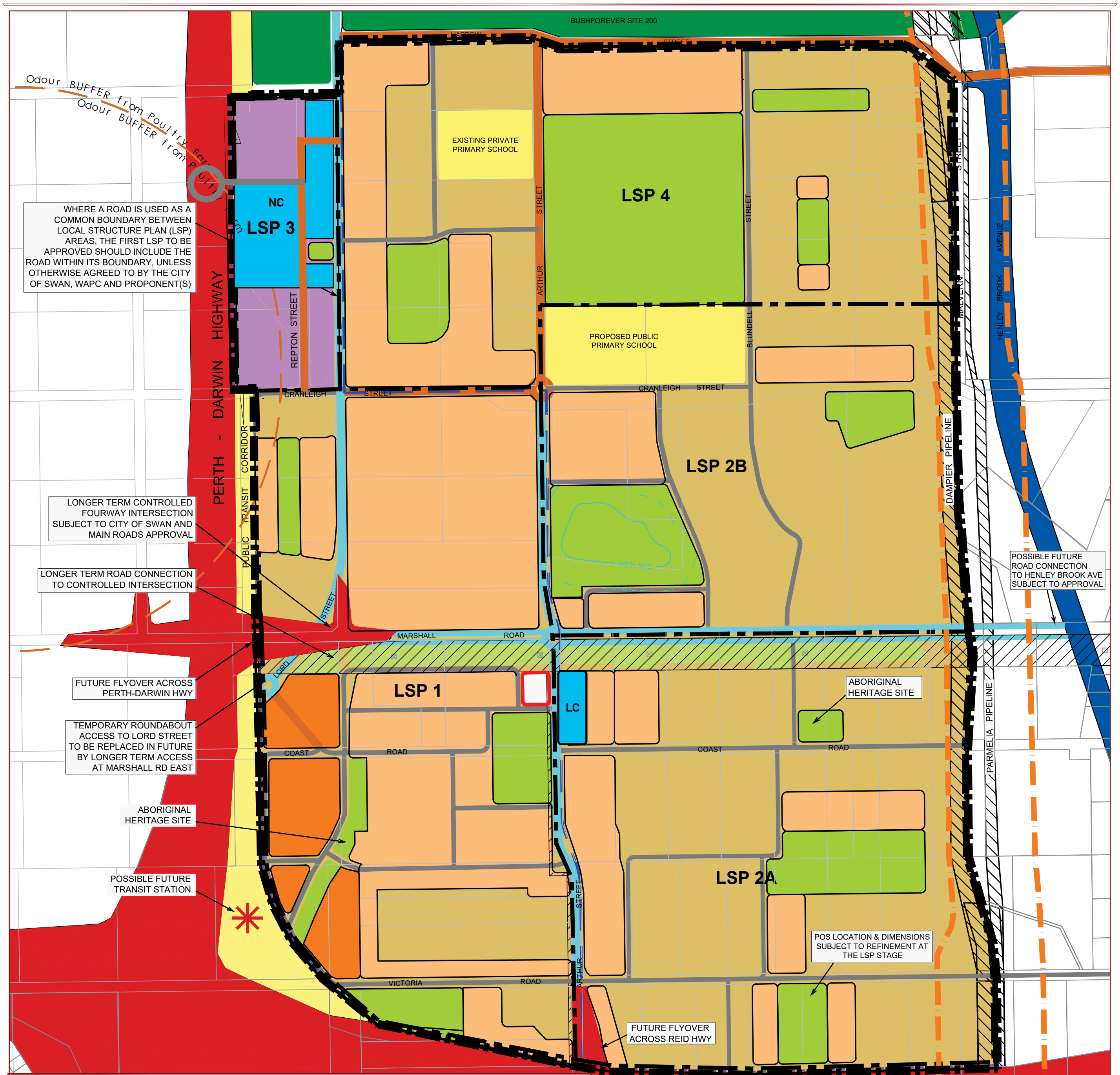
- Memorials to be placed on those lots within Exposure Level 2 advising of the possible noise impacts and also a requirement for this to be transferred to any rental agreements so that possible tenants are also advised.

Note that the benefit of thicker glazing systems will be negated when windows and doors are open. Therefore, consideration should be given to forced ventilation to allow these to be closed.

The draft WAPC Policy strictly applies to the ground floor of dwellings due to the difficulty in controlling noise to upper floors (e.g. boundary walls are ineffective). If multiple storey dwellings are constructed, residents should still consider architectural treatments to improve their internal amenity. Since the upper floor does not receive the benefit of the boundary wall, the façade treatments should be increased, such as 10mm thick laminated glass in commercial grade frames, acoustic (as opposed to thermal) insulation on top of the ceiling and *anitcon* insulation to the underside of the roof.

APPENDIX A

District Structure Plan



ESTIMATED RESIDENTIAL YIELDS & PUBLIC OPEN SPACE PER LSP.

LSP	Gross Area	Gross Subdivisible Area[1]	Gross Residential Area[2]	Nett Residential Area[3]	Low Density	Medium Density	High Density	Total Dwelling Yield[4]	Gross POS	POS Credit[5]
1	65.27	61.87ha	56.87ha	41ha	100	690	300	1090	5.59ha	4.71ha
2A	67.2	60.4ha	55ha	38ha	530	200	0	730	5.37ha	4.1ha
2B	48.8	42.9ha	36.25ha	24ha	360	160	0	520	6.52ha	2.7ha
3	10.83	3.57ha	0ha	0ha	0	0	0	0	0.11ha	0ha
4	63.9	63.7ha	43.63ha	31ha	290	464	0	754	17.85ha	14.7ha
Total	**256ha**	**232.44ha**	**191.75ha**	**134ha**	**1280**	**1514**	**300**	**3094**	**35.44ha**	**26.21ha (11.3%)**

All figures are estimates only & subject to refinement at the local structure planning stages.

NOTES

PUBLIC OPEN SPACE AND DRAINAGE
Public Open Space and Drainage areas are indicative and subject to detailed design and modelling at the Local Structure Plan stage.

DISTRICT OPEN SPACE FACILITIES
12ha of District Open Space Facilites are to be located within a minimum of 13ha of public open space, adjacent to the Public Primary School along Arthur street.

SERVICE COMMERCIAL
Uses within the site are as per the Service Commercial Use class table listed in the District Structure Plan with emphasis on creating a Mixed Business/Service Commercial development site.

LOCAL NEIGHBOURHOOD CENTRE
Uses within the local neighbourhood centre site are as per the City of Swan General Commercial use class with emphasis on encouraging a main street style local neighbourhood centre.

SPECIAL USE - COMMUNITY SITE
Uses within the site are generally intended for civic and community purposes, with emphasis on a design complementary to the Activity corridor and public open space.

HERITAGE
The identified heritage sites are to be protected within public open space or alternative, subject to detailed design at the Local Structure Plan stage.

RESIDENTIAL
Uses within the Residential areas are as per the City of Swan Residential Zone use class. Residential densities are indicative only and shall be confirmed at the local structure plan stage, aiming to achieve a minimum of 22 dwelling units per hectare across the structure plan area with higher/medium densities concentrated along the Activity Corridor, Commercial centre and areas of POS.

ACTIVITY CORRIDOR
The Activity Corridor is intended as the central spine for movement and activity connecting Albion with Caversham through West Swan and shall provide the function of a frequent public transport route with higher residential densities, home based businesses and some commercial and community uses encouraged alongside it.

INFRASTRUCTURE CORRIDOR & EASEMENT
Use, development and ownership of the infrastructure corridor & easement are to be to the satisfaction of the City of Swan and Western Power and is subject to more detailed design at the Local Structure Plan stage.

GAS PIPELINE SETBACK
Use and development within the gas pipeline setback area is restricted and subject to futher refinement at the Local Structure Plan Stage.

LOCAL STRUCTURE PLANS
Subdivision and development of the subject area is to be in accordance with an endorsed applicable Local Structure Plan unless otherwise approved by the City of Swan and/or Western Australia Planning Commission.

LEGEND

⌜⌟	Subject Area
🟫	Low Density Residential (R5-R20)
🟧	Medium Density Residential (R20-R60)
🟧	High Density Residential (R60-R100)
NC	Neighbourhood Centre
LC	Local Centre
🟪	Service Commercial
🟨	Primary Schools
🟩	POS/Drainage/Conservation Area
🟥	Special Use - Community
▨	Powerline Easement
▨	Gas Pipeline Easement
🟩	Infrastructure Corridor
○	Dual Lane Roundabout
▬	Gas Pipeline Setback
▬	Noise Attenuation Measures as appropriate
▬	Odour Buffer
✳	Possible Future Transit Station
▬	Activity Corridor
🟥	MRS Primary Regional Road
🟦	MRS Other Regional Roads
🟦	Integrator B Road
🟧	Neighbourhood Connector Road
⬜	Access Streets
🟨	MRS Public Purpose Reserve
⌜⌟	Local Structure Plan Boundaries

URBIS

DAYTON COMMERCIAL CENTRE
DISTRICT STRUCTURE PLAN

DATE: 09.11.2021
JOB NO: PA1574
DWG NO: 3
REV: A

APPENDIX 3

PUBLIC OPEN SPACE CALCULATIONS DAYTON

LSP2A POS SCHEDULE - TABLE 1

	ASP WES ST/ 141010b_Dayton POS Schedule.xlsx	ha	ha
	Gross Area		
	LSP 2A	63.3472	
A	**TOTAL**		**63.3472**
	Less Environmental/Ecological Considerations		
	Non Creditable open area's (1:1 drainage)	1.1020	
B	**TOTAL**		**1.1020**
C	**NET SITE AREA (A-B=C)**		**62.2452**
	Non-Residential Deductions		
	Local Neighbourhood Centre (LSP 2A)	1.7891	
	Transmission Corridor - Power (LSP 2A)	0.2436	
	MRS Regional Road Reserve (LSP2A)	0.8073	
	Transmission Corridor - Gas (Non-Developable)	2.4643	
D	**TOTAL**		**5.3043**
E	**Net Subdivisible Area (C-D=E)**		**56.9409**
F	**10% Requirement (10% of E = F)**		**5.6941**
	POS Requirement		
G	Minimum 80% Unrestricted Open Space (80% of F=G)	4.5553	
H	Maximum 20% Restricted Open Space (20% of F=H)	1.1388	
	POS Provided		
U	Total Unrestricted Open Space (T)		2.2646
V	Total Restricted Open Space (S)		0.9380
W	Creditable Restricted Open Space (to a max H)		0.9380
X	**Total Unrestricted + Creditable Restricted POS Provided** (U+W)		**3.2026**
Y	**Total Unrestricted POS + Creditable POS** (U+W as a %)		**5.62%**
Z	**Surplus POS Area** (X-F)		**-2.4915**
Z1	Gross POS (I)		**4.3046**
Z2	Gross POS /Gross Area (I/A)		**6.80%**

*THE CITY OF SWAN IS TO BE CONSULTED TO CONFIRM PUBLIC OPEN SPACE CONTRIBUTIONS FOR THE STRUCTURE PLAN AREA AND THE BROADER DAYTON AREA

DAYTON POS SCHEDULE - TABLE 1

	ASP WES ST/ 141010b_Dayton POS Schedule.xlsx	ha	ha
	Gross Area		
	LSP 1	66.3200	
	LSP 2A	63.3472	
	LSP 2B	54.1818	
	LSP 3	9.4594	
	LSP 4	63.2106	
A	**TOTAL**		**256.5190**
	Less Environmental/Ecological Considerations		
	Non Creditable open area's (1:1 drainage)	2.8620	
	Non Creditable open area's (Wetland Core)	1.6999	
B	**TOTAL**		**4.5619**
C	**NET SITE AREA (A-B=C)**		**251.9571**
	Non-Residential Deductions		
	Public Primary School (LSP 2B)	5.5744	
	Private Primary School (LSP 4)	2.3981	
	Local Neighbourhood Centre (LSP 2A)	1.7891	
	Cranleigh Street Road Reserve Drainage	1.0309	
	Service Commercial (LSP 3)	7.5362	
	Special Use - Community (LSP1)	0.3306	
	Transmission Corridor - Power (LSP1,2B & 2A)	4.8894	
	MRS Regional Road Reserve (LSP1/3)	1.5746	
	MRS Regional Road Reserve (LSP2A)	0.8073	
	Transmission Corridor - Gas (Non-Developable)	6.2493	
D	**TOTAL**		**32.1799**
E	**Net Subdivisible Area (C-D=E)**		**219.7772**
F	**10% Requirement (10% of E = F)**		**21.9777**
	POS Requirement		
G	Minimum 80% Unrestricted Open Space (80% of F=G)	17.5822	
H	Maximum 20% Restricted Open Space (20% of F=H)	4.3955	
	POS Provided		
U	Total Unrestricted Open Space (T)		25.8169
V	Total Restricted Open Space (S)		6.9245
W	Creditable Restricted Open Space (to a max H)		4.3955
X	**Total Unrestricted + Creditable Restricted POS Provided** (U+W)		**30.2124**
Y	**Total Unrestricted POS + Creditable POS** (U+W as a %)		**13.75%**
Z	**Surplus POS Area** (X-F)		**8.2347**
Z1	Gross POS (I)		**37.3033**
Z2	Gross POS /Gross Area (I/A)		**14.54%**

DAYTON POS SCHEDULE - TABLE 2

ASP WES ST/ 141010b_Dayton POS Schedule.xlsx

(NOTE: all figures quoted in 'ha')			I	J	K	L	M	O	N	P	Q	R	S	T
BDG Code	**POS LOCATION**	**DCP CODE**	**Gross POS**	1:1 Area (Outside of Buffer)	1:1 (Area Within Buffer)	Wetland Core	**Total Non Creditable (J+K+L)**	**Net Area (I-M)**	Total Wetland Buffer Area	Wetland Buffer Area - Deductions (N-K)	1:5 Area (outside of Buffer)	1:5 Area outside Buffer - 1:1 Area outside Buffer (Q-J)	**Total Restricted Area (P+R)**	**Total Unrestricted (O-S)**
POS 1	LSP3	Part (E-POSF15)	0.5069	0.0000	0.0000	0.0000	**0.0000**	**0.5069**	0.0000	0.0000	0.2800	0.2800	**0.2800**	**0.2269**
POS 2	LSP3	Part (E-POFS15)	0.2811	0.1500	0.0000	0.0000	**0.1500**	**0.1311**	0.0000	0.0000	0.1800	0.0300	**0.0300**	**0.1011**
POS 3	LSP4	E-POSF04	1.4616	0.4000	0.0000	0.0000	**0.4000**	**1.0616**	0.0000	0.0000	0.9900	0.5900	**0.5900**	**0.4716**
POS 4	LSP4	E-POSF01	4.0867	0.0000	0.0000	0.0000	**0.0000**	**4.0867**	0.0000	0.0000	0.0000	0.0000	**0.0000**	**4.0867**
	LSP4	E-POSF12	2.8048	0.0000	0.0000	0.0000	**0.0000**	**2.8048**	0.0000	0.0000	0.0000	0.0000	**0.0000**	**2.8048**
DISTRICT	LSP4	S-CIF1a S-CIF1b S-CIF1c S-CIF1d	10.7770	0.0000	0.0000	0.0000	**0.0000**	**10.7770**	0.0000	0.0000	0.0000	0.0000	**0.0000**	**10.777**
POS 5	LSP4	E-POSF02	1.0153	0.1800	0.0000	0.0000	**0.1800**	**0.8353**	0.0000	0.0000	0.5800	0.4000	**0.4000**	**0.4353**
POS 7	LSP2B	E-POSF05	1.3827	0.1700	0.0000	0.0000	**0.1700**	**1.2127**	0.0000	0.0000	0.4700	0.3000	**0.3000**	**0.9127**
POS 8	LSP2B	E-POSF07	5.0776	0.0850	0.1650	1.6999	**1.9499**	**3.1277**	2.9015	2.7365	0.1650	0.0800	**2.8165**	**0.3112**
POS 9	LSP1	E-POSF16	0.5305	0.1100	0.0000	0.0000	**0.1100**	**0.4205**	0.0000	0.0000	0.3300	0.2200	**0.2200**	**0.2005**
POS 10	LSP1	E-POSF08	1.9123	0.1000	0.0000	0.0000	**0.1000**	**1.8123**	0.0000	0.0000	0.5500	0.4500	**0.4500**	**1.3623**
POS 11	LSP1	Part (E-POSF13)	0.5665	0.0900	0.0000	0.0000	**0.0900**	**0.4765**	0.0000	0.0000	0.2400	0.1500	**0.1500**	**0.3265**
POS 12	LSP1	Part (E-POSF13)	0.4390	0.0500	0.0000	0.0000	**0.0500**	**0.3890**	0.0000	0.0000	0.1300	0.0800	**0.0800**	**0.309**
POS 13	LSP1	E-POSF09	1.6486	0.2000	0.0000	0.0000	**0.2000**	**1.4486**	0.0000	0.0000	0.6700	0.4700	**0.4700**	**0.9786**
POS 14	LSP2A	E-POSF14	0.6920	0.1500	0.0000	0.0000	**0.1500**	**0.5420**	0.0000	0.0000	0.2900	0.1400	**0.1400**	**0.402**
POS 15	LSP2A	NA	0.4717	0.0220	0.0000	0.0000	**0.0220**	**0.4497**	0.0000	0.0000	0.1000	0.0780	**0.0780**	**0.3717**
POS 16	LSP2A	E-POSF10	3.1409	0.9300	0.0000	0.0000	**0.9300**	**2.2109**	0.0000	0.0000	1.6500	0.7200	**0.7200**	**1.4909**
POS 18	LSP1	E-POSF06	0.5081	0.0600	0.0000	0.0000	**0.0600**	**0.4481**	0.0000	0.0000	0.2600	0.2000	**0.2000**	**0.2481**
TOTAL			**37.3033**	2.862		1.6999	**4.5619**	**32.7414**	2.9015	2.7365	6.885	4.188	**6.9245**	**25.8169**

Issue:	Date:	Author:	Revision:
1	20/09/2013	Mitch Bisby	
2	17/01/2014	Mitch Bisby	Removed Wetland buffer from E-POSF01 and District (S-CIF1a-d) following reclassification by DPAW
3	10/10/2014	Mitch Bisby	Updated POS 18 location to LSP1 and area to 0.5081ha. Areas of LSP1 & LSP3 updated. PTA Transit site removed from Deductions. *0.2819 non creditable POS removed from LSP2A, MRS Road Reserve Area in LSP2A updated, and E-POSF14 area updated (amd 02/12/14)*

LEGEND

🟥 MRS Road Regional Road

🟨 School

🟦 Local Neighbourhood Centre

▭ Community Site

🟪 Service Commercial

⬜ Transmission Corridor - Power

🟦 Transmission Corridor - Gas

▨ Cranleigh St Rd Reserve/Drainage

🟩 Public Open Space

🟦 Wetland

- - Wetland 50m Buffer

NORTH

0 50 100 150 200 250

SCALE 1:6,000 (A3)

DISTRICT POS SCHEDULE
DAYTON
CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN
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Plan No: ASP WES-3-22Ai Planner: KON
Date: 17.01.14 Client: St Leonards Estate

APPENDIX 4

LANDSCAPE MANAGEMENT PLAN

TABLE OF CONTENTS

1. PLANNING AND DESIGN

1.1. PUBLIC OPEN SPACE

The public open space at St Leonard's Estate within the suburb of Dayton, is designed as the focal point for community gathering and activities, informal recreation, public facilities, and visual relief from the urban form. It also takes on a ecological significance as a key area for the control and biofiltration of stormwater flows and therefore presents an opportunity for habitat creation and educational interpretation.

The design of these POS areas aims to locate various facilities and feature elements at focal points which are easily visible from vehicles and by pedestrians.

This maximises passive surveillance and clearly conveys the facilities available. All passive and active POS areas within St Leonards are integrated and linked through a network of shared paths, and the continuity of the living streams flowing through the public open space provides a visual and functional connection.

The depth of fill proposed to the entire development enables the POS area to be elevated above the groundwater table. Stormwater flows are directed from the catchments into living streams and biofiltration areas to strip nutrients and detain the flows prior to the water re-entering the groundwater flows. A specifically selected Biofiltration media assists in the reduction of nutrients entering the ground water system and enhances the biofiltration of drainage. The use of living streams enables a larger area of open space to remain dry during the winter months and thereby increases the amount of usable open space available.

The basins designated for biofiltration and detention are designed to encourage residents to appreciate the flows of water through the catchments and through the placement of interpretive signage and displays the developers aims to educate the community about the need for careful management of stormwater, limiting the use of fertilisers, the importance of vegetation and biofiltration media in stripping nutrients and the importance of these areas as habitat for flora and fauna.

Planting in POS areas will consist mainly of native species which will enhance the original nature of the site and reduce the amount of turfed areas over the development. In general there will be an emphasis in these areas on indigenous plantings as opposed to turf. In areas where it is preferred to have turf, irrigation and fertiliser management measures will be applied.

The design aims to locate various facilities and feature elements at focal points which are easily visible from vehicles and by pedestrians. This maximises passive surveillance and clearly conveys the facilities available.

Various facilities proposed for creation within the public realm may include:

- Discovery and learning playgrounds
- Shelters
- Viewing platforms
- BBQs and gathering spaces
- Boardwalks
- Integrated path systems
- Feature lighting
- Security and safety lighting
- Informal open recreation spaces
- Smaller contemplative spaces
- Interpretive signage
- Public art

1.2. RECREATION FACILITIES

- Discovery and learning playgrounds for children
- Shelters catering for parents and informal gathering
- BBQs and gathering spaces catering for parents and informal or formal gathering
- Integrated path systems and Boardwalks catering for walking, cycling and skateboarding
- Informal open recreation spaces for general undefined uses by all ages
- Smaller contemplative spaces for less active persons and relaxation for all ages

Recreation facilities throughout St Leonards will cater for a wide range of residents. There will be discovery and learning playgrounds for children. Shelters will be established to cater for parents and informal gatherings as well as BBQs and gathering spaces.

Integrated path systems and boardwalks will create areas suitable for walking, dog walking, cycling, skateboarding and similar. Informal open recreation spaces will be available for a wide range of uses as well as formal recreation spaces associated with schools and organised sports for all ages. Educational display signage is proposed as a key tool in providing the community with information regarding the filtration basins and the seasonal variations of the living stream.

1.3. PROPOSED LANDSCAPE PLANTING

The provision of planting in public areas and streetscapes serves to provide character, shade, interest, habitat and a point of reference in major streets or feature locations. The following list is an indication of the species proposed for the site. Full detailed design, co-ordination and approval through City Of Swan will be sought prior to implementation.

Locations

The locations of public planting and types of vegetation will include:

- Exotic specimen and shade trees at feature points,
- Exotic feature tree avenues in nominated high profile street or entry locations,
- Native habitat trees in nominated locations,
- Bushland and habitat regeneration in disturbed areas,
- Shrub planting to screening and spatial definition areas,
- Groundcover planting to medians, planters and areas requiring clear view sheds,
- Stabilisation planting to banks and batters,
- Reed and sedge planting to wetlands, swales and watercourses,
- Grass to usable formal or informal usable space and recreation areas,

Character

The proposed mix of endemic native species and exotic cultural plantings in feature locations will provide a blend of character and define feature points.

Design Considerations

The selection and placement of species shall consider adjacent elements so as to limit future maintenance and public health and safety issues, promote the survival and health of the vegetation concerned and provide ongoing social and visual benefits. Items of consideration may include:

- Suitable proximity to traffic sightlines to ensure suitable view corridors
- Suitable proximity and alignment to underground services to ensure no adverse impact
- Maximised seasonal influence of shade on adjacent facilities and areas
- Passive solar benefits influencing adjacent built form and residential dwellings
- Provision of seasonal visual colour
- Provision of a seasonal food source to local fauna
- Plant selection based on suitability to local climate, soils, rainfall and temperatures
- Selection based on reduced maintenance, trimming, pruning, fertilising and watering
- Develop a species palette with subtle variations through the development to tie in with identifiable communities
- Buffer screening will be provided to residential or sensitive areas where required

Street trees

- Along major roads, proposed trees will form a strong visual avenue, and not impede traffic flow, safety or sightlines
- In residential streets, the roads may vary in character from precinct to precinct; however they are characterised as smaller scale pedestrian friendly environments. Therefore street trees will be of a smaller scale, and take advantage of passive solar principles allowing summer shade and winter sun.

Parkland Planting (POS Areas) Species List

Shrubs/Sedges/Herbs/Groundcovers	
Species Name	Common Name
Acacia cognata 'Limelight'	Limelight
Anigozanthus ‘Coral Queen’	Kangaroo Paw
Anigozanthus ‘Gold Fever’	Kangaroo Paw
Adenanthos sericea	Albany Woolly Bush
Baumea articulata	Jointed Twig Rush
Boronia crenulata 'Pink Passion'	Pink Passion
Brachychome ‘Jumbo Tricolur’	
Callistemon ‘Great Balls of Fire’	Great Balls of Fire
Calothamnus quadrifidus 'One Sided Bottlebrush"	One Sided Bottlebrush
Calothamnus quadrifidus 'Little Ripper'	Little Ripper
Conostylis candicans "Grey Cottonheads	Grey Cottonheads
Convulvulus ‘Moroccan Beauty’	
Dianella ‘Baby Bliss’	Dianella
Dianella ‘Cassa Blue’	Dianella
Dianella revoluta ‘Variegated’	Dianella
Dianella ‘Tas Red’	Dianella
Dryandra nivea	Honeypot Dryandra
Eremophila 'Carramar Grey'	Carramar Grey
Eremophila nivea	Spring Mist
Ficinia nodosa	Knotted Club Rush
Grevillea crithmifolia	
Grevillea preissii	Mini Marvel
Grevillea thelemanniana	Spidernet Grevillea
Hypocalymma xanthopetalum	Golden Myrtle
Juncus krausii	Sea Rush
Juniperus conferta	Shore Juniper
Kennedia prostrata	Running Postman
Lomandra longifolia	Lomandra
Melaleuca conothamnoides	
Olearia axillaris	Little Smokie
Rosmarinus ‘Blue Lagoon’	Rosemary
Scaevola ‘Mauve Clusters’	Fan Flower
Scaevola ‘Misty Blue’	Fan Flower
Scaevola ‘White Carpet’	Fan Flower
Tulbaghia violacea	Society Garlic
Westringia fruticosa	Coastal Rosemary
Trees	
Species Name	Common Name
Agonis flexuosa	Native Peppermint
Corymbia calophylla	Marri
Corymbia ficifolia	Red Flowering Gum
Eucalyptus rudis	Flooded Gum
Eucalyptus sideroxylon	Iron Bark
Fraxinus raywoodii	Claret Ash
Jacaranda mimosifolia	Jacaranda
Melaleuca rhaphiophylla	Swamp Paperbark
Prunus cerasifera ‘Nigra’	Flowering Plum
Pyrus nivalis	Snow Pear

Streetscape Planting Species List

Shrubs/Sedges/Herbs/Groundcovers	
Species Name	Common Name
Acacia cognata 'Limelight'	Limelight
Anigozanthus ssp.	Kangaroo Paw
Dianella ssp.	Dianella
Eremophila ssp	Eremophila
Ficinia nodosa	Knotted Club Rush
Grevillea ssp.	Grevillea
Lomandra ssp	Lomandra
Olearia axillaris	Coastal Daisy Bush
Westringia fruticosa	Coastal Rosemary

Trees	
Species Name	Common Name
Agonis flexuosa	Native Pepeprmint Tree
Corymbia ficifolia	Red Flowring Gum
Eucalyptus torquata	Coral Gum
Jacaranda mimosifolia	Jacaranda
Lagerstroemia indica	Crepe Myrtle
Fraxinus raywoodii	Claret Ash
Olea europaea	Olive
Prunus nigra	Plum
Pyrus nivalis	Snow Plum
Tipuana tipu	Pride of Bolivia

Retained Vegetation

The retention of existing vegetation in defined locations caters for existing habitat, preserves the sites natural assets and provides visual relief against broader site clearing.

Whilst most of the vegetation on site has suffered through the effect of the various past land uses and management some stands of vegetation offer positive outcomes if the development can be engineered so as the stands are protected.

Street Trees

Street trees will reinforce the significant nature of major roads by forming strong visual avenues & views to distant feature elements.

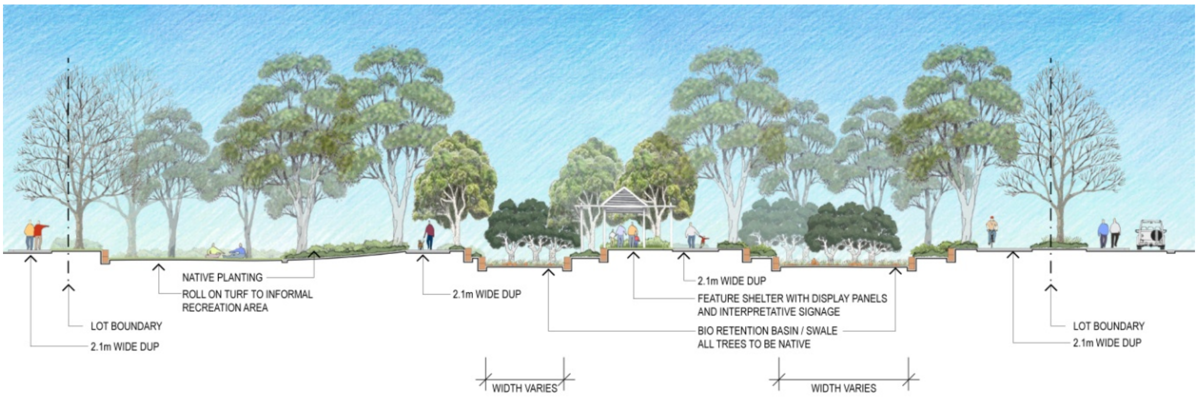
- Street trees will reinforce the significant nature of these major roads by forming strong visual avenues.
- Views to distant feature elements to provide orientation

Drainage/Stormwater

The landscape design for St Leonards aims to utilise water sensitive urban design principles. Water sensitive urban design recognises the linkages in the water cycle between residential development, stormwater systems and the quality of downstream ecosystems.

The development aims to utilise water sensitive urban design principles covering the following:

- Stormwater detention in POS areas to minimise downstream flows following major storm events.
- Bio retention swales to collect stormwater runoff
- Swales/Basins should also provide for multiple uses – recreation and storm water management. They also encourage natural habitat creation.
- Reed and fringing vegetation to provide a nutrient stripping function.
- Specifically selected Biofiltration Media to assist in the nutrient stripping function of the Biofiltration Basins.



A species list outlining the species that will be used in the drainage basin planting areas is provided below.

Living Stream/Drainage Basin Species List

Shrubs/Sedges/Herbs/Groundcovers	
Species Name	Common Name
Baumea articulata	Jointed Twig Rush
Ficinia nodosa	Knotted Club Rush
Juncus krausii	Sea Rush
Gahnia trifida	Coast Saw Sedge
Lepidosperma longitudinale	Pithy Sword Sedge
Pericalymma elipticum	Swamp Teatree
Trees	
Species Name	Common Name
Eucalyptus rudis	Flooded Gum
Melaleuca rhaphiophylla	Swamp Paperbark

1.4. IRRIGATION STRATEGY

A general principle has been adopted throughout the planning stage to reduce the amount of irrigated areas within St Leonard's Estate. Reduced irrigation use methods include reduction in areas of turf, avoidance of species which require extensive irrigation and the design of irrigation systems for efficiency (to be detailed at subdivision stage).

Irrigation, when necessary shall aim to incorporate elements of subsurface, drip and trickle water application methods, with water application based on seasonal need and a reduced number of areas under surface spray water application. As described above, water-wise principles will be employed to achieve a minimum 30% of POS not requiring irrigation. This will ensure that St Leonards meets the Department of Water guidelines that groundwater allocation be 7500 kilolitres/hectare/annum.

It is proposed to install a series of groundwater bores utilizing existing allocations to irrigate the public area. Each of these bores and infrastructure will be designed and specified to suit City of Swan requirements. It is anticipated that the City will take over control of both the groundwater licence and the infrastructure at the conclusion of the Developers maintenance period.

Water Wise Planting

In line with the overall principle to reduce irrigation water demands it is proposed that native species will be the predominant planting type to minimise irrigation requirements. Soil conditioning will be employed to reduce leaching and increase soil moisture holding capacity. All garden beds will be mulched to reduce water loss through evaporation.

1.5. SITE FURNITURE

The provision of public area furniture will be in line with the intended use of POS and reserve areas. The inclusion of quality street furniture elements reinforces the intended design theory, develops a sense of community and ownership among residents and encourages and caters for outdoor use.

The location of street furniture elements will closely correspond with more intensive areas of human use, gathering and recreation. Basic functional requirements shall include the local availability for the quick and cost effective installation, ongoing replacement and maintenance of installed furniture.

Public area furniture will have a robust design to minimise the effects of vandalism or weathering and appropriate fixing methods to allow maintenance and prevent theft. Colour will be defined but neutral where possible to enable the maximum blending with other site elements and have galvanised and powder coated finishes to maximise lifespan.

Elements shall provide a visually recognisable, clear and useful function. The types of street furniture envisaged would include, picnic settings, shade structures, bridges, BBQs, seating (formal and informal), rubbish bins, tree guards and bollards.

The provision of street furniture demonstrates detailed consideration of human use and comfort. The inclusion of quality street furniture elements reinforces the intended design theory, develops a sense of community and ownership among residents and encourages and caters for outdoor use.

1.6. PUBLIC ART

The selection and installation of appropriate public art creates interest, social discussion and promotes a sense of community and ownership to public spaces. Public art can provide historic, social, cultural and environmental comment and act as a reference to define a local area, generic resident profiles and community values.

It is intended that public art be distributed at either high profile points or community gathering spaces to ensure its value in place making is maximised. Locations should include vista and axis views from roads or pedestrian paths, inclusion into playgrounds or placement adjacent picnic locations and the like. Individual lighting may be desirable in some instances to provide additional importance and focus to specific pieces.

1.7. MAINTENANCE MINIMISATION

The reduction of turf areas and use of native species will minimise the maintenance required throughout St Leonard’s Estate.

A key consideration for all landscaped areas will be to minimise long term maintenance requirements given that these areas will ultimately be transferred to the City of Swan.

In conjunction with the detail design of public open space and verge areas to be ultimately vested and controlled by the Council, a maintenance minimisation review is undertaken by the design consultant team to best reduce likely future maintenance costs at the time of subdivision detailed design . This process may typically include:

- review of all materials to ensure fitness for purpose and lifespan
- review of corners, edges and trim to ensure definition of maintainable edges
- review of the volume of planting and turf areas
- review of plant and turf species and their specific growth habits and requirements
- water quality design review of open water bodies and water courses
- water monitoring of groundwater quality and levels, lakes, wetlands and overflows
- review of irrigation materials and standards to ensure best practice
- implementation of sustainability and water wise principles to enable the reduction of ongoing costs through removal of some short term landscape establishment assets
- review of all structural design to ensure fitness for purpose and lifespan

2. PUBLIC OPEN SPACE TYPOLOGIES

2.1. GENERAL

The key public open space objective is to provide a readily usable, aesthetically pleasing environment to potential residents. Open space areas shall incorporate features and facilities to provide public amenity and aesthetic value.

POS areas have been strategically located to provide good connectivity through the development. The POS designs allow for the POS's to act both as a thoroughfare and a destination. The design of the individual POS areas is aimed at providing a good mix of recreational opportunities for the residents and visitors.

The Public Open Space areas have been designed to provide an integrated network of parkland that includes neighbourhood parks, local open space, living streams, and tree lined avenues. A key design objective is to provide a balance between ecological function, amenity and public recreation that creates a readily usable, interconnected, aesthetic and liveable environment to potential residents from the development's inception.

An emphasis will be placed on the predominant use of native plant species throughout the POS areas, however, exotic plant species may be used in various locations.

A combination of passive recreational (neighbourhood parks, linear parks) and active recreational (local open space associated with the areas schools) opportunities will be provided. The landscape network will include a variety of easily accessible passive and active recreational facilities including the following:

- Discovery and learning playgrounds
- Shelters
- Viewing platforms
- BBQs and gathering spaces
- Boardwalks
- Integrated path systems
- Feature lighting
- Security and safety lighting
- Informal open recreation spaces
- Fitness trails
- Smaller contemplative spaces
- Interpretive signage and Educational areas
- Public art

The areas of POS within St Leonards have been separated into broad categories based on their specific treatments and design. The Landscape Masterplan indicates the location of these areas and includes the following:

2.2. LANDSCAPE STRATEGY

LANDSCAPE STRATEGY

LEGEND

- - - EXTENT OF WORK

▨ DRAINAGE STORAGE AREAS

✱ PLAYGROUND

◎ SHELTER

✱ ABORIGINAL HERITAGE SITE

✱ POTENTIAL ARTWORK /SIGNAGE

Ⓐ PUBLIC OPEN SPACE

PUBLIC OPEN SPACE SUMMARY

🟩 **NEIGHBOURHOOD PARKS**

- *Balance of native planted pockets and open turf areas*
- *Small & Large gathering nodes and picnic/BBQ facilities*
- *Pedestrian/Cycle Path network which links into the greater Dayton development*
- *Primary focus on passive recreation*
- *Retain and protect existing trees where possible*
- *POS C to contain large expansive turf area*
- *Centrally located and easily accessible to the entire community*
- *Large gathering spaces to cater for community events*
- *Shaded nooks with seating opportunities*
- *Informal active recreation spaces*
- *Active recreation space including informal kickabout areas*
- *Interpretation signage*

NORTH
nts

DAYTON LOCAL STRUCTURE PLAN 2A
NOVEMBER 2012 : REV B

emerge ASSOCIATES
Integrated Science & Design

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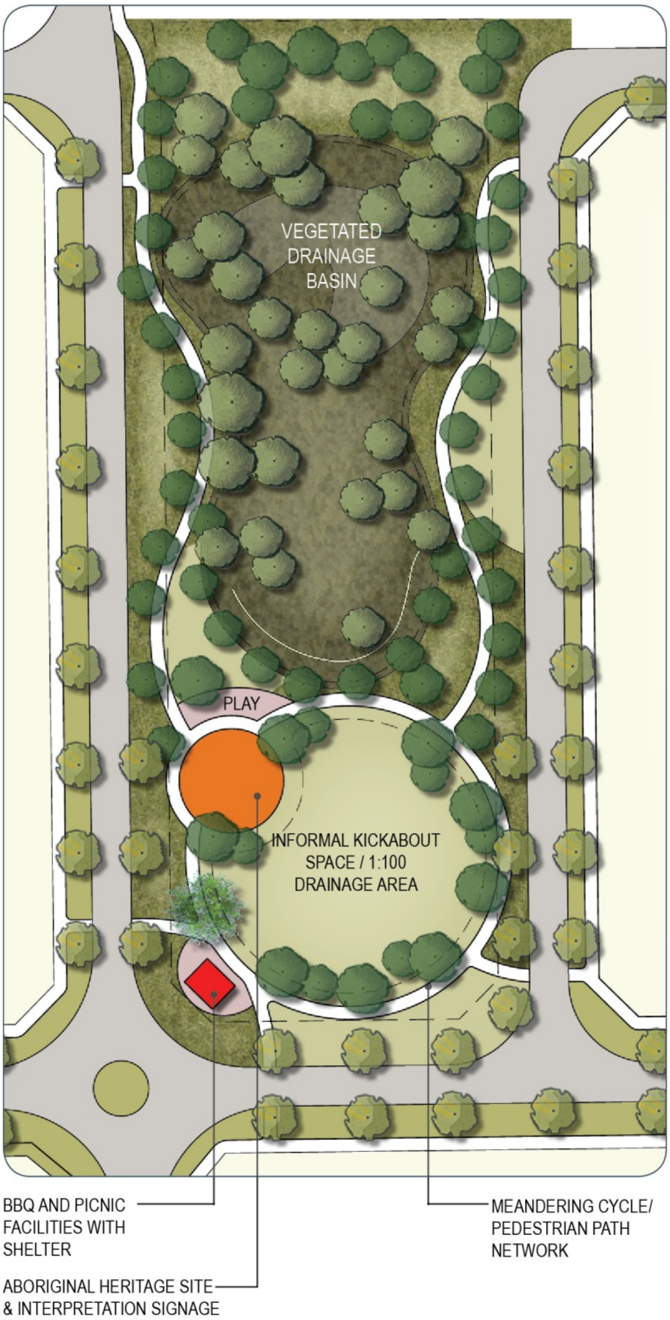
POS A CONCEPT



POS TYPOLOGY

- Neighbourhood Informal

SIZE (excluding verges)

- 7,624 square metres

CONCEPT

- Provide a neighbourhood park to cater for residents within a 200 - 400m walking catchment
- Create a safe local park which is intended to be heavily planted in pockets with shade trees
- Provide low key facilities for residents to play and a mixture of both active and passive spaces.
- Provide safe pedestrian and cycle linkages to the broader path network and greenlinks.
- Aboriginal Heritage Site & Interpretation signage

FUNCTIONS

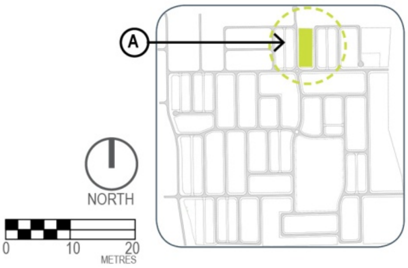
- Turf - small pockets
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Picnic Facilities for family/friend gatherings
- Play elements
- Path network connecting into broader path network.
- Drainage

ENVIRONMENTAL CONSIDERATIONS

- Waterwise native planting
- Planting design to be zoned according to irrigation requirement
- Dry gardens with gravel mulch, clumping plants and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials
- Integrated stormwater / biofiltration basins

DRAINAGE CONSIDERATIONS

1:1	1,500 m2 storage required
1:5	2,900 m2 storage requiredz
1:100	3,400 m2 storage required



Considered - Balance turf and planted areas

Connectivity - Pedestrian and Cycle links

Comfort - Shaded nooks

DAYTON LOCAL STRUCTURE PLAN 2A
NOVEMBER 2012 : REV B

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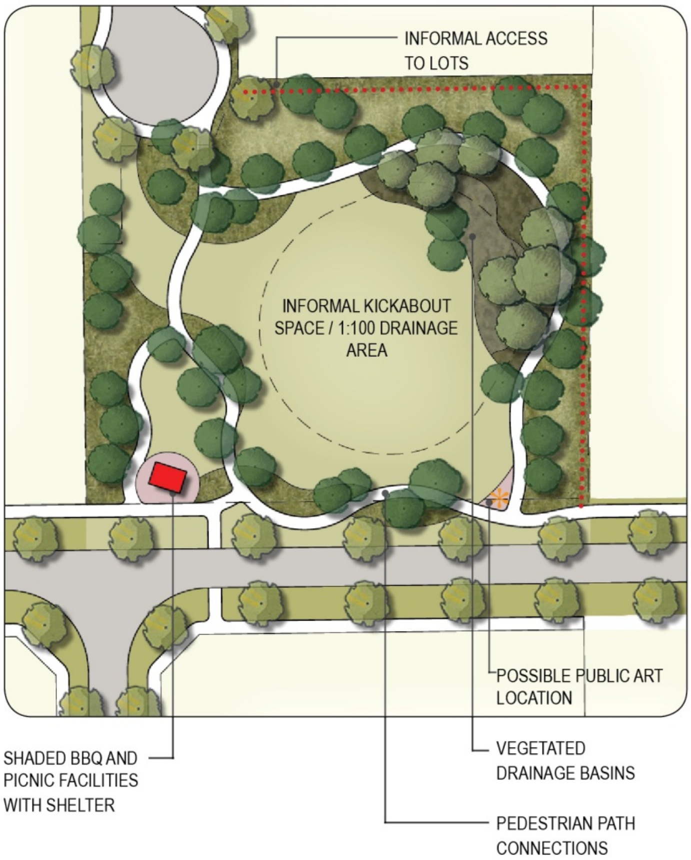
POS B CONCEPT



POS TYPOLOGY

- Neighbourhood Park

SIZE (excluding verges)

- 4,717 square metres

CONCEPT

- Provide a large active turf space for the broader community
- Provide safe pedestrian and cycle linkages
- Provide shaded picnic facilities & bbq
- Possible public art located on key access road

FUNCTIONS

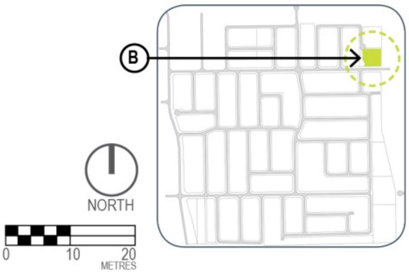
- Turf - Larger turf areas for informal recreation
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Shelter & picnic Facilities for family/friend & community gatherings
- Path network connecting into broader path network and green-ways.
- Drainage

ENVIRONMENTAL CONSIDERATIONS

- Waterwise native planting
- Planting design to be zoned according to irrigation requirement, with full irrigation requirements to the informal turf playing area
- Dry gardens - gravel mulch, clumping plants & limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials
- Integrated stormwater / biofiltration basins

DRAINAGE CONSIDERATIONS

1:1	220 m2 storage required
1:5	1,000 m2 storage required
1:100	1,500 m2 storage required



Comfortable - Informal gathering spaces

Connection - Meandering pathways

Textural - Local material palette

DAYTON LOCAL STRUCTURE PLAN 2A
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POS C CONCEPT

POS TYPOLOGY
- Neighbourhood Park

SIZE (excluding verges)
- 23,572 square metres

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park which caters for drainage requirements whilst providing pockets of turf and nooks for play, gatherings and informal recreation.

FUNCTIONS
- Turf - Informal kick-about areas
- Native waterwise planting with areas of dry gardens
- Maximise shade trees to perimeter of turf area
- Picnic Facilities for family/friend gatherings
- Play elements for all age groups
- Path network connecting into broader path network
- Drainage

ENVIRONMENTAL CONSIDERATIONS
- Waterwise native planting
- Planting design to be zoned according to irrigation requirement, with full irrigation requirements to the informal turf playing area
- Dry garden with gravel mulch, clumping plants and limited irrigation
- Source local materials where possible
- Integrated stormwater and active POS areas
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS

1:1	7,000 m2 storage required
1:5	12,200 m2 storage required
1:100	13,200 m2 storage required

Fun - Space to run

Considered - Planted drainage retention

Connection - Utilising drainage areas

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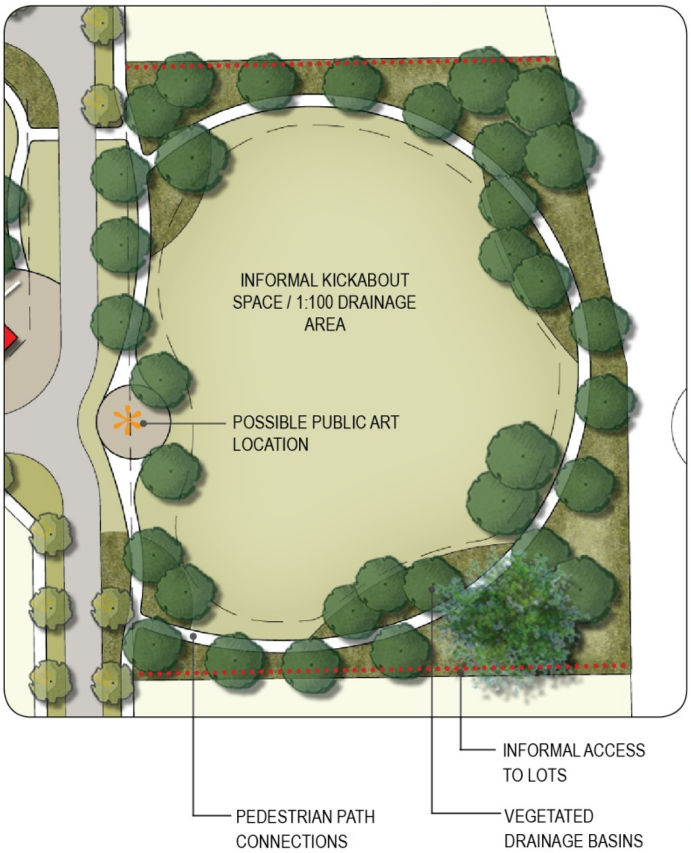
POS D CONCEPT



POS TYPOLOGY

- Neighbourhood Park

SIZE **(excluding verges)**

- 7,772 square metres

CONCEPT

- Provide a large active turf space for the broader community
- Provide safe pedestrian and cycle linkages
- Provide shaded facilities and connection with adjacent POS
- Possible public art located on key road axis

FUNCTIONS

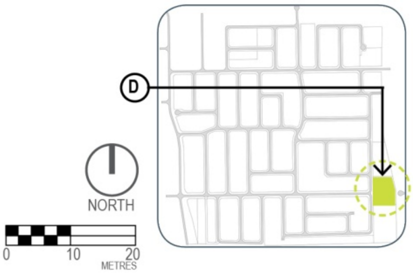
- Turf - Larger turf areas for informal recreation
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Path network connecting into broader path network and green-ways.
- Drainage

ENVIRONMENTAL CONSIDERATIONS

- Waterwise native planting
- Planting design to be zoned according to irrigation requirement, with full irrigation requirements to the informal turf playing area
- Dry gardens - gravel mulch, clumping plants & limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials
- Integrated stormwater / biofiltration basins

DRAINAGE CONSIDERATIONS

1:1	2,300 m2 storage required
1:5	4,300 m2 storage required
1:100	5,000 m2 storage required



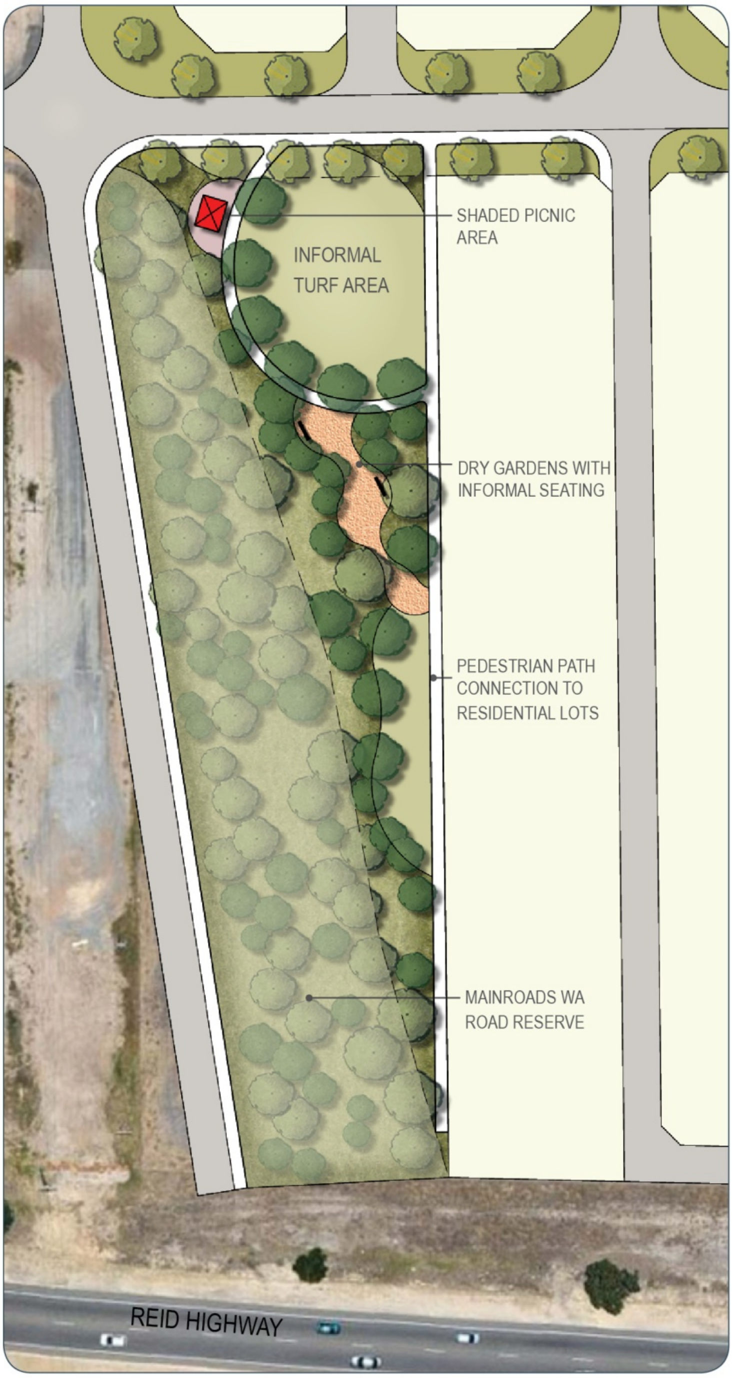
Comfortable - Informal gathering spaces

Considered - Planted drainage retention

Connection - Meandering pathways

DAYTON LOCAL STRUCTURE PLAN 2A
NOVEMBER 2012 : REV B

POS E CONCEPT



POS TYPOLOGY

- Local Informal

SIZE **(excluding verges)**

- 2,813 square metres

CONCEPT

- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide pedestrian access to the lots fronting POS

FUNCTIONS

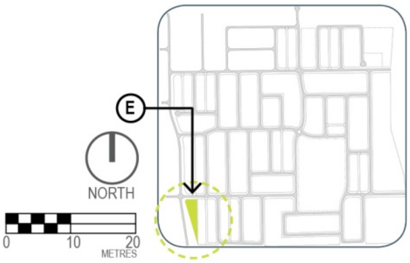
- Turf - small pockets
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Limited picnic facilities
- Path network connecting into greenlink and broader path network.

ENVIRONMENTAL CONSIDERATIONS

- Waterwise native planting
- Planting design to be zoned according to irrigation requirement
- Dry gardens with gravel mulch, clumping plants and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS

- Not Applicable




Connectivity - Nodes along journey


Textural - Dry gardens


Comfort - Shaded nooks

DAYTON LOCAL STRUCTURE PLAN 2A
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2.3. LIVING STREAMS

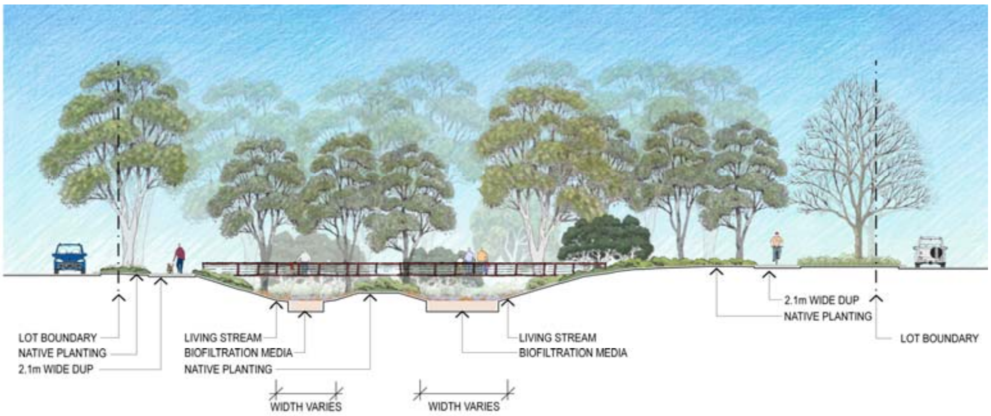
Due to the low lying nature of the site and the requirement to convey stormwater reliably away from high use areas the Living Stream runs through the majority of the public open space in one form or another. Described below are two scenarios

- The Living Stream in a Neighbourhood Park

The Living Stream will provide not only a viable drainage function but also a variety of ecological zones and restoration opportunities.

Planting is to consist of endemic species with a variety of tree, shrub, groundcover, reed and sedge species to be encouraged.

The living stream will include a DUP in close proximity. There will be native shrub planting on the banks and native reed and sedge planting to enhance nutrient uptake. Bank stabilisation will be incorporated into the design and a variety of tree species will be used to provide a diverse tree canopy. The sections below show a typical cross section of the living stream with mostly revegetated areas and a passive recreational node.

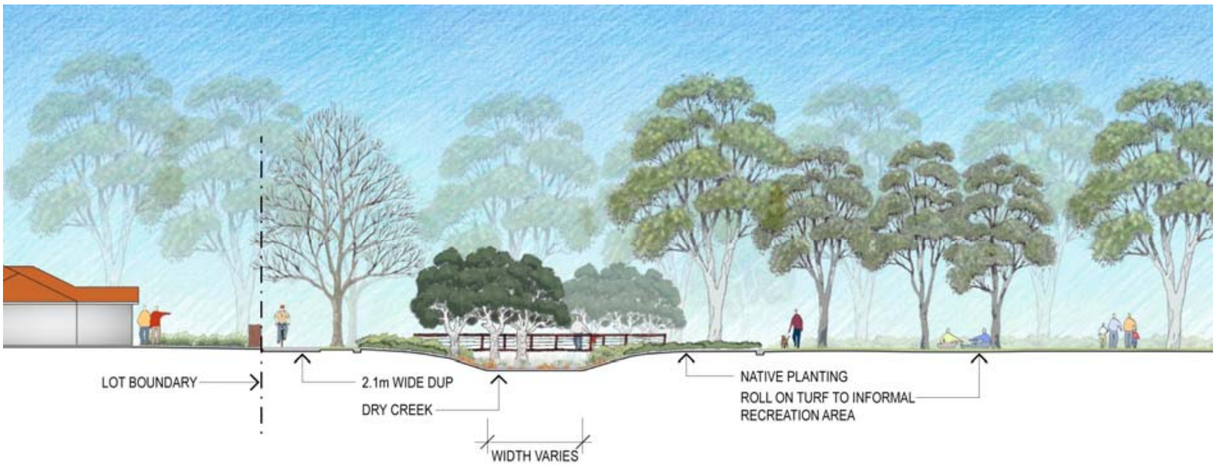


Living Stream through Linear Park

- Dual Use Path to one or both sides of the Living Stream
- Irrigated native shrub planting to banks
- Irrigated native reed and sedge planting within bioretention swales to enhance nutrient uptake.
- Bank stabilisation
- Variety of tree species to provide a diverse tree canopy
- Shelter/boardwalks & feature viewing platform to encourage interaction with the Stream
- Irrigated planting to high impact areas
- Rehabilitation of streamline in accordance with Aboriginal significance

Living Stream through Neighbourhood parks

The Living Stream also runs through the Neighbourhood Parks. Some areas along the living streams, as outlined in the Landscape Masterplan will include parkland turfed areas for passive recreation.



Living Stream through Neighbourhood Park

- Dual Use Footpath to both sides of Living Stream
- Walking trail
- Irrigated native shrub planting to banks
- Irrigated native reed and sedge planting to base of Park Avenue to enhance nutrient uptake potential
- Open parkland for passive recreation
- Creek stabilisation
- Variety of tree species to provide a diverse tree canopy
- Playground, shelters and boardwalks at designated locations

APPENDIX 5

TRANSPORT ASSESSMENT REPORT

DAYTON
LOCAL STRUCTURE PLAN 2A

TRANSPORT ASSESSMENT

transport planning • traffic engineering • project management

Dayton
Local Structure Plan 2A

Transport Assessment

Prepared for:
Aspen Group

Revised January 2014

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Author: R White

Project manager: B Bordbar

Client: Aspen Group

Project: Dayton LSP2A

Document version: r01d

Project number: t11.191

TABLE OF CONTENTS

APPENDICES

Appendix A	**Dayton Local Structure Plan 2A**
Appendix B	**Road Cross Sections**
Appendix C	**Medium Term Traffic Flows for LSP 2A**
Appendix D	**SIDRA Intersection Analysis**

1.0 Summary

This Transport Assessment addresses the proposed Local Structure Plan 2A (LSP2A) for Dayton (formerly known as West Swan East) in the City of Swan.

LSP2A is anticipated to accommodate approximately 1230 dwellings and a neighbourhood shopping centre site.

The LSP makes provision for a future Activity Corridor along Arthur Street adjacent to this site in accordance with the *Swan Urban Growth Corridor Sub Regional Structure Plan*. The proposed Activity Corridor will ultimately form an important public transport corridor within Dayton.

The transport assessment considers the same two long-term road network scenarios considered for the overall West Swan East District Structure Plan: an interim scenario with access into the Dayton area from Lord Street in the west and the planned Henley Brook Avenue in the east; and an ultimate scenario when the Perth-Darwin National Highway (PDNH) is constructed with a flyover at Marshall Road over PDNH and the Arthur Street flyover across Reid Highway. This ultimate scenario is in accordance with current reservations in the Metropolitan Region Scheme (MRS) and has been the basis for long-term planning in this corridor.

If current Main Roads WA proposals to realign the future PDNH alignment to the western side of Whiteman Park do proceed through the MRS amendment process it is assumed that a district distributor road would ultimately be constructed on the current PDNH alignment west of Dayton as planning of this area has been based on this road alignment ultimately relieving traffic demand on Lord Street. Supplementary information has been added to this report relating to revised planning in 2013 for this potential district distributor road and Henley Brook Avenue.

Short-term road network access for development in Dayton is also considered, with and without road connections to West Swan Road. In the medium term the proposed construction of Henley Brook Avenue from Reid Highway to Marshall Road and extension of Marshall Road from Arthur Street to Henley Brook Avenue will provide access on the eastern side of Dayton and will relieve traffic flows on this section of West Swan Road.

2.0 Introduction and Background

This Transport Assessment of the proposed Dayton Local Structure Plan 2A (LSP2A) has been prepared by Transcore on behalf of the Aspen Group.

LSP2A covers the southeast portion of the West Swan East District Structure Plan.

Transcore prepared a report titled *West Swan East Structure Plan, City of Swan, Transport Impact Statement Update* (October 2009), which will be referred to in this transport assessment as the West Swan East TIS report.

Transcore has also prepared a *Dayton Local Structure Plan 1 Transport Assessment* (April 2011), which covers the southwest quarter of the West Swan East District Structure Plan area and a *Dayton Local Structure Plan 2B Transport Assessment* (revised November 2012), which covers land immediately north of LSP2B.

Supplementary information has been added to this latest version of this report relating to revised planning in 2013 for a potential district distributor road on the Perth Darwin National Highway alignment west of Dayton and planning for Henley Brook Avenue.

3.0 Structure Plan Proposal

The location of the Dayton LSP2A area is illustrated in Figure 1, which shows it in its regional context within the Metropolitan Region Scheme. The location of the other local structure plan areas that make up Dayton (i.e. LSP1, 2B, 3 and 4) are also shown in Figure 1.

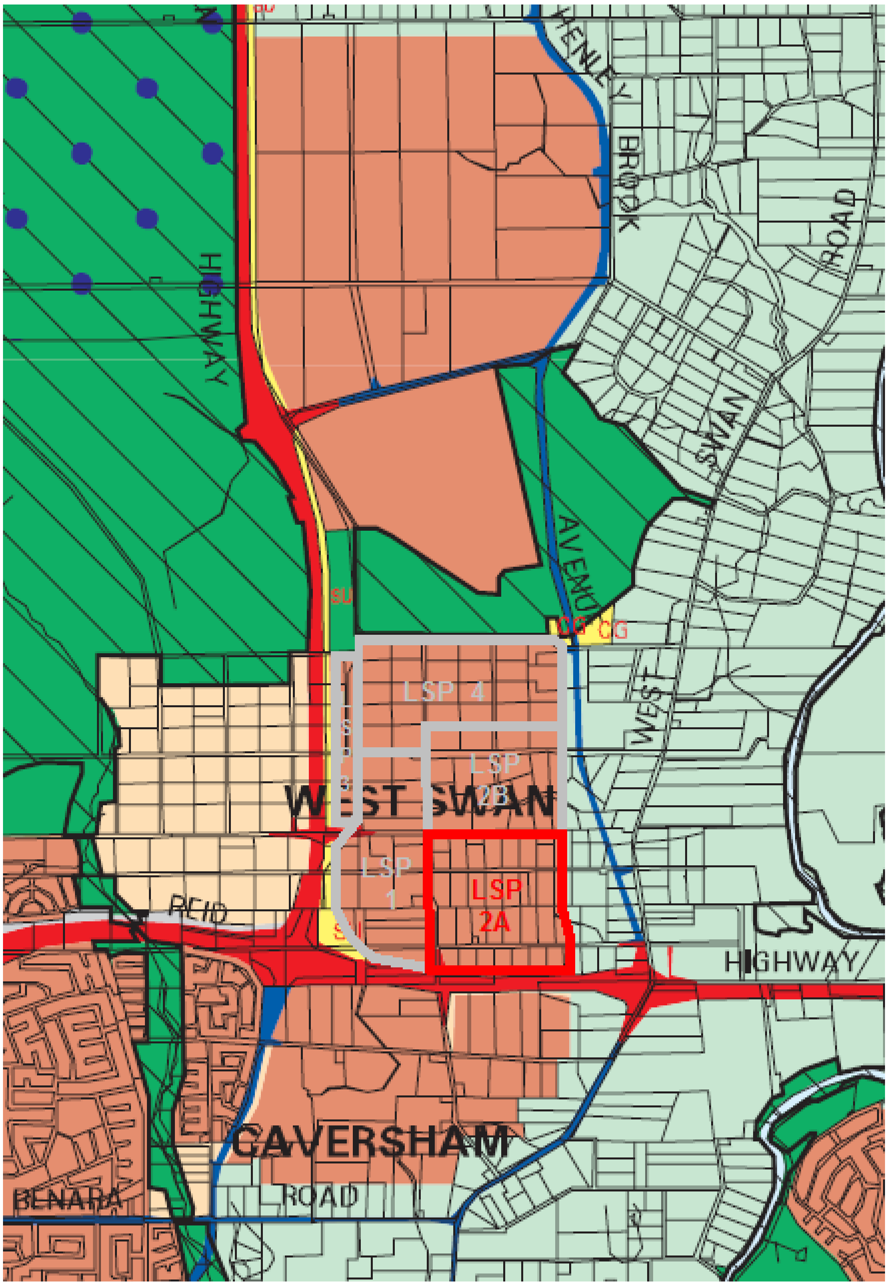


Figure 1. Site location

LSP2A is bounded by Arthur Street on its western side, the future alignment of Marshall Road extension on the north, Reid Highway on the south and the WA natural gas easement on the east.

The proposed LSP2A plan (as at October 2012) is included at Appendix A of this report.

The wider West Swan East District Structure Plan provides for a total of approximately 2,800 dwelling units (including a wide range of residential densities, two school sites, a neighbourhood shopping centre, community facilities and a 6.5-hectare service/commercial site.

LSP2A will accommodate approximately 1230 dwellings and the neighbourhood shopping centre site.

4.0 Existing Situation

The LSP2A area is located approximately 18 km northeast of the Perth CBD.

There are a number of existing rural dwellings units and other agricultural and rural land uses currently in place on existing properties (typically 2-hectare lots) within the LSP2A area. Residential subdivision development has commenced on about 4ha within the LSP2A area between Marshall Road and Coast Road and provides temporary access (until Marshall Rd is constructed) to a similar area of subdivision development north of Marshall Road. Residential subdivision development is well-advanced in the LSP1 area west of Arthur Street opposite the LSP2A area

There is an existing primary school (Caversham Primary School) on the south side of Coast Road east of the LSP2A area, as well as an existing private primary school on Arthur Street south of Harrow Street (1km northwest of the LSP2A area) and Culunga Aboriginal School north of Harrow Street (1km north of the LSP2A area).

4.1 Existing road network

Table 1 outlines the existing road system in and around the LSP2A area.

Table 1: Existing Road Network

Road	*Existing Cross-Section*	*Speed Limit*	*Road Classification*	*Jurisdiction*
Reid Highway (Lord Street to West Swan Rd)	2-lane undivided rural cross-section	90 km/h	Primary Distributor	Main Roads WA
West Swan Rd (Reid Hwy to Harrow Street)	2-lane undivided	70 km/h	District Distributor A	City of Swan
Arthur Street (South of Harrow Street)	2-lane rural cross-section, school zone south of Harrow Street	70 km/h; 40 km/h school zone in vicinity of school	Local Distributor	City of Swan
Arthur Street (South of Marshall Road)	2- lane undivided, cul-de-sacked north of Reid Hwy	70 km/h	Local Distributor	City of Swan
Victoria Road (west of West Swan Road)	2- lane undivided, cul-de-sacked east of Lord Street	70 km/h	Local Distributor	City of Swan
Coast Road	2-lane undivided with teardrop traffic islands before and after school.	70 km/h, 40 km/h school zone near West Swan Road	Access Road	City of Swan
Marshall Road (Arthur Street to Lord Street)	2-lane undivided	70 km/h	Access Road	City of Swan
Cranleigh Street	2-lane undivided unmarked narrow rural cross-section	70 km/h	Access Road	City of Swan
Blundell Street	2-lane undivided rural cross-section	70 km/h	Access Road	City of Swan
Sam Rosa Place	Narrow 2-lane undivided, rural cross-section	70 km/h	Access Road	City of Swan
Malvern Street	Narrow 2-lane undivided rural cross-section, gravel shoulders	70 km/h	Access Road	City of Swan
Harrow Street	2-lane rural cross-section	70 km/h, 40 km/h school zone near Arthur Street	Local Distributor	City of Swan

Arthur Street is currently cul-de-sacked midway between Cranleigh Street and Harrow Street opposite the existing private primary school. Access to the school is provided from the northern section of Arthur Street.

Table 2 outlines the existing traffic control measures at the primary intersections within the surrounding road system.

Table 2: Existing Traffic Control Measures

Intersection	*Level of Traffic Control*	*Turn Pockets/Intersection Flaring*
Reid Hwy / Lord Street	Stop sign control on Lord St approach	Left turn slip lanes on west and north approaches and right turn pocket on east approach.
Lord St / Marshall Rd west / St Leonards Bvd	4-way roundabout	
Lord Street / Marshall Rd east	Give Way control on Marshall Rd approach	Lord Street northbound approach flares to the west to allow northbound through traffic to pass right turning vehicles.
Lord Street / Cranleigh Street	Stop sign control on Cranleigh St approaches	
Arthur Street / Victoria Street	Give Way control on Arthur St approach	
Arthur Street/ Coast Road	Give Way control on Coast Rd approach	
Arthur Street / Marshall Road	Give Way control on Marshall Rd approach	
Arthur Street / Cranleigh Street	Give Way control on Arthur St approaches	
Reid Hwy / West Swan Road	Signalised 4-way intersection	Both roads widened to 4 lanes through the intersection. Left turn slip lanes and right turn pockets on all approaches.
West Swan Road / Victoria Road	Stop sign control on Victoria Rd approaches	
West Swan Road / Victoria Road	Give Way control on Coast Rd approaches	West Swan Rd southbound approach flares to the east to allow southbound through traffic to pass right turning vehicles.
West Swan Road / Coast Road	Give Way control on Coast Rd approaches	West Swan Rd southbound approach flares to the east to allow southbound through traffic to pass right turning vehicles.
West Swan Road / Harrow Street	Give Way control on Harrow St approach	West Swan Rd southbound approach flares to the east to allow southbound through traffic to pass right turning vehicles.

Other existing intersections within and abutting the LSP2A area (including Arthur Street / St Leonards Bvd) are simple priority-controlled T-Junctions.

4.2 Existing traffic volumes

Table 3 details existing daily traffic volumes for the road network in and around the LSP2A area.

Table 3: Existing Traffic Volumes

LOCATION	SOURCE	DAILY VOLUME (vpd)	DATE
Arthur Street, North of Cranleigh Street	City of Swan	60 vpd	July 2007
Arthur Street, North of Marshall Road	City of Swan	210 vpd	July 2007
Arthur Street, North of Coast Road	City of Swan	640 vpd	July 2007
Arthur Street, North of Victoria Road	City of Swan	340 vpd	July 2007
Blundell Street, South of Harrow Street	City of Swan	60 vpd	March 2010
Coast Road, East of Arthur Street	City of Swan	480 vpd	March 2010
Coast Road, West of West Swan Road	MRWA City of Swan	690 vpd 770 vpd	May 2011 March 2010
Cranleigh Street, East of Lord Street	City of Swan	165 vpd	July 2007
Harrow Street, East of Lord Street	City of Swan	950 vpd	March 2010
Harrow Street, East of Fillip Way	City of Swan	950 vpd	March 2010
Harrow Street, West of West Swan Road	MRWA	860 vpd	May 2011
Lord Street, north of Reid Highway	MRWA City of Swan	13,807 vpd 14,410 vpd	September 2012 December 2010
Lord Street, North of Marshall Road	City of Swan City of Swan	15,480 vpd 15,960 vpd	September 2012 December 2010
Marshall Road, East of Lord Street	City of Swan	530 vpd	July 2007
Sam Rosa Place, South of Cranleigh St	City of Swan	110 vpd	July 2007
Reid Highway, West of West Swan Road	MRWA	25,430 vpd	May 2011
Victoria Road, West of West Swan Road	City of Swan	490 vpd	March 2010
West Swan Road, North of Reid Hwy	City of Swan MRWA City of Swan	16,848 vpd 15,485 vpd 15,560 vpd	October 2012 May 2011 March 2010
West Swan Road, South of Harrow St	City of Swan	14,909 vpd	September 2012

4.3 Existing public transport

The main existing bus service consists of a line haul service via Lord Street from Ellenbrook to Morley (Route 955: Ellenbrook-Morley Bus Station). This service operates generally at 30-minute headways throughout the weekday (20-minute headways in the peak direction during peak hours), with hourly service provided during the evening off-peak period and on Sundays, and half-hourly on Saturdays.

Route 956 (Ellenbrook – Bassendean Station) provides additional bus services between route 955 bus services on weekdays, so the 955 and 956 together provide relatively high frequency service between Ellenbrook and Bassendean Station on weekdays.

Route 335 (Ellenbrook – Midland Station) runs a very limited number of services on weekday for commuters and students via West Swan Road. These existing bus routes are illustrated on Figure 2.

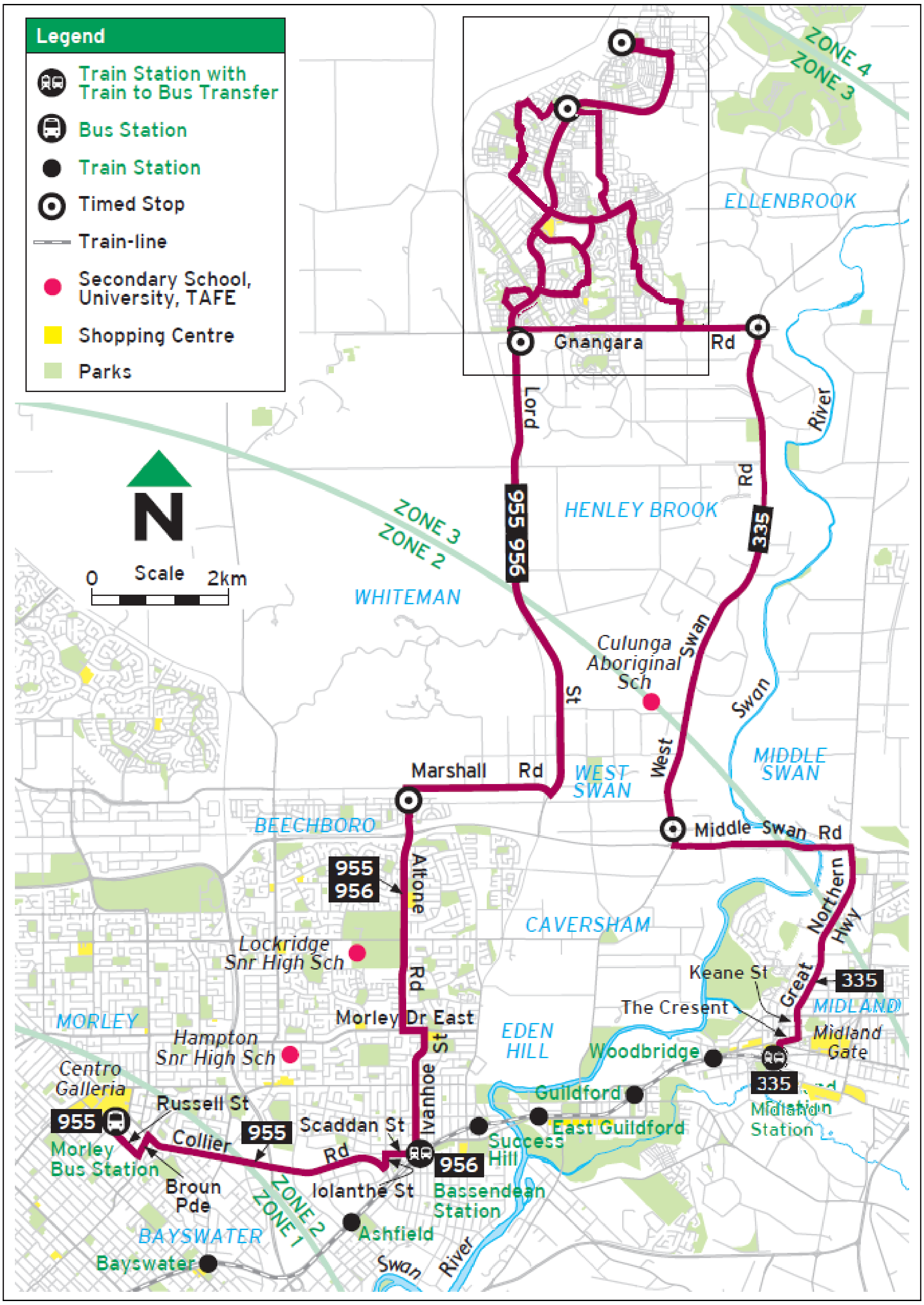


Figure 2. Existing public transport

4.4 Existing pedestrian and cyclist facilities

The Perth Bike Map series published by the Department of Transport shows the local roads around the site are good road riding environments. There are also bicycle lanes on sections of Reid Highway, West Swan Road and Lord Street in this area and a shared path along sections of West Swan Road.

There is also a shared path link across Reid Highway via an underpass west of Arthur Street that provides pedestrian and cyclist access from Victoria Road (within LSP1) to Caversham south of Reid Highway as shown in Figure 3.

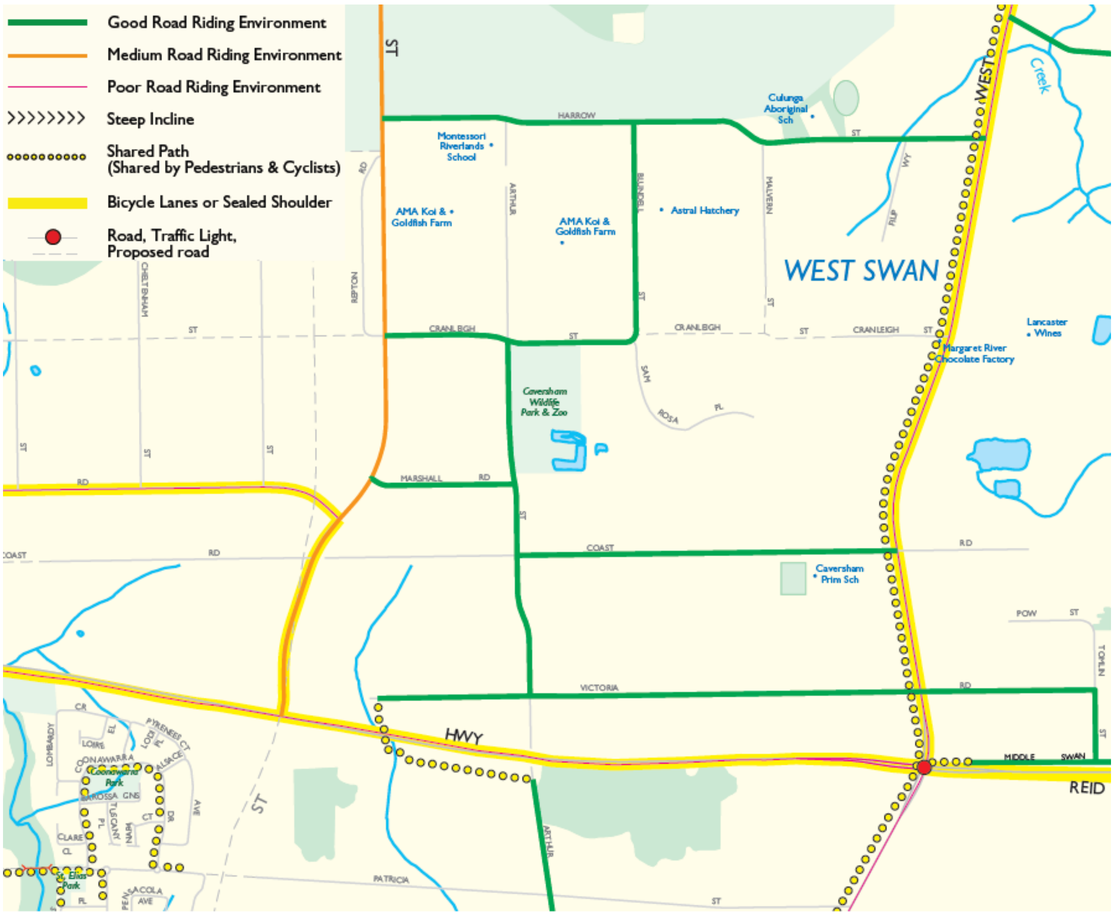


Figure 3. Existing cycling facilities

5.0 Proposed Internal Transport Network

5.1 Road Hierarchy

The hierarchy of roads within and adjacent to the LSP2A area is illustrated in Figure 4 using the road hierarchy defined in *Liveable Neighbourhoods (2007).*

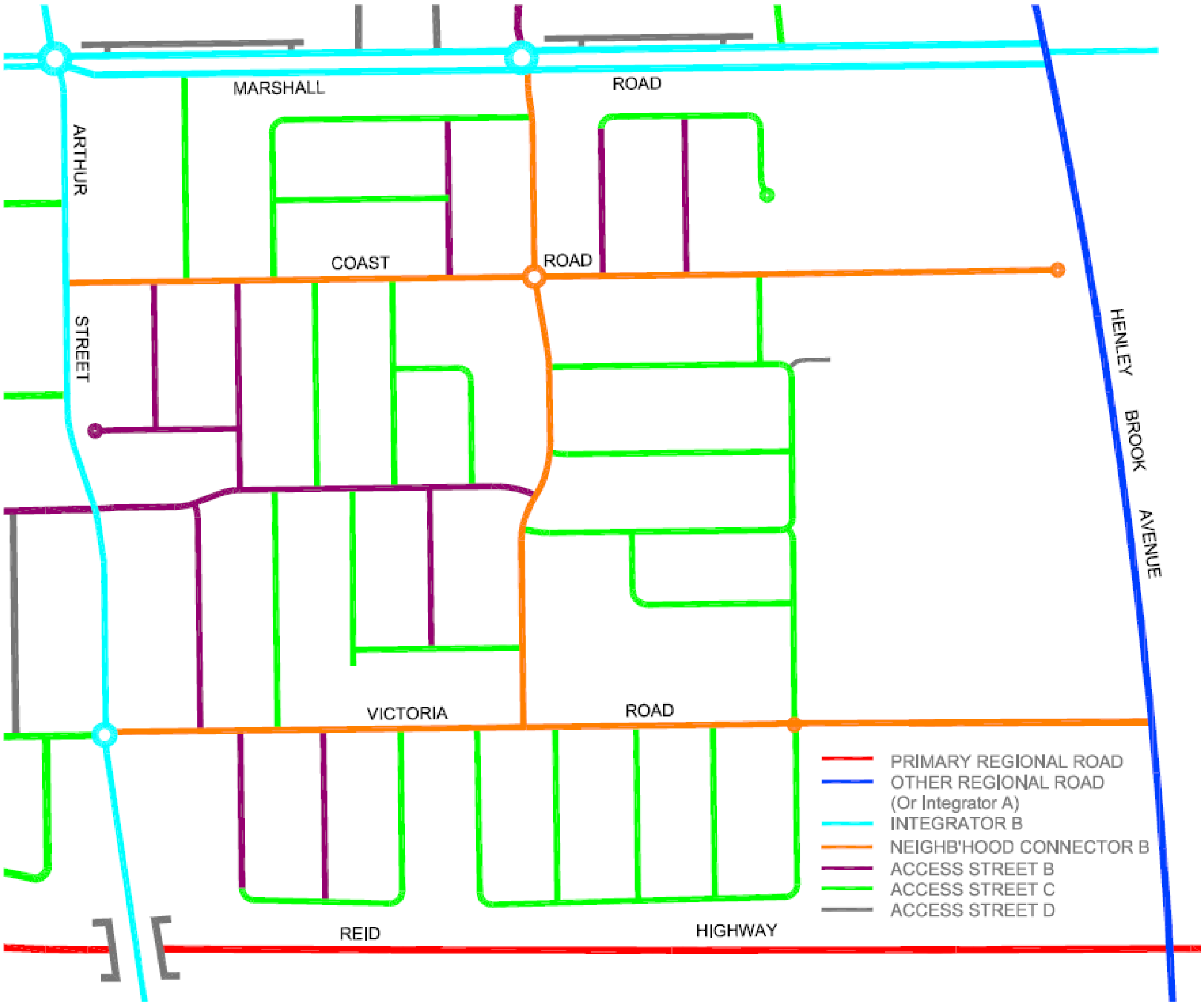


Figure 4. Road Hierarchy

Some key characteristics of the relevant road classifications have been summarised from Liveable Neighbourhoods in Table 4 below. The relevant cross-section diagram in Liveable Neighbourhoods is also indicated.

Table 4. Road Hierarchy

Road Classification	Indicative upper volume (vpd)	Indicative road reserve width (m)	Indicative road pavement width (m)
Integrator B – outside centres *(LN Figure 15)*	15,000	29.2	2 x 7.5m (incl. on-street parking and cycle lanes), 6m median
Integrator B – centres *(LN Figure 16)*	15,000	25.2	2 x 7.5m (incl. on-street parking and cycle lanes), 2m median
Neighbourhood Connector A *(LN Figure 17)*	7,000	24.4	2 x 7.1m (incl. on-street parking and cycle lanes), 2m median
Neighbourhood Connector B *(LN Figure 18)*	3,000	18.0 – 19.4	11.2m (incl. embayed or on-street parking)
Access Street B *(LN Figure 20)*	3,000	16.5 – 18.0	9.7m (incl. embayed or on-street parking)
Access Street C *(LN Figure 21)*	3,000	15.4 – 16.0	7.2m
Access Street D *(LN Figure 22)*	1,000	14.2 – 15.0	6m typical
Laneway *(LN Figure 24)*	300	6.0 – 6.4	6m typical

It should be noted that these reserve widths are indicative and might be subject to further adjustment in consultation with the Department of Planning during detailed subdivision design.

Marshall Road

Marshall Road is anticipated to carry up to 7,000 vpd through West Swan East, 8,000 vpd at Henley Brook Avenue and up to 15,000 vpd at the Lord Street flyover in the ultimate scenario. This is consistent with a classification of *Integrator B*. A 25m road reserve width is proposed between Lord Street and Arthur Street. East of Arthur Street (abutting the LSP2A area) the reserve width will be designed to accommodate drainage in a widened central median and controlled access place (CAP) service roads on the northern side where required for access to abutting properties in LSP2B. On the southern side of Marshall Road in LSP2A there is a powerline easement so there are no abutting residential properties. The proposed cross section for this section of Marshall Road is shown at **Appendix B**.

Arthur Street

Arthur Street is anticipated to function as a *Neighbourhood Connector* road in the interim scenario but the planning needs to take into consideration the ultimate scenario of an Arthur Street flyover over the Reid Highway. Extensive consultation has previously been carried out on this issue with adjoining landowners, DPI, MRWA and City of Swan.

In the ultimate scenario all of Arthur Street south of Cranleigh Street is planned to form part of an activity corridor linking through Albion, West Swan and Caversham. This section is expected to carry up to 6,000 vpd adjacent to LSP2A and will be classified as an *Integrator B*. A 25m road reservation will be appropriate for this section of Arthur Street. Suggested 25m cross-sections for Arthur Street are illustrated in **Appendix B**.

Coast Road

The section of Coast Road east of Arthur Street is designated as a Neighbourhood Connector B road in Figure 4 as it serves the proposed local centre in LSP2A and existing Caversham Primary School east of LSP2A. The existing 20m road reserve is sufficient to accommodate a Neighbourhood Connector B cross-section as illustrated in the 20m Neighbourhood Connector cross section in Appendix B, which is a modified version of the standard Neighbourhood Connector B cross-section.

Other Neighbourhood Connectors

The north south road connecting from Victoria Road to a future roundabout on Marshall Road will generally carry traffic volumes less than 3000 vpd and is also indicated as a Neighbourhood Connector B in Figure 4 within the LSP2A area.

Access Streets

Other existing roads within the LSP2A area will be classed as Access Streets. Victoria Road is already a 20m wide road reserve and will not be changed from this existing reserve width.

Within the West Swan East District Structure Plan area the *Access Street B* classification (typical reservation of 16.5m) will be used for streets adjacent to high-density residential development (R60 and R80), schools, shops and the service industrial area. On-street parking will be highly utilised in these areas. A reservation width of 18m is recommended for Access Street B roads that may potentially form future bus routes. This 18m road reserve could accommodate a 7m carriageway for bus routes and 5.5m verges with embayed parking.

The road on the eastern side of the neighbourhood centre has been approved as a 15.4m Access Street C as part of an early release subdivision development on the basis that the shopping centre will not have access directly from this link and traffic volumes will therefore be low. If the shopping centre development subsequently proposes access from this link or relies upon on-street parking on this road then there would be a requirement for road widening onto the shopping centre site to bring this road up to Access Street B standard.

The *Access Street C* (typical reservation of 15.4m) will be used for streets adjacent to medium-density development (R30 and R40) and other access streets with volumes likely to exceed 1,000 vpd.

The *Access Street D* (typical reservation of 14.2m to 15m) will be used for low volume (less than 1,000 vpd) streets adjacent to residential development of R20 or less. The standard Access Street D width in *Liveable Neighbourhoods* is 14.2m although the City of Swan prefers 15m road reserve width. The City of Swan has advised that it would consider a 13m road reserve on access streets that abut public open space provided that they have no services (including street lights) on the verge of the POS, otherwise these streets have to be 15m unless previously approved.

Laneways

In relation to the minimum requirements for the proposed rear laneways within the Structure Plan area, a minimum width of 6.0 metres (in accordance with Liveable Neighbourhoods) is acceptable to accommodate two-way movement and rubbish collection. Details relating to the design of these laneways will be addressed in more detail during the subdivision planning stages.

Visitor car parking (in a ratio of 1 bay per 2 lots) is to be constructed in the road reserve adjacent to proposed lots serviced by laneways.

5.2 Public Transport

Existing bus services in this area are described in section 4.3 of this report.

Previous liaison with PTA/Transperth has indicated some opportunities to service the West Swan East District Structure Plan area (and LSP2A) with bus services.

The Metropolitan Region Scheme (MRS) has reserved an alignment for a rapid transit public transport service through Ellenbrook (from Maralla Road connecting with the Perth-Midland railway line), to the immediate west of the West Swan East District Structure Plan area and along the east side of the proposed PDNH alignment and north of Reid Highway. There has also previously been a proposal to extend the transitway east of the PDNH to run along Reid Highway in the central median of the future dual carriageway.

As part of this planning, a transitway station was ultimately planned at the Reid Highway interchange with PDNH, although information provided by the Department of Transport in relation to Dayton LSP1 indicates that a site at the northwest corner of the Marshall Road/Lord Street intersection is under consideration as a potential transit station location.

The Department of Transport's public transport plan, Public Transport for Perth in 2031 (July 2011) proposes Morley to Ellenbrook bus rapid transit infrastructure before 2020. It states, "The Plan supports the development of a rapid transit service for Ellenbrook, with the projected numbers of passengers justifying a road-based rapid transit service for the next 10 to 20 years. An option of running a Bus Rapid Transit (BRT) service between Ellenbrook and Bassendean and across to Morley is feasible. This provides quick transfer to the railway at Bassendean for trips to the central area and Midland, and access to commercial / community facilities at Morley. A railway reservation should be identified and secured, and a master plan prepared, to provide a long term rail option for the corridor (It is noted that the Government has allocated funding in 2012/13 for a Master Plan to be undertaken)." This work subsequently indicated a potential bus rapid transit alignment along Marshall Road (west) as shown in Figure 5, however the current state government position has returned to favouring rail as the future rapid transit service in this area.

The future activity corridor along Lord Street – Cranleigh Street – Arthur Street would ultimately offer a high-frequency bus service through Albion, West Swan and Caversham.

Potential bus routes servicing the LSP2A area are shown in Figure 5, based on recent advice from the Department of Transport regarding the latest planning for future transit routes in this area.

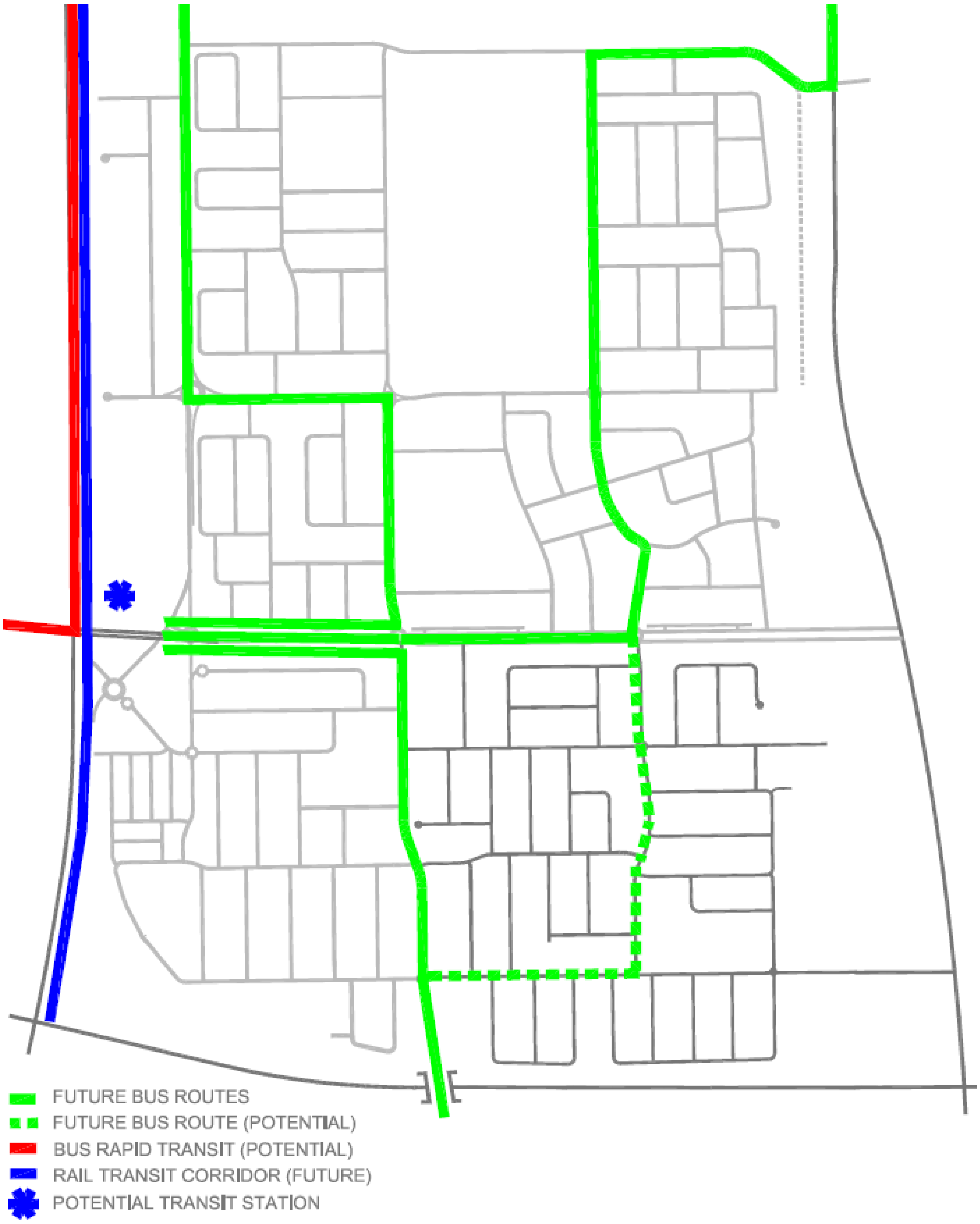


Figure 5. Potential public transport routes

It should be noted that the City of Swan requires that roads for bus routes have a minimum two-way 7.4m carriageway width or 3.7m for a one-way carriageway. The City has identified that Victoria Road and the north south neighbourhood connector road within LSP2A also offer a potential future bus route that would enhance the public transport service in this area, so this option is being protected in the planning for LSP2A.

5.3 Pedestrian and Cyclist Facilities

The reasonably flat topography of the area and the proposed permeable grid of the road network within the LSP2A area create an excellent opportunity for provision of good pedestrian and cyclist facilities to maximise non-motorised transport modes.

Figure 6 outlines the proposed pedestrian and cyclist network for the LSP area.

It is proposed to provide shared paths on the *Integrator Arterial* and *Neighbourhood Connector* roads. These roads would also have a footpath on the opposite side as required in Liveable Neighbourhoods. In the case of Marshall Road the service corridor along its southern side provides an opportunity for a regional shared path through Dayton and across the future PDNH, linking the Swan Valley to Whiteman Park.

It is also proposed to provide shared paths on some of the *Access Street B* roads where a demand is anticipated such as next to the primary school.

Footpaths would be provided on at least one side of all roads. There would be paths on both sides of roads adjacent to schools.

Laneway lots are to have footpath access to the visitor parking bays provided for them in the road reserve.

On-street cycle lanes will be included on the Integrator B and Neighbourhood Connector A roads, as indicated in the details of the road hierarchy listed in Table 4. For LSP2A this means Marshall Road and Arthur Street.

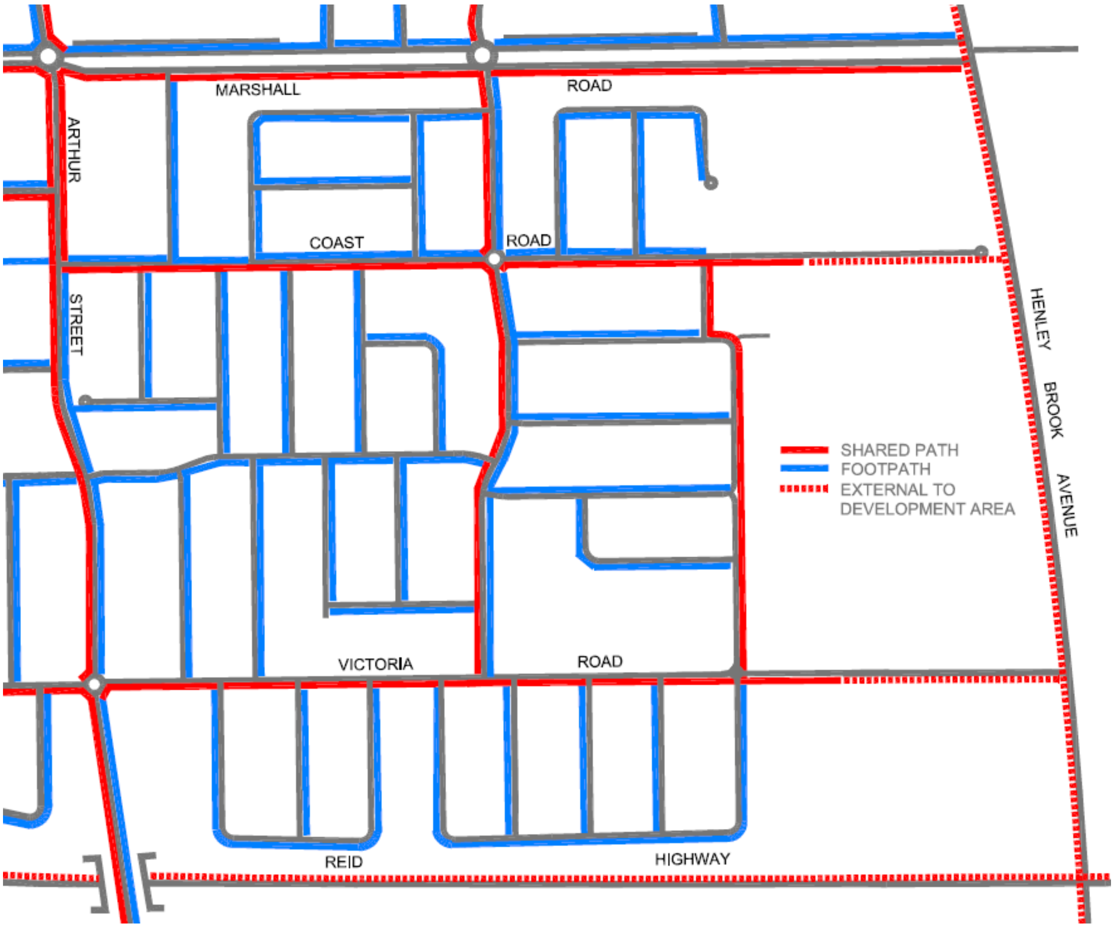


Figure 6. Pedestrian and cyclist facilities

6.0 Changes to External Transport Network

6.1 External Road Network

Reid Highway
Previous discussions with the former Department for Planning and Infrastructure (DPI) indicated 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. This potential land requirement is currently zoned as Urban Deferred in the Metropolitan Region Scheme (MRS) and does not affect the LSP2A area.

Main Roads WA comments on the West Swan East District Structure Plan advised that access to Primary Regional Roads will be limited to the existing planned locations.

Arthur Street
Arthur Street will ultimately form part of a sub-regional activity corridor through this area. This corridor is proposed to include the northern portion of Lord Street, western portion of Cranleigh Street, and Arthur Street south of Cranleigh Street. This activity corridor will connect the district centre within Albion in the north, to

the mixed business site in Dayton and the local commercial centres in Dayton and Caversham, ultimately offering a high frequency public transport service. A range of uses is to be encouraged along this activity corridor, supported by medium and higher densities to help achieve overall viability and vibrancy.

The future Arthur Street flyover at Reid Highway is reserved as a Primary Regional Roads reserve in the Metropolitan Region Scheme. The West Swan East District Structure Plan (DSP) and the neighbouring Caversham Structure Plan have at all times reflected the existence of this reservation as part of the primary regional road network, which therefore would fall under the jurisdiction of MRWA. This reservation is shown, however, to reflect the potential long-term (ultimate) transport network. Hence the transport assessment (detailed in Section 8 of this report) has included this flyover as part of the ultimate scenario for this area.

Perth-Darwin National Highway
The future Perth-Darwin National Highway (PDNH) alignment northwards from Reid Highway is reserved as Primary Regional Road (red road) in the MRS as shown in Figure 1. Detailed concept designs have been developed by the Department of Planning for the section of the PDNH alignment from Reid Highway to Gnangara Road. This includes several interchanges and flyovers in the vicinity of the West Swan East DSP area, including a flyover serving the site directly at Marshall Road and full interchanges at Reid Highway and Youle-Dean Road (to the south-west and north-west of the subject lands, respectively).

Main Roads WA comments on the West Swan East DSP advised that access to Primary Regional Roads will be limited to the existing planned locations.

In the vicinity of the West Swan East DSP area, the PDNH would function as the primary north-south road transport corridor in the area and would remove most of the through traffic currently carried by Lord Street.

Earlier in 2012 the City of Swan considered a Main Roads WA proposal that involves realignment of the future Perth-Darwin National Highway to the west of Whiteman Park. This would completely change the ultimate road network scenario considered in this report but in accordance with discussions with planning officers at City of Swan the PDNH alignment currently reserved in the Metropolitan Region Scheme must be taken into consideration until such time as the proposed alternative alignment becomes official. If this proposal to realign the future PDNH alignment to the western side of Whiteman Park does proceed through the MRS amendment process it is assumed that a district distributor road would ultimately be constructed on the current PDNH alignment west of Dayton as planning of this area has been based on this road alignment ultimately relieving traffic demand on Lord Street. Further information relating to planning in 2013 for a potential district distributor road on the PDNH alignment is presented in Appendix E of this report.

Lord Street
In the interim period until the construction of PDNH the existing alignment of Lord Street will provide access from the West Swan East DSP area to the surrounding road system.

Lord Street is likely to require upgrading to four lanes to accommodate traffic growth in this interim period. This is addressed in the West Swan East TIS report and Dayton LSP1 Transport Assessment report.

If and when PDNH is constructed Lord Street will no longer connect to Reid Highway and traffic flows on Lord Street will be substantially reduced.

Henley Brook Avenue
The future Henley Brook Avenue is reserved as an Other Regional Road (blue road) in the MRS east of the West Swan East DSP area, as shown in Figure 1. It will take over the district distributor road function currently performed by West Swan Road between Reid Highway and Gnangara Road. The Other Regional Roads reservation indicates that Henley Brook Avenue will have connections on the west at Victoria Road and Harrow Road within the West Swan East DSP area and on the east side the connection to West Swan Road is shown at Coast Road.

In discussions with the Department of Planning in relation to Dayton LSP2B it was agreed that Marshall Road should also connect to Henley Brook Avenue to improve access to the West Swan East DSP area. This principle was supported by submissions on Dayton LSP2B from the Department of Planning and the Department of Transport.

In 2013 the Department of Planning has investigated future intersection requirements on Henley Brook Avenue in this area. The department has advised that current planning now indicates four-way signalised intersections at Harrow Street and at Marshall Road, with no connection at Coast Road on either side.

6.2 Public Transport

Future public transport developments in the surrounding area have been discussed in section 5.2 of this report.

6.3 Pedestrian and Cyclist Networks

As noted in section 5.3 the proposed shared use path and footpath network shown in **Figure 6** illustrates the connections to path networks outside the structure plan area. This includes shared path links to the existing pedestrian underpass beneath Reid Highway west of Arthur Street.

It is also proposed to accommodate on-street cycle lanes on Arthur Street and Marshall Road to connect with the existing cycle lanes on Reid Highway, Lord Street and West Swan Road.

7.0 Integration with Surrounding Area

As the LSP2A area is being planned in accordance with the West Swan East District Structure Plan the integration of the transport network across this wider area is assured.

8.0 Analysis of Internal Transport Network

8.1 Development trip generation and distribution

Detailed traffic modelling was undertaken for the West Swan East TIS update report of October 2009. That traffic model has now been further refined to model each of the local structure plan areas in more detail.

Traffic generation rates for the structure plan land uses were primarily sourced from the Roads and Traffic Authority, NSW, *"Guide to Traffic Generating Developments",* with additional information from the Institute of Transportation Engineers *"Trip Generation Manual, 7th Edition"* where required.

The residential traffic generation rates used range from 9 vehicles per day (vpd) per dwelling for the lower residential densities, 7 vpd for medium density dwellings, 5 vpd for high-density units close to transit, and 3 vpd for retirement village units.

The shopping centre traffic generation has been based on the Thursday traffic generation formula from the NSW guidelines, which results in a total of 5,250 vpd for the particular mix of uses anticipated in this shopping centre as detailed in the West Swan East TIS report. The rate assumed for the community facilities is 20 vpd per 100m^2 GFA. The trip generation rate used for the service industry area west of Lord Street is 150 vpd per hectare based on ITE trip rates.

Based on guidance in the WAPC *Transport Assessment Guidelines for Developments* (2006) a school trip generation rate of 2 vpd (vehicles per day) per student has been adopted for this assessment.

The trip distribution to the surrounding regional road network has been estimated based on information previously obtained for a similar study in Caversham from a sub area matrix of the MRWA regional traffic model. The resultant external distribution used in this analysis is as follows:

- 8% Lord Street north (6% PDNH / 2% Lord St);
- 8% Henley Brook Avenue north (6% HBA / 2% West Swan Rd);
- 16% Reid Highway east;
- 19% West Swan Road south,
- 20% Lord Street south,
- 5% Benara Road west,
- 20% Reid Highway west, and
- 4% Marshall Road west.

8.2 Road Network Scenarios

The assessment was undertaken for two major long-term scenarios:

Interim scenario: Lord Street functions as the primary north-south travel corridor in the area prior to the construction of the PDNH. Lord Street and Marshall Road (East and West) maintain their staggered geometry while Lord Street, Marshall Road West and St Leonards Boulevard form a 4-way intersection (roundabout), as has now been constructed. This interim access arrangement will apply until PDNH is ultimately constructed.

Ultimate scenario: the PDNH has been constructed and Marshall Road realigned to form a fly-over over PDNH. The access arrangement to the primary boundary road system has been modified and includes the downgrade of St Leonards Boulevard to a cul-de-sac (at its western end) and realignment of Lord Street to form a 4-way intersection (roundabout) with Marshall Road and an internal subdivision road. The ultimate scenario also includes the future construction of the Arthur Street flyover across Reid Highway as part of a future activity corridor link through Dayton and Caversham.

In this ultimate scenario, site-generated traffic wishing to travel south and west is doing so via Marshall Road to the west and the proposed Henley Brook Avenue to the east.

Both scenarios include Henley Brook Avenue. Connections from the West Swan East DSP area to Henley Brook Avenue are assumed at Harrow Street, Marshall Road and Victoria Road.

Based on 2013 investigations by the Department of Planning and Main Roads WA in consultation with the City of Swan these scenarios have subsequently been revised to include 4-way intersections at Henley Brook Ave / Marshall Road and Henley Brook Ave / Harrow St.

Short-term scenarios: An initial short-term scenario based on development of LSP1 only, with only the existing road network in the surrounding area, has been modelled and documented in the Dayton LSP1 Transport Assessment report (April 2011). A second short-term scenario for LSP1 plus LSP2B has also been modelled and is documented in the Dayton LSP2B Transport Assessment report (revised November 2012).

An alternative type of short term scenario has been considered the Dayton LSP4 Transport Assessment report (February 2013) and is also considered in **Appendix C** of this report. In this case land ownership and developers' intentions are taken into consideration instead, because the land ownership throughout Dayton is quite fragmented and many landowners are not expected to subdivide their land in the short term.

8.3 Traffic Flow Forecasts

The existing traffic volume along Lord Street north of Marshall Road East is approximately 15,480 vehicles per day (vpd), although some of this traffic would be expected to use Henley Brook Avenue in future. In addition, the Albion Structure Plan area to the north of the West Swan East District Structure Plan is anticipated to generate approximately 8,000 vpd on Lord Street, some of which will filter through the West Swan East DSP area.

The daily traffic generated by the West Swan East DSP area (including LSP2A) has been assigned onto the road network by a traffic model using the *EMME* transport modelling software package.

Total daily traffic flows for the ultimate scenario have been derived based on regional road network traffic projections prepared by consultants for DPI for a traffic and transport workshop held on 13 September 2007 for development of a sub-regional structure plan for Albion, Caversham and West Swan. Total daily traffic flows for the interim scenario are estimated based on consideration of this work and other information such as existing traffic volumes on Lord Street.

Figure 7 shows daily traffic flows in the interim scenario in the LSP2A area. The numbers not in brackets are the estimated daily traffic flows generated by the LSP2A area. Total daily traffic flows including the rest of Dayton as well as through traffic from surrounding areas are shown in brackets.

Figure 8 illustrates the ultimate scenario, which includes the PDNH and construction of the Marshall Road and Arthur Street flyovers.

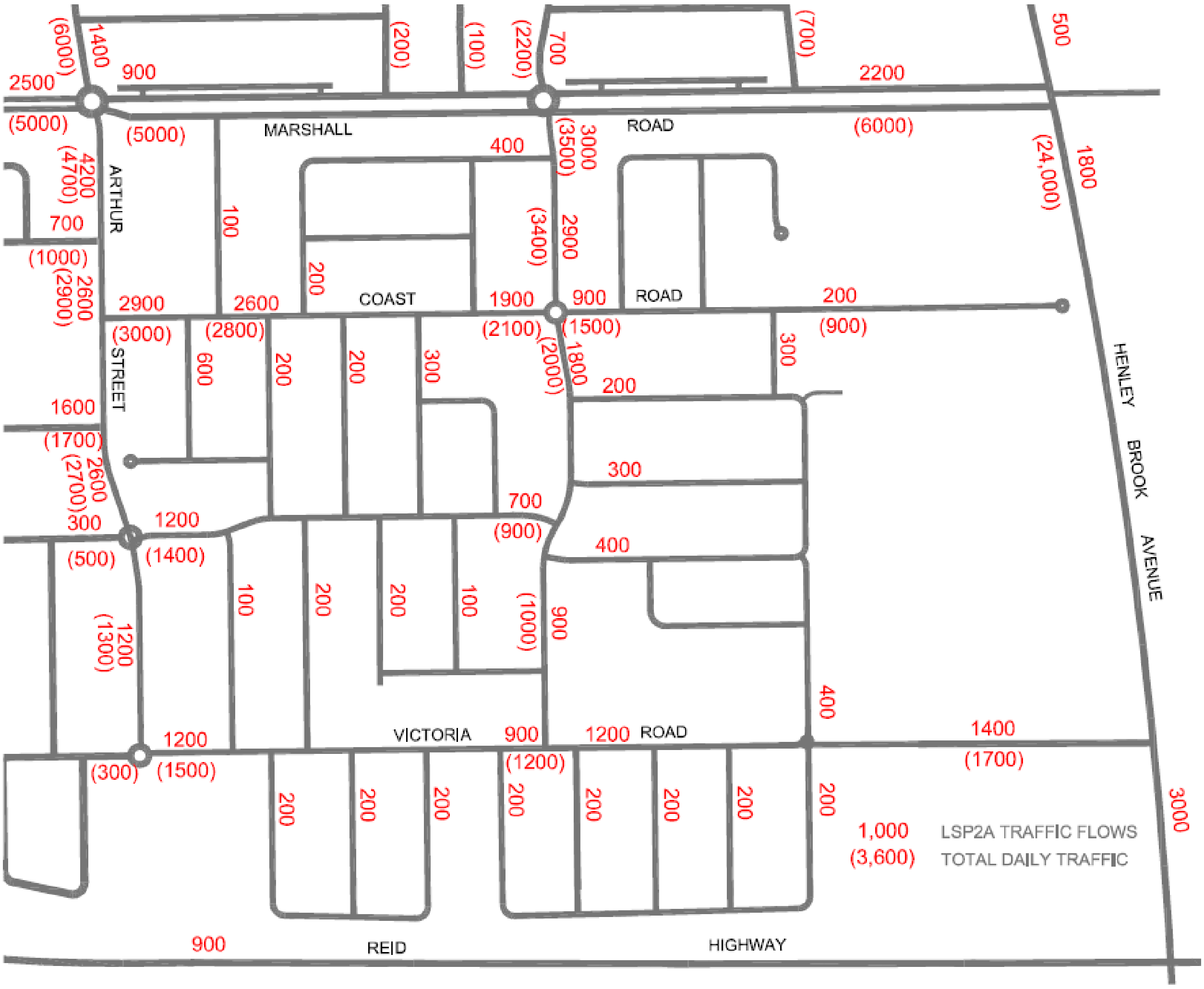


Figure 7. Daily Traffic Volumes – Interim Scenario

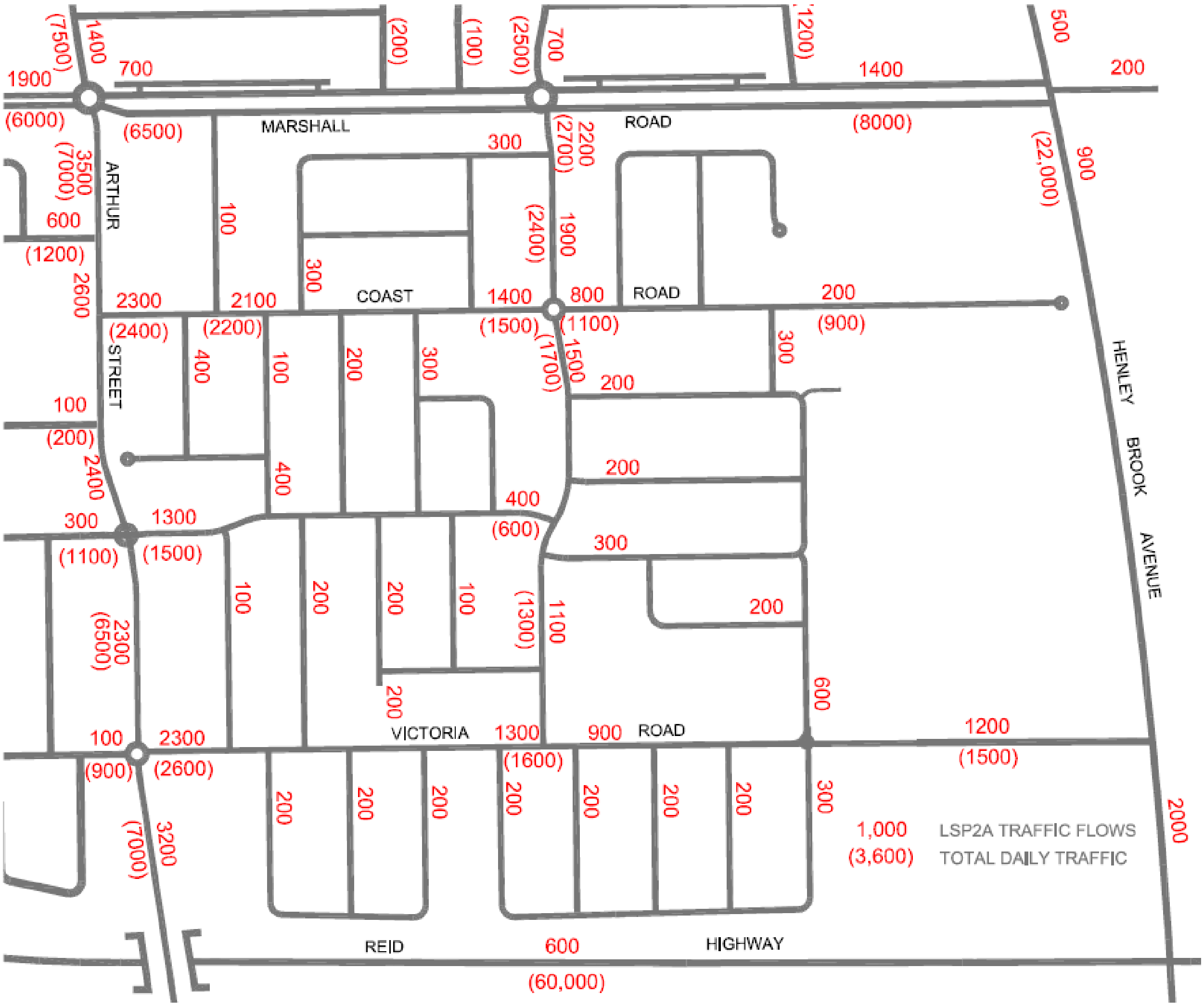


Figure 8. Daily Traffic Volumes – Ultimate Scenario

8.4 Roads and Intersections

The proposed road network to accommodate these traffic volumes has been detailed in section 5 of this transport assessment, including the details of the proposed road hierarchy and proposed cross sections in section 5.1.

8.4.1 Intersection Treatments

Figure 9 details the proposed intersection controls for the key internal and external intersections of the LSP2A area for the interim scenario. In establishing the proposed intersection controls, consideration was given to the road network layout, road hierarchy and estimated traffic volumes.

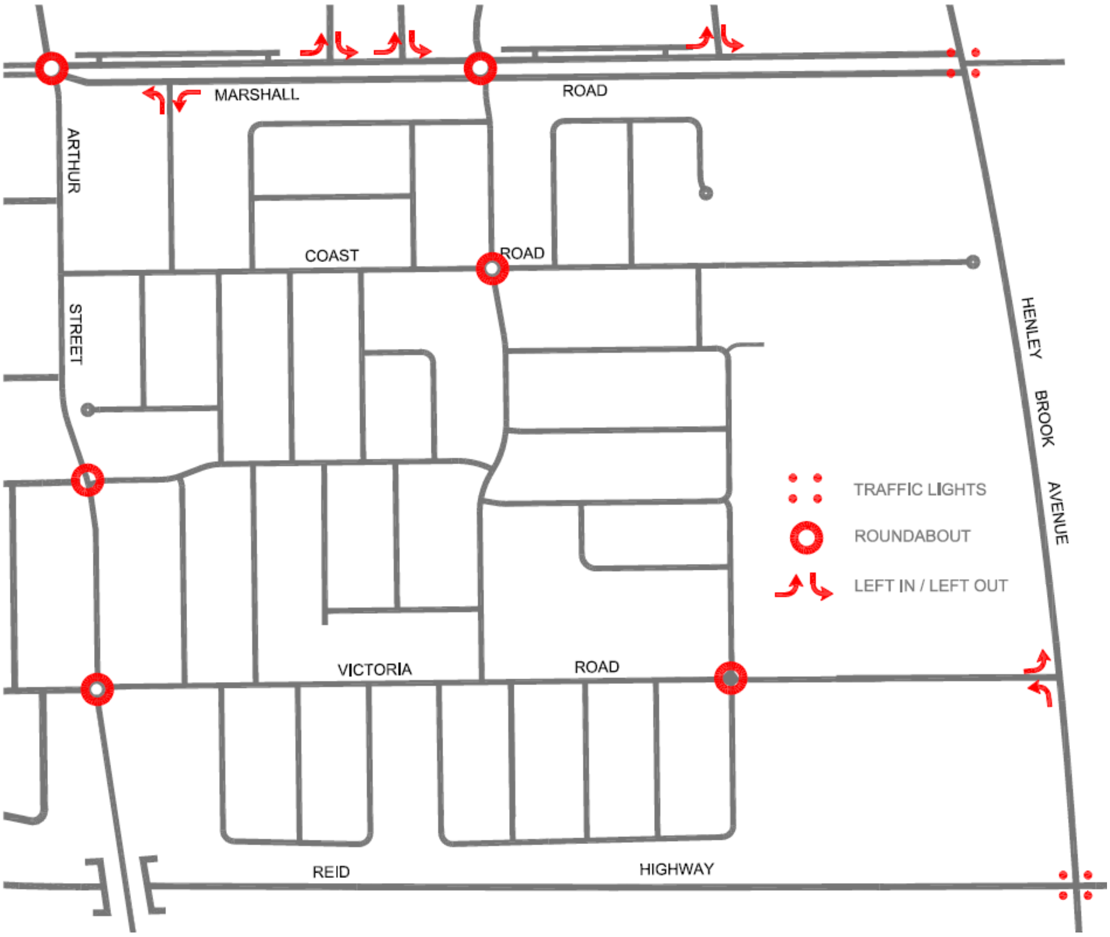


Figure 9. Intersection treatments

Three 4-way intersections on Arthur Street in the LSP2A area (at Marshall Road and at Victoria Road as well as another 4-way intersection midway between Victoria Road and Coast Road) are recommended to be constructed as roundabouts.

Another full-movement 4-way intersection will be created on Marshall Road by the road link south from Sam Rosa Place in LSP2B. It is appropriate that this link continue southward across Marshall Road to facilitate a potential future bus route through this eastern part of the West Swan East District Structure Plan area, so it is also recommended for this 4-way intersection to be constructed as a roundabout.

At detailed design stage the design of roundabouts along Marshall Road and Arthur Street will pay particular attention to requirements to facilitate pedestrian and cycle movement.

Elsewhere along Marshall Road adjacent to the LSP2A area Marshall Road is proposed to have a wide drainage swale in the central median so no other median openings are proposed. Therefore all other side road intersections along Marshall Road are proposed to be left in / left out only as indicated on **Figure 9**.

There is a proposed 4-way intersection of road reserves on Coast Road within the LSP2A area that is also proposed to be a roundabout, and another on Victoria Road.

On Coast Road there are currently two 'blister island' traffic calming devices at the existing Caversham Primary School east of the LSP 2A area. One of these is close to the LSP2A area and will continue to restrict traffic speeds in this vicinity. The proposed roundabout on Coast Road will also perform a similar function.

Details relating to future traffic control within and on the immediate periphery of the LSP2A area, along with the requirements for slip lanes and localised intersection widening, will also be addressed through the subdivision planning process.

8.4.2 Intersection Capacity

To evaluate the required intersection improvements, intersection capacity has been analysed for proposed key intersections along Arthur Street and Marshall Road adjacent to the LSP2A area. The intersections analysed are:

- Arthur St / Marshall Rd (roundabout)
- Marshall Rd / LSP2A access street / LSP2B access street (roundabout)
- Arthur St / Coast Rd (give-way controlled T-junction)
- Arthur St / LSP1 access street / LSP2A access street (roundabout)
- Arthur St / Victoria Rd (roundabout)

These intersections have been analysed for future AM and PM peak hour traffic flows corresponding to the long term ultimate scenario traffic volumes shown in Figure 8, which has the highest future traffic flows on Arthur Street and Marshall Road.

Intersection capacity has been analysed using the SIDRA intersection analysis software program. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These items are defined as follows:

- **Degree of Saturation**: 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 0% for very low traffic flow up to 100% for saturated flow or capacity.
- **Level of Service**: 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 service, designated from A to F, with Level of Service A representing the best operating condition and Level of Service F the worst. In SIDRA intersection analysis the level of service is based on the average delays experienced by each traffic movement.
- **Average Delay**: is the average of all travel time delays for vehicles through the intersection.

- **95% Queue**: is the queue length below which 95% of all observed queue lengths fall.

The SIDRA results and the intersection layouts modelled in SIDRA for the five intersections analysed on Marshall Road and Arthur Street are summarised in **Appendix D.** The SIDRA results indicate that all movements at all five intersections will operate at level of service A or B in both the AM and PM peak periods in this ultimate scenario, which is a very satisfactory outcome.

8.4.3 Timing of Road Network Upgrades

In terms of the staging of development in Dayton the first stages of development have been in the LSP1 area and have progressed into the northwest corner of LSP2A and southern parts of LSP2B. Over the next few years there is expected to be further development scattered throughout each of the LSP areas due to the fragmented land ownership in each of these areas.

The proposed short-term access strategy for Dayton is discussed in detail in Appendix C.

Marshall Road

Sections of Marshall Road adjacent to LSP2B will be constructed in conjunction with subdivision development of the first stages of development in the LSP2B area.

West of Arthur Street, Marshall Road has been upgraded to a sealed width of approximately 7m with kerbing on both sides. This will be sufficient to accommodate traffic volumes from LSP1, 2A and 2B until Marshall Road is extended eastwards and connects to Henley Brook Avenue.

West Swan Road and Henley Brook Avenue

The analysis in Appendix C has concluded that existing intersections along West Swan Road cannot cope with additional through traffic on West Swan Road from development at Dayton and this has implications for the extent and timing of development in Dayton. This is discussed in detail in Appendix C.

It is understood that the City of Swan's draft DCP for Dayton proposes construction of Henley Brook Avenue from Reid Hwy to Marshall Road by 2019. Construction of the remainder of Henley Brook Avenue is scheduled to be completed by 2023.

Arthur Street

Arthur Street is anticipated to carry less than 3,000 vpd until some of the other external road connections are constructed. The Marshall Road connection to Henley Brook Avenue will increase traffic volumes on Arthur Street north of Marshall Road.

In the ultimate scenario the construction of the Arthur Street flyover across Reid Highway will increase traffic volumes on Arthur Street south of Marshall Road as well.

Sections of Arthur Street north and south of Coast Road Street (abutting early release subdivision development in LSP1) have been upgraded to a seal width of approximately 6.2m with kerbing on the western side. In the Dayton LSP1 Transport Assessment report (April 2011) it is recommended that Arthur Street abutting LSP1 be upgraded to this standard during development of adjacent sections of LSP1 and that the full widening to integrator B standard be implemented during development of adjacent parts of LSP 2A and 2B on the eastern side of Arthur Street.

The section of Arthur Street abutting LSP2B (from Marshall Road to Cranleigh Street) should be upgraded to the final integrator B standard when Marshall Road is connected to Henley Brook Avenue or as development is completed on each side of sections of Arthur Street.

8.4.4 Timing of Intersection Improvements

Arthur Street Intersections

To evaluate timing of intersection improvements, intersection capacity has been analysed for existing intersections along Arthur Street adjacent to the LSP1 area in the Dayton LSP1 Transport Assessment report.

The following existing intersections along Arthur Street (abutting the LSP2A area) have been assessed in the Dayton LSP1 Transport Assessment report:

- Arthur Street / Marshall Road
- Arthur Street / Coast Road
- Arthur Street / Victoria Road

All have been assessed as simple 3-way or 4-way intersections controlled by stop or give-way signs for the traffic flows in the long term interim road network scenario with full development of Dayton in accordance with the West Swan East District Structure Plan. Intersection capacity was analysed using the SIDRA intersection analysis software program.

All four intersections will operate at a very good level of service in this long term interim scenario with minimal queues and delays. All movements will be at level of service A except the eastern approach on Marshall Road, which will operate at level of service B. Therefore, in terms of intersection capacity, no intersection upgrades are required on Arthur Street until the Arthur Street flyover across Reid Highway is constructed in the ultimate scenario.

However, from a more practical point of view it would be appropriate for the Arthur Street / Marshall Road intersection to be upgraded to a roundabout when Marshall Road is extended east of Arthur Street to serve LSP 2A and 2B.

Arthur Street / Coast Road will automatically be upgraded as a simple give-way controlled T-junction when this section of Arthur Street is fully upgraded, which is suggested to be in conjunction with development of adjacent parts of LSP 2A.

Arthur Street / Victoria Road intersection will not carry significant traffic volumes until the Arthur Street flyover is constructed, so construction of a roundabout at this intersection could be incorporated in the Arthur Street Flyover construction project.

Marshall Road Intersections

The following intersections in or associated with LSP2A are included on the development contribution plan for West Swan East:

- Marshall Road / Arthur Street (roundabout)
- Marshall Road / link to Sam Rosa Place (roundabout)
- Marshall Road / eastern LSP2B access street (priority controlled intersection)
- Marshall Road / Henley Brook Avenue (traffic lights)

All of these intersections will be required to be constructed in conjunction with the parts of LSP2A and 2B that they serve, or when Marshall Road is extended to Henley Brook Avenue.

As noted in the Dayton LSP2B Transport Assessment report it is recommended that Marshall Road / Henley Brook Avenue intersection should be a roundabout. This would facilitate staged construction of Henley Brook Avenue.

8.4.5 Summary of Timing of Improvements

The timing of road network improvements and intersection improvements is discussed in sections 8.4.3 and 8.4.4 respectively. The suggested timing of these improvements is summarised in Table 5.

Table 5. Triggers for DCP or works required as part of LSP2A

DCP Code	Description of DCP item	Description if the DCP item needs to be acquired and/or constructed in stages	Trigger (dwelling units or equivalent)
E-IRF01	Roundabout Cnr Marshall Road and Arthur Street	Construct roundabout	1200 du
E-TRF01 & E-TRF02	Upgrade Arthur Street (Marshall Rd to Coast Rd)	1. Widen and kerb west side	Central LSP1 (200 du?)
		2. Upgrade to integrator B standard	Northern LSP 2A (1800du?)
E-ITF01	Priority T intersection at Arthur Street and St Leonards Boulevard	Construct T-junction (done)	Central LSP1 (200 du?)
E-TRF36	Upgrade Arthur Street (Coast Rd to Victoria Rd)	1. Widen and kerb west side	Southern LSP1 (950 du?)
		2. Upgrade to integrator B standard	Southern LSP2A (2200du?)
E-IRF06	Roundabout Cnr Victoria Road and Arthur Street	Construct roundabout	With Arthur St flyover across Reid Hwy (long term)
E-TRF37	Upgrade Arthur Street (south of Victoria Rd)	Connect to future flyover across Reid Hwy	With Arthur St flyover across Reid Hwy (long term)
E-TRF05	Upgrade Marshall Road (Lord St to Arthur St)	Upgrade to integrator B standard	1200 du
E-TRF04			
E-TRF32	Construct Marshall Road (east of Arthur Street)	Construct to integrator B standard	1200 du
E-IRF05	Roundabout Cnr Marshall Road and link to Sam Rosa Place	Construct roundabout	1200 du
E-TRF38	Construct Marshall Road (eastern section of LSP2A)	Construct to integrator B standard	1200 du**
E-ITF02	Intersection of Marshall Road and LSP2A eastern access street	Construct priority controlled intersection	1200 du**
E-TRF39	Construct Marshall Road (west of Henley Brook Ave)	Construct to integrator B standard	1200 du**
E-ISE01	Roundabout cnr Marshall Road and Henley Brook Ave	Construct roundabout (or intersection designed to accommodate future signalisation when Henley Brook Ave is completed)	1200 du**
***	Upgrade to Coast Road between Arthur Street and West Swan Road	Localised widening and enhanced street lighting	1200 du
***	Intersection of Coast Road and West Swan Road	Construct priority controlled intersection	1200 du
E-TRF25 to 29, 33, 34 & 35, E-ACQ07 to 13	Construct Henley Brook Avenue (Marshall Road to Reid Highway)	Land acquisition and construct first carriageway.	1200 du**
		Construct second carriageway	Year 2019
E-ITF04	Intersection of Henley Brook Ave and Victoria Rd	Construct priority controlled intersection	1200 du**

Given Henley Brook Avenue depends on land acquisitions and Marshall Rd depends on the willingness of multiple affected landowners to subdivide, these roads may not be available by the time the 1200 dwelling unit trigger is reached. If Marshall Rd and Henley Brook Ave are not available, then Coast Rd (notated * on Table 5) is presented as an interim arrangement that a subdivider (or the City and WAPC through a condition of subdivision) can implement until the ultimate access arrangement (Marshall Road & Henley Brook Avenue) or an alternative access strategy is agreed upon & implemented. See Appendix C for these alternative access strategies.

8.5 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* requires that "Development along integrator B and neighbourhood connector streets with ultimate vehicle volumes over 5000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7000 vehicles per day."

Future traffic volumes will be greater than 5000 vpd on Arthur Street and Marshall Road. Therefore, special consideration of vehicle access from properties abutting these roads is required. Laneway access is already indicated for the lots abutting Arthur Street in LSP2A. No residential lots have frontage onto Marshall Road within the LSP2A area due to the power line easement on the south side of Marshall Road.

8.6 Pedestrian / Cycle Networks

The proposed network of footpaths and shared use paths for pedestrians and cyclists is described in section 5.3 of this transport assessment. This network of paths will provide an excellent level of accessibility and permeability for pedestrians and cyclists within Dayton, and connections to neighbouring precincts at strategic locations.

There are several locations where there is anticipated to be strong demand for pedestrian and cyclist movements crossing the road network, which warrant further consideration. In particular these are around the Caversham Primary School site (south side of Coast Road east of the LSP2A area) and the proposed Neighbourhood Centre (southeast of Arthur Street / Marshall Road).

The WAPC *Transport Assessment Guidelines for Developments* (2006) provides guidance on the levels of traffic volumes that are likely to affect the ability for pedestrians to cross various types of road. Based on that guidance an undivided two-lane road should be acceptable for pedestrians crossing traffic volumes of up to approximately 11,000 vpd and this threshold can be increased to around 28,000 vpd by adding a central median or pedestrian refuge islands. On a four-lane road, because of its greater carriageway width, this threshold is lower; even with a median island the threshold is only around 16,000 vpd.

Arthur Street and Marshall Road are expected to carry up to 7,000 vpd and 8,000 vpd respectively, adjacent to the LSP2A area in the ultimate scenario. The proposed one traffic lane in each direction, with a central median, should therefore be satisfactory for pedestrians and cyclists to cross both of these roads.

8.7 Access to Public Transport

At this stage of the structure planning process neither bus stop locations nor subdivision lot layout are known. However, in these circumstances the WAPC *Transport Assessment Guidelines for Developments* (2006) suggest that it is desirable for at least 90 per cent of dwellings to be within 400m straight line distance of a bus route.

The PTA advice of potential bus routes shown on Figure 5 includes bus routes on Arthur Street and Marshall Road adjacent to LSP2A. The LSP2A area extends approximately 750m east of Arthur Street and 850m south of Marshall Road, so the southeast quarter of the LSP2A area will be more than 400m from those future bus routes. The option remains open for one of those potential future bus routes to be deviated through the LSP2A area via Victoria Road and the central north south spine road to bring that southeast quarter within 400m walking distance if PTA consider that necessary to satisfy this guideline.

9.0 Analysis of External Transport Network

9.1 Traffic Volumes on External Road Network

The daily (weekday) traffic volumes generated within the LSP2A area on the surrounding road links are shown in Figures 7 and 8.

The WAPC *Transport Assessment Guidelines for Developments* (2006) suggests that traffic impact should be assessed on those parts of the surrounding road network where an increase of 100 vehicles per hour is generated on any traffic lane. As daily traffic volumes have been used in this transport assessment this threshold is converted to a two-way daily traffic flows of about 1,500 vpd (which assumes the peak hour is around 10% of weekday traffic with about two thirds of the traffic travelling in the peak direction).

From Figures 7 and 8, traffic volumes generated by LSP2A are expected to be higher than this threshold on sections of Marshall Road, Arthur Street and Henley Brook Avenue. These flows are part of the ultimate volumes shown on Figure 8 and the road hierarchy shown at Figure 4 has taken these ultimate traffic volumes into consideration. Therefore the design of Marshall Road and Arthur Street as Integrator B roads and Henley Brook Avenue as an Integrator A road will be able to accommodate the traffic from this area.

Future total daily traffic volumes are shown in brackets on Figures 7 and 8. The source of these future daily traffic flow estimates is detailed in section 8.3 above. An alternative scenario modelled in 2013/14 is presented in Appendix E.

9.2 Intersections

Intersection treatments at several intersections surrounding the LSP2A area will be affected by traffic flows generated within this site. Intersections on Arthur Street and Marshall Road abutting the study area are already addressed in the intersection treatments shown in Figure 9 and section 8.4 of this report.

Lord Street Intersections

The existing Lord Street / Marshall Road East intersection will be progressively upgraded as traffic volumes on Lord Street increase. First a right turn pocket will be provided on Lord Street. Later, depending on future traffic volumes, the right turn out from Marshall Road East to Lord Street may become unviable and may need to be prohibited. This right turn traffic flow would then be accommodated at the proposed Lord Street / Marshall Road West / Coast Road roundabout or another proposed roundabout at the Lord Street / Cranleigh Street intersection.

In the ultimate scenario the existing Lord Street / Marshall Road intersections disappear with the construction of the Marshall Road flyover across the PDNH and transit corridor.

It should be noted that the roundabout at Lord Street / Marshall Road West and the associated St Leonards Boulevard link will maintain access for Lord Street during the future construction of PDNH and the Marshall Road flyover.

Henley Brook Avenue Intersections

The Dayton LSP2B Transport Assessment report recommended that the future Henley Brook Avenue / Marshall Road intersection should be designed as a two-lane roundabout. This would have sufficient capacity to service the 8,000 vpd forecast on the eastern end of Marshall Road in the interim and ultimate scenarios.

However, Henley Brook Avenue is reserved as an Other Regional Road in the MRS and therefore responsibility for long term planning of this road rests with the Western Australian Planning Commission and the Department of Planning (DoP). DoP undertook a road design study for Henley Brook Avenue in 2013, which is understood to have recommended four-way signalised intersections at the Harrow Street and Marshall Road intersections and no connection on either side at Coast Road. These intersection treatments are therefore included in the additional scenario that has been added in Appendix E of this report.

9.3 Pedestrian / Cyclist Networks

The proposed network of footpaths and shared use paths for pedestrians and cyclists is described in section 5.3 of this transport assessment, including connections to neighbouring precincts. These external connections have been discussed in further detail in section 8.6.

10.0 Conclusions

The main findings of the transport assessment for Dayton Local Structure Plan 2A (LSP2A) are outlined below.

- Dayton LSP2A is located within the larger West Swan East District Structure Plan, south of Marshall Road and east of Arthur Street.

- The future traffic flows and road network of the West Swan East District Structure Plan are assessed in the *West Swan East Structure Plan, City of Swan, Transport Impact Statement Update* (October 2009).

- Two road network scenarios have been assessed:

  - Interim Scenario: Perth-Darwin National Highway (north of Reid Highway) and Arthur Street flyover (across Reid Highway) not yet constructed. Lord Street still connects directly to Reid Highway.

  - Ultimate Scenario: Perth-Darwin National Highway (PDNH, north of Reid Highway), Marshall Road flyover (across PDNH) and Arthur Street flyover (across Reid Highway) all constructed. Lord Street no longer connects directly to Reid Highway. LSP2A access west and south is via these two flyovers and connections to Henley Brook Avenue in the east.

- In the ultimate scenario Arthur Street will carry up to 7,000 vpd adjacent to LSP2A and Marshall Road up to 8,000 vpd adjacent to LSP2A.

- In the LSP2A area, a 25m road reserve is proposed for Arthur Street and on Marshall Road east of Arthur Street (abutting the LSP2A area) the road reserve width will be designed to accommodate drainage in a widened central median and controlled access place (CAP) service roads on the northern side where required for access to abutting properties in the neighbouring LSP2B area.

- Existing 20m road reserves will be retained for sections of Coast Road and Victoria Road within the LSP2A area.

- Appropriate road cross sections based on Liveable Neighbourhoods guidelines have been identified for all roads within the LSP2A area.

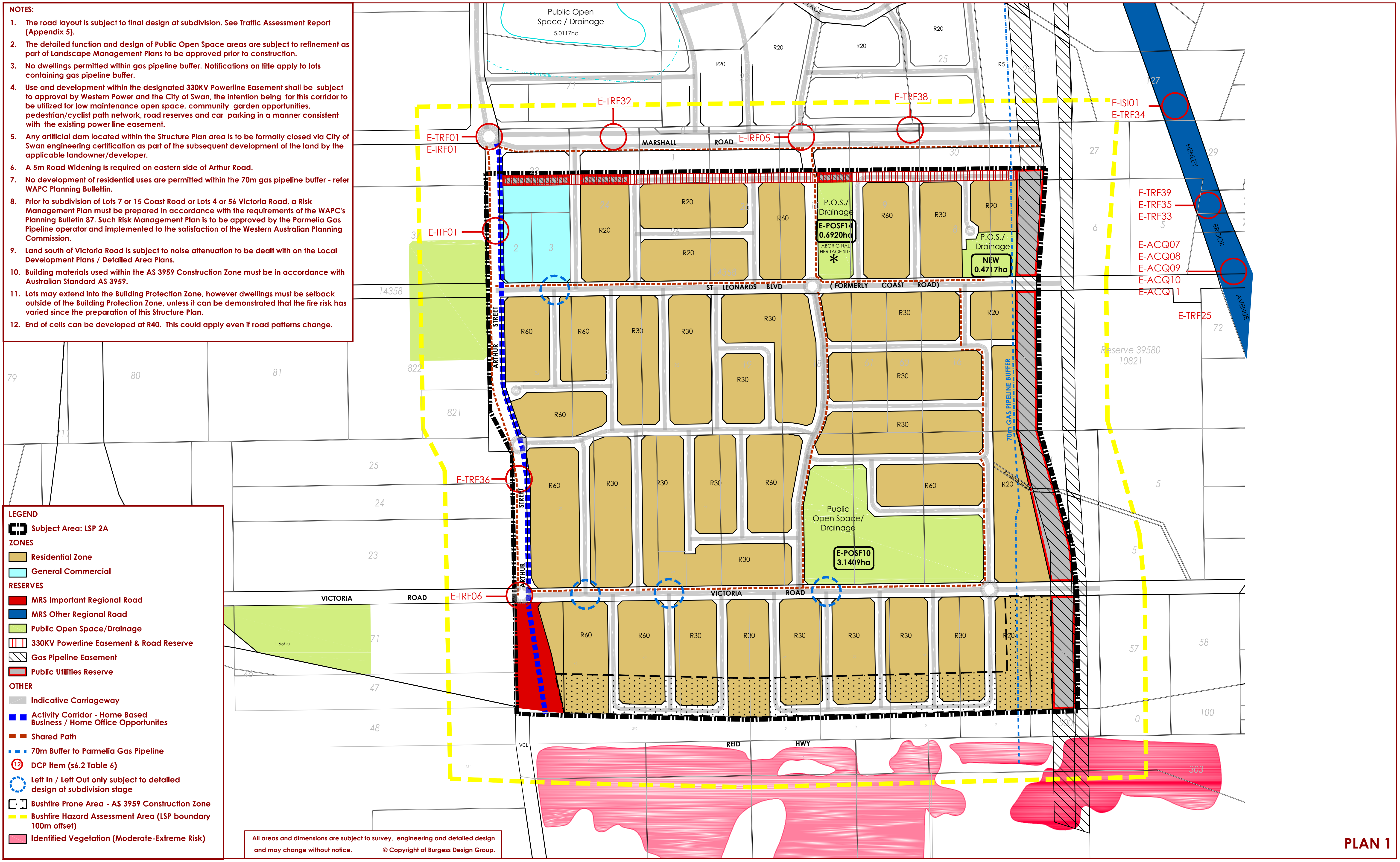
- Ultimately, a sub-regional activity corridor is planned along the northern portion of Lord Street, western portion of Cranleigh Street and Arthur Street south of Cranleigh Street. This activity corridor will link Albion, West Swan East and Caversham via the future Arthur Street flyover, ultimately offering a high frequency public transport route adjacent to the LSP2A area.

- Potential future bus routes on Arthur Street and Marshall Road adjacent to the LSP2A area have been advised by the Public Transport Authority. The LSP2A plan keeps open the potential option to deviate one of those routes through LSP2A via Victoria Road and the north south spine road if it is decided greater public transport penetration is required.

- Shared paths are to be provided on one side of Arthur Street, Coast Road, Victoria Road, the LSP2A eastern boundary road and Marshall Road within the LSP2A area.
- 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 schools.
- It is proposed that on-street cycle lanes be provided on Arthur Street and Marshall Road to connect to the existing external cycle network.
- Access arrangements for the short-term scenario of development in Dayton prior to construction of Henley Brook Avenue are addressed in Appendix C.

APPENDIX A

DAYTON
LOCAL STRUCTURE PLAN 2A



NOTES:

1. The road layout is subject to final design at subdivision. See Traffic Assessment Report (Appendix 5).
2. The detailed function and design of Public Open Space areas are subject to refinement as part of Landscape Management Plans to be approved prior to construction.
3. No dwellings permitted within gas pipeline buffer. Notifications on title apply to lots containing gas pipeline buffer.
4. Use and development within the designated 330KV Powerline Easement shall be subject to approval by Western Power and the City of Swan, the intention being for this corridor to be utilized for low maintenance open space, community garden opportunities, pedestrian/cyclist path network, road reserves and car parking in a manner consistent with the existing power line easement.
5. Any artificial dam located within the Structure Plan area is to be formally closed via City of Swan engineering certification as part of the subsequent development of the land by the applicable landowner/developer.
6. A 5m Road Widening is required on eastern side of Arthur Road.
7. No development of residential uses are permitted within the 70m gas pipeline buffer - refer WAPC Planning Bullettin.
8. Prior to subdivision of Lots 7 or 15 Coast Road or Lots 4 or 56 Victoria Road, a Risk Management Plan must be prepared in accordance with the requirements of the WAPC's Planning Bulletin 87. Such Risk Management Plan is to be approved by the Parmelia Gas Pipeline operator and implemented to the satisfaction of the Western Australian Planning Commission.
9. Land south of Victoria Road is subject to noise attenuation to be dealt with on the Local Development Plans / Detailed Area Plans.
10. Building materials used within the AS 3959 Construction Zone must be in accordance with Australian Standard AS 3959.
11. Lots may extend into the Building Protection Zone, however dwellings must be setback outside of the Building Protection Zone, unless it can be demonstrated that the fire risk has varied since the preparation of this Structure Plan.
12. End of cells can be developed at R40. This could apply even if road patterns change.

LEGEND

Subject Area: LSP 2A

ZONES

Residential Zone

General Commercial

RESERVES

MRS Important Regional Road

MRS Other Regional Road

Public Open Space/Drainage

330KV Powerline Easement & Road Reserve

Gas Pipeline Easement

Public Utilities Reserve

OTHER

Indicative Carriageway

Activity Corridor - Home Based Business / Home Office Opportunities

Shared Path

70m Buffer to Parmelia Gas Pipeline

(12) DCP Item (s6.2 Table 6)

Left In / Left Out only subject to detailed design at subdivision stage

Bushfire Prone Area - AS 3959 Construction Zone

Bushfire Hazard Assessment Area (LSP boundary 100m offset)

Identified Vegetation (Moderate-Extreme Risk)

All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

PLAN 1

NORTH

LOCAL STRUCTURE PLAN 2A
LSP2A DAYTON
CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN
PO Box 8779, Perth Business Centre 6849
www.burgessdesigngroup.com.au
P (08) 9328 6411
F (08) 9328 4062

Plan No: ASP WES 2A 3-02X Client: St Leonards Estate Pty Ltd
Date: 16.01.14 Planner: KO

0 50 75 100 150
SCALE 1:5,000 A3

APPENDIX B

ROAD CROSS SECTIONS

Road Cross-sections

Standard cross-sections referred to in Table 4 Road Hierarchy (extracted from WAPC Liveable Neighbourhoods, January 2009). These are typical versions of each cross-section but variations are possible. Refer to Liveable Neighbourhoods for footnotes for each cross-section.

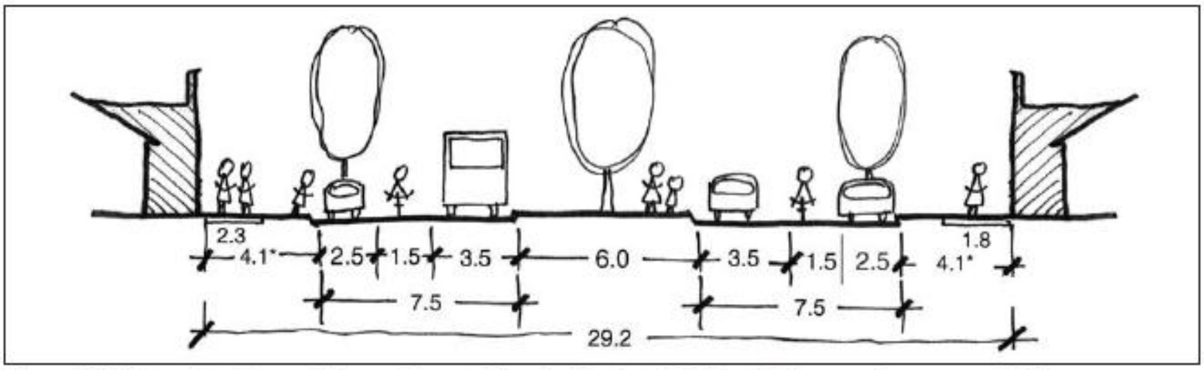


Figure 15: Integrator B – outside centres – 60 km/hr (up to 15 000 vehicles per day - see note 2).

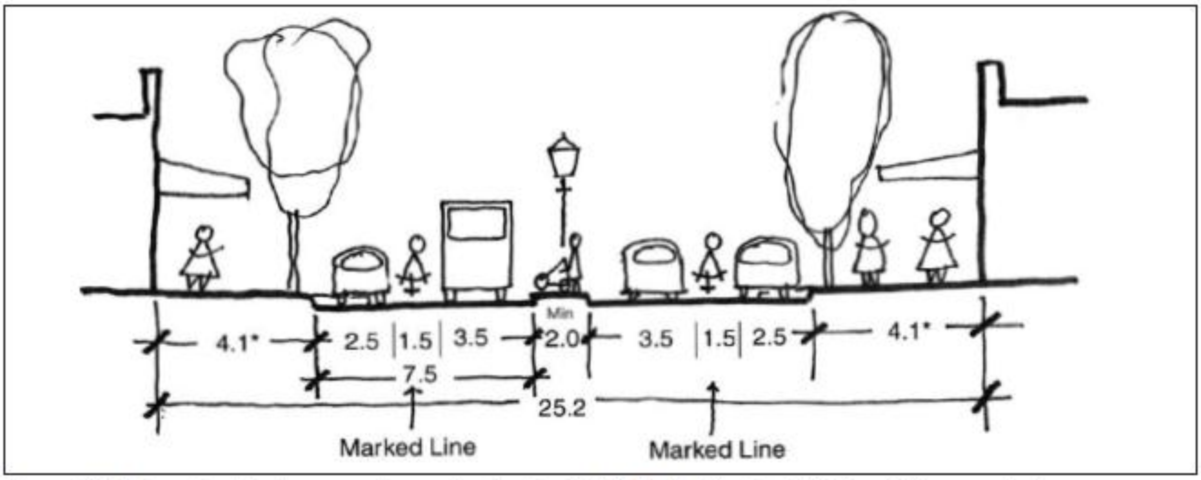


Figure 16: Integrator B – town centre main street – 40-50 km/hr (up to 15 000 vehicles per day).

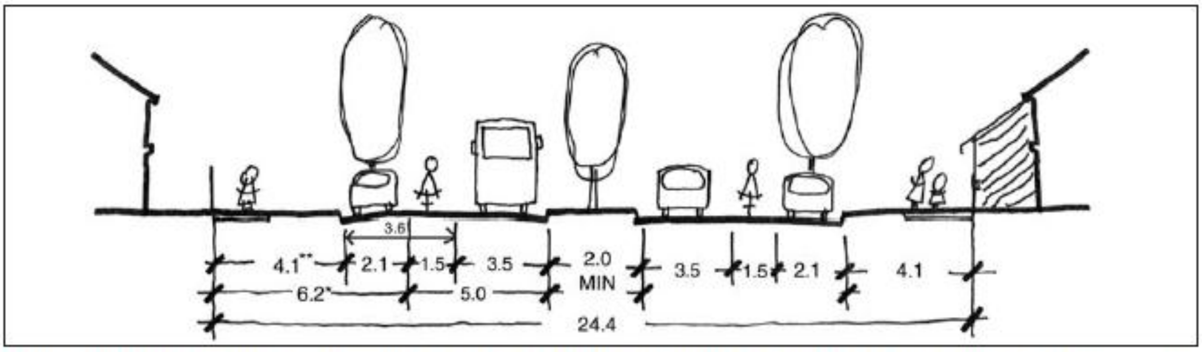


Figure 17: Neighbourhood connector A – 50 km/hr (up to 7000 vehicles per day, with >3000 vehicles per day preferred).

(Note – Figures 15-17: City of Swan requires 3.7m traffic lanes on bus routes, which will reduce the verge widths where required. LN allows verge reduction if parking is embayed.)

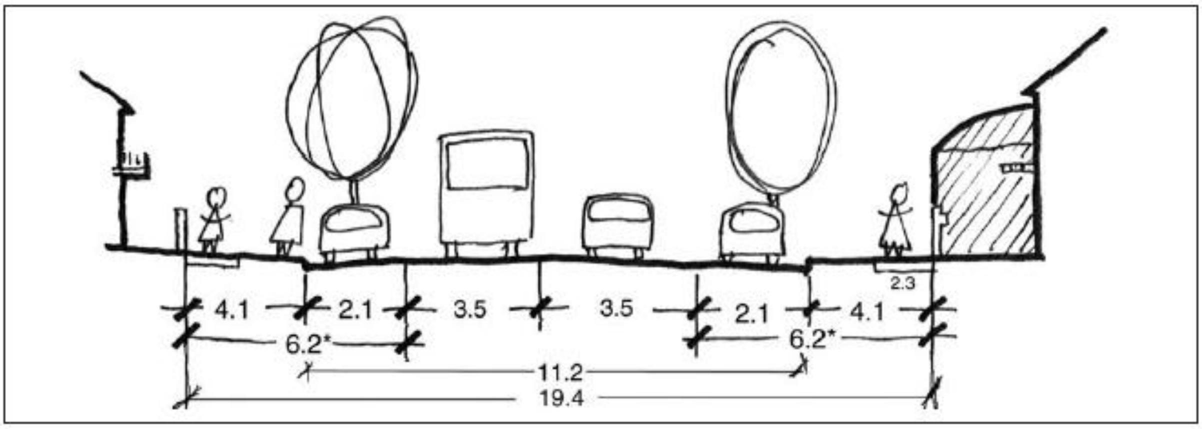
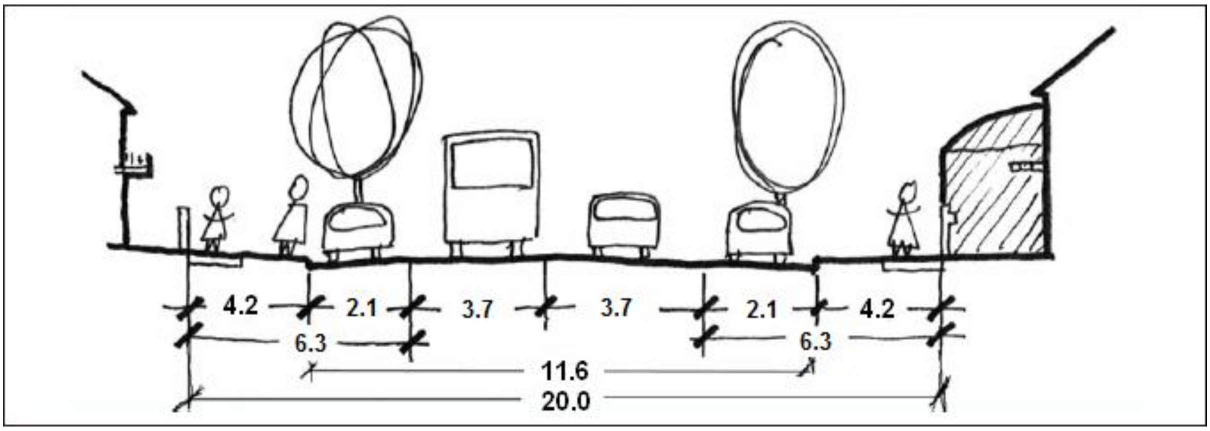


Figure 18: Neighbourhood connector B – 50 km/hr (<3000 vehicles per day).

(Note – Figure 18: City of Swan requires 3.7m traffic lanes on bus routes, which will reduce the verge widths where required. LN allows verge reduction if parking is embayed.)



Variant 20-metre Neighbourhood Connector B Cross-section

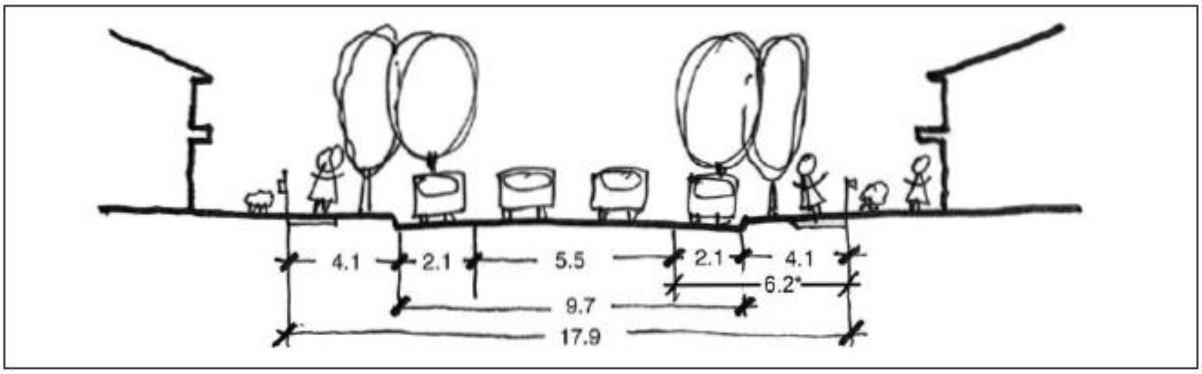


Figure 20: Access street B – wider access street Target speed 40 km/hr (< 3000 vehicles per day).

(Note – Figure 20: On an Access Street B that is a potential future bus route, on-street parking would only be permited on one side to meet City of Swan requirement of bus route 7.4m carriageway.)

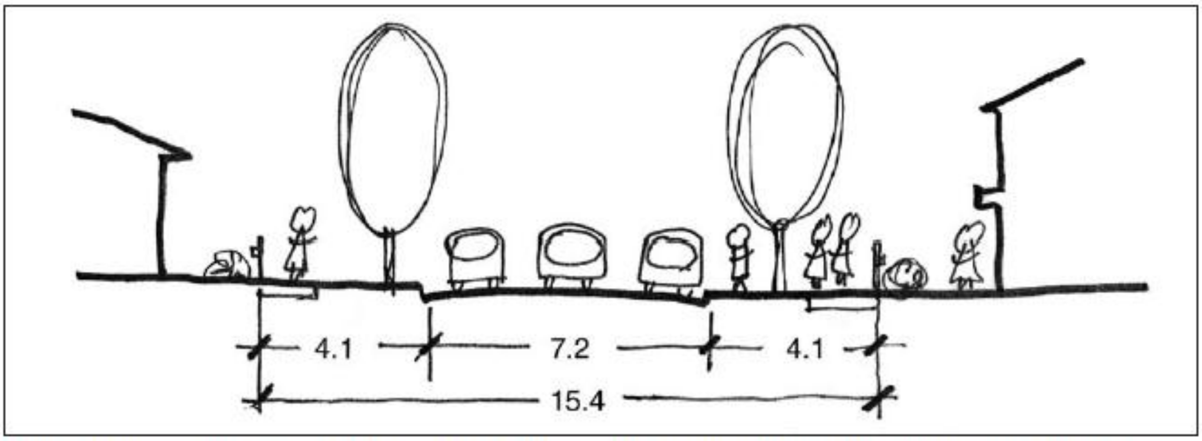


Figure 21: Access street C – yield (or give way) street – Target speed 40 km/hr (< 3000 vehicles per day).

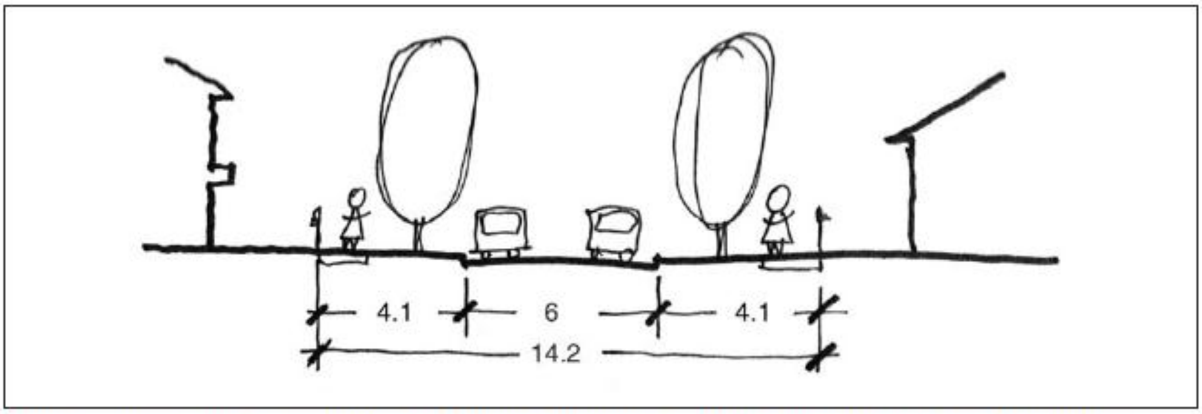


Figure 22: Access street D – narrow yield (or give way) street – Target speed 30 km/hr (< 1000 vehicles per day).

(Note – Figure 22: City of Swan prefers 15m road reserve width for Access Street D, which will increase the verge widths to 4.5m)

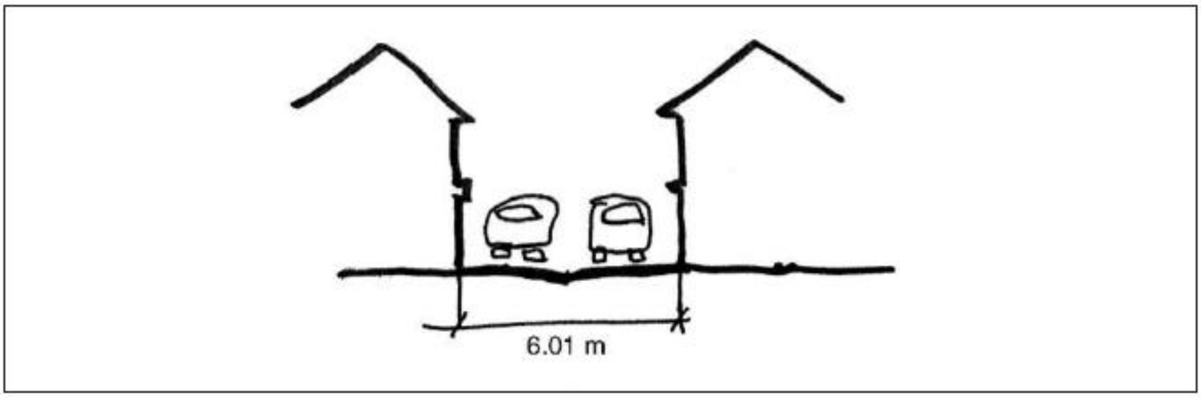
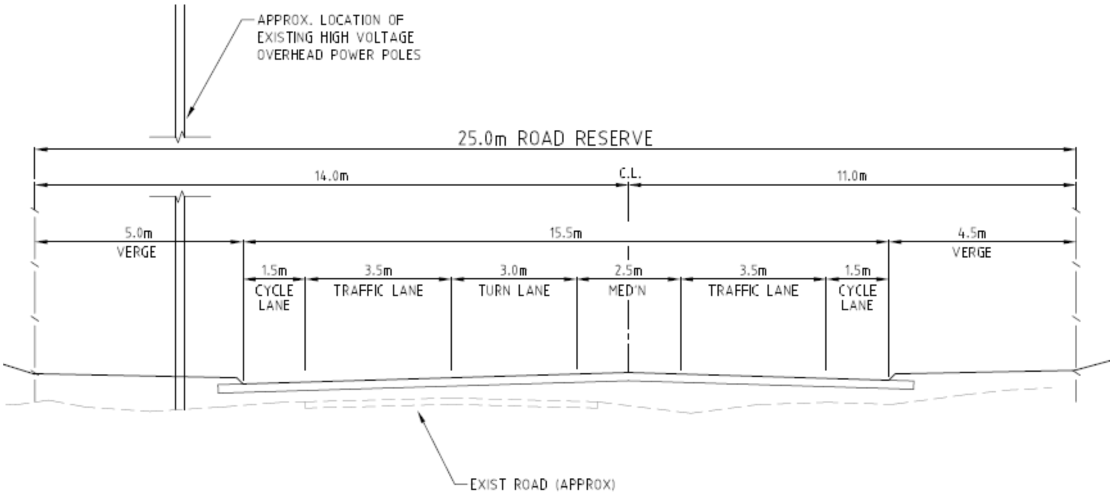
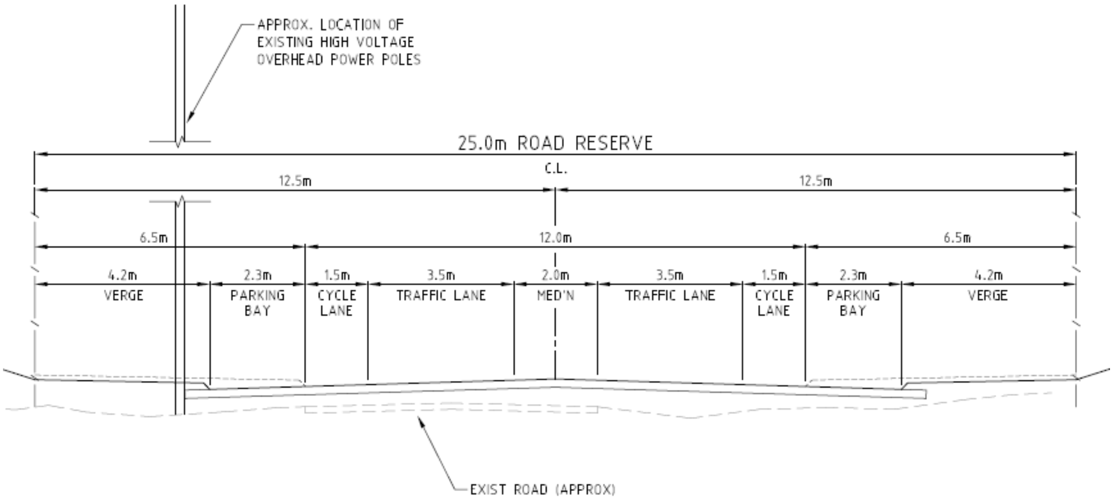


Figure 24: Laneway – for rear vehicle access – Target speed 15 km/hr.

Arthur Street Cross-sections

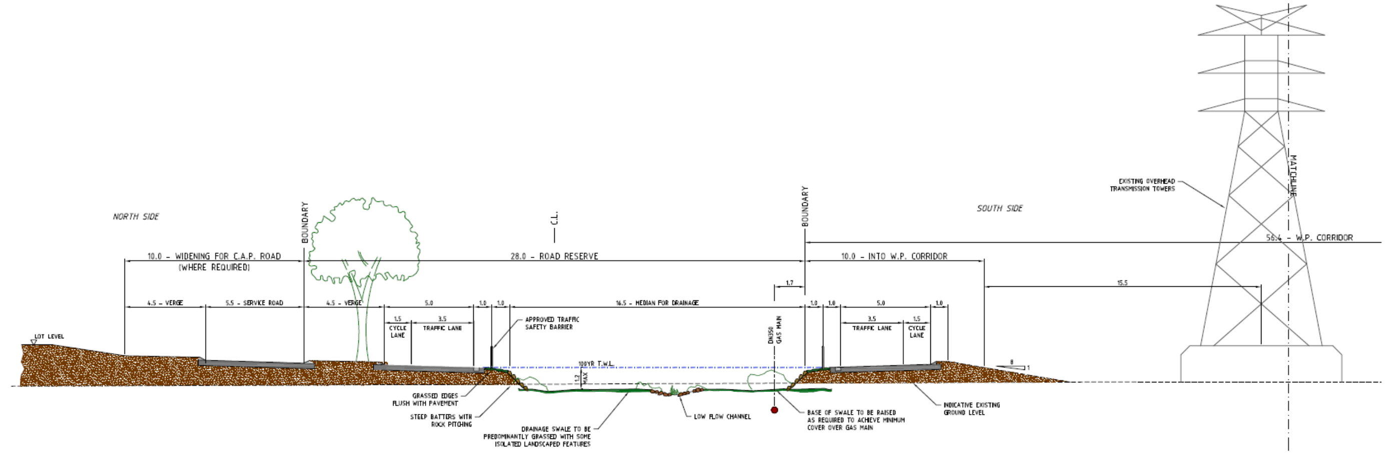


AT INTERSECTIONS EXCEPT ROUNDABOUTS

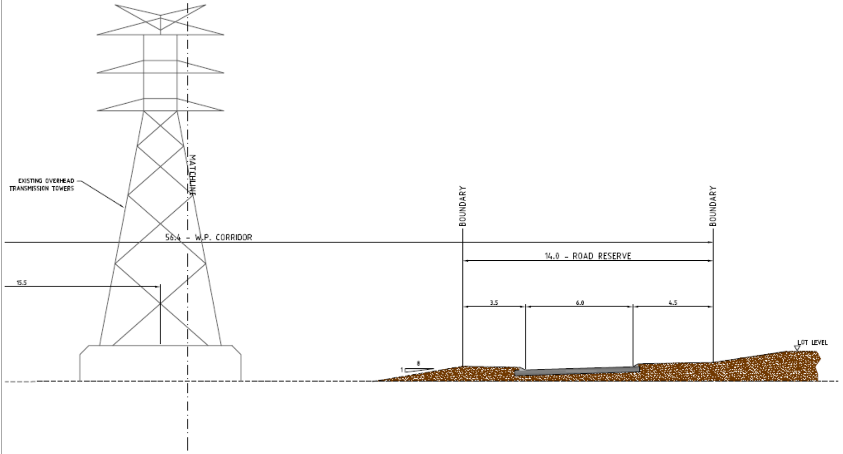


MIDBLOCK WITHIN ACTIVITY CENTRES

Marshall Road cross section



MARSHALL ROAD CROSS SECTION



MARSHALL ROAD CROSS SECTION

Marshall Road
Ultimate Cross Section

DRAWING NUMBER
2223-00-SK36-1

ISSUE
D

TABEC
Civil Engineering Consultants

TABEC Pty Ltd ACN 090 796 204
14 Wickham Street, East Perth WA 6004
Telephone 9225 4100, Fax 9225 4188
Email info@tabec.com.au

APPENDIX C

MEDIUM TERM TRAFFIC FLOWS FOR LSP2A

APPENDIX C

SHORT TERM TRAFFIC FLOWS FOR LSP2A

C1. Introduction

Transcore has previously prepared transport assessment reports for structure planning of Dayton (formerly known as West Swan East) on behalf of the Aspen Group and more recently Little Property Group and GM Dayton Land Pty Ltd. This has included reports for Local Structure Plans (LSP) 1, 2B and 4 within the broader West Swan East District Structure Plan area.

The transport planning for the West Swan East District Structure Plan and these LSP areas has focussed on two long-term scenarios. The interim scenario envisages construction of Henley Brook Avenue. The ultimate scenario looks forward to the future construction of the Perth-Darwin National Highway with a bridge over the highway at Marshall Road and a bridge over Reid Hwy at Arthur Street.

For LSP1 the City of Swan requested additional traffic modelling of a short-term scenario in which Henley Brook Avenue is not yet constructed and existing road links such as Victoria Road, Coast Road, Harrow Street and West Swan Road carry the traffic from development at Dayton instead.

Subsequent analysis by Transcore indicated that the existing West Swan Road / Coast Road and West Swan Road / Victoria Road intersections could only cope with the additional traffic from development of 290 residential lots in Dayton before major upgrading of those intersections would be required. Various intersection treatments were considered but the most feasible scheme involved intersection upgrading and traffic lights at West Swan Road / Coast Road and banning of right turn movements at West Swan Road / Victoria Road.

City of Swan officers advised that they could not support that short-term access strategy and recommended that a solution for LSP1 (only) could be the temporary closure of access to Coast Rd from LSP1, and a similar temporary closure of Victoria Rd. That initial short-term access strategy for development of LSP1 prior to construction of Henley Brook Avenue has been analysed and documented in the Dayton LSP1 Transport Assessment report (April 2011).

Upgrading of sections of Lord Street including the intersections of Lord Street with Cranleigh St, Marshall Rd east and the St Leonards Bvd roundabout were found to be required when approximately 760 dwellings have been constructed in Dayton.

The potential for that initial short-term scenario to serve the first part of development of LSP2B was investigated in the Transport Assessment for LSP 2B and it was concluded that it would operate satisfactorily until 1200 dwellings were constructed in Dayton, at which point an alternative access strategy to the east would be required.

Those short term strategy analyses for LSP1 and 2B assumed full development of those two LSP areas as the initial phases of development in Dayton. In reality the fragmented land uses in this area and varying intentions of landowners regarding future redevelopment of their land means that development will be far more scattered across all of the five LSP areas in Dayton.

This Appendix looks at those landholdings considered most likely to progress in the short to medium term (the next 5-10 years) and considers the future traffic flows resulting from that pattern of development.

C2. Modelled Land Uses

LSP1 and 2B will accommodate approximately 950 dwellings and 505 dwellings, respectively, for a total of 1455 dwellings. In comparison the landholdings of the largest landowners in this area (the Aspen Group, Little Property Group and GM Dayton Land Pty Ltd) are estimated to potentially yield 1420 dwellings (including some properties already subdivided, sold and developed in this area). Those landholdings are considered the most likely to be developed first in this area and potentially within the next 5 years. This is the land that is modelled in this Appendix.

C3. Modelled Road Network

The local road network of each of the planned LSP areas has been modelled in accordance with the local structure plans (approved or draft, as applicable) and is consistent with modelling undertaken for the transport assessment for this application. Road links that cross other people's landholdings have been excluded from the modelled road network in this short-term scenario.

Short-term road network scenario 1 includes:

- Marshall Road extension eastward does not go as far as Henley Brook Avenue yet;
- Coast Road remains open from Arthur Street to West Swan Road; and
- Victoria Road remains open between Arthur Street and West Swan Road but restricted to left-in/left-out movements on the western side at West Swan Road.

Short-term road network scenario 2 includes:

- Marshall Road extension eastward does not go as far as Henley Brook Avenue yet;
- Coast Road closed opposite the Caversham Primary School as proposed for the short term scenario for LSP1; and
- Victoria Road closed at the gas pipeline easement alignment (West Swan Road / Victoria Road intersection provides access to existing properties along Victoria Road east of the gas pipeline).

Generally the road network has been modelled in its existing form (except as noted above). This includes:

- Harrow Street connection to West Swan Road;
- Harrow Street, Cranleigh Street and Marshall Road connections to Lord Street and St Leonards Boulevard connection to Lord Street roundabout in LSP1;
- Arthur Street discontinuity at the private primary school south of Harrow Street;
- Blundell Street connection to Harrow Street (70 km/h area speed limit);
- West Swan Road (70km/h speed limit);
- Lord Street north of Reid Highway (80 km/h speed limit), with Lord Street not extended south of Reid Highway; and
- Reid Highway (90 km/h speed limit).

Various local road links within landholdings included in this scenario are modelled in accordance with the current draft or approved LSPs.

Note that the short-term road networks modelled in this technical note are different than the 'interim' scenario modelled in the transport assessment reports for each LSP. The interim scenario is a long-term scenario where Henley Brook Avenue and the Lord Street extension south of Reid Highway have been constructed. These additional road links will change the routes taken by traffic travelling to and from external locations so differences in traffic patterns are to be expected between the short-term and interim scenarios.

C4. Traffic Generation and Distribution

Detailed traffic modelling of full development of Dayton was undertaken for the West Swan East TIS update report of October 2009. That traffic model was subsequently refined to model the LSP1 and 2B areas in more detail for the LSP1 and 2B transport assessment reports and has been further updated to reflect recent changes to the proposed LSP2B.

Traffic generation rates for the structure plan land uses were primarily sourced from the Roads and Traffic Authority, NSW, *"Guide to Traffic Generating Developments",* with additional information from the Institute of Transportation Engineers *"Trip Generation Manual, 7th Edition"* where required.

The residential traffic generation rates used range from 9 vehicles per day (vpd) per dwelling for the lower residential densities, 7 vpd for medium density dwellings and 5 vpd for high-density units close to transit.

Based on guidance in the WAPC *Transport Assessment Guidelines for Developments* (2006) a school trip generation rate of 2 vpd (vehicles per day) per student has been adopted for this assessment.

The same trip generation rates have been applied in the short-term scenario modelled in this appendix.

The same trip distribution to the surrounding regional road network has been used in this short-term scenario as was developed for the full development scenarios as documented in the previous transport assessment reports. The external distribution used in this analysis is as follows:

- 8% Lord Street north;
- 8% Henley Brook Avenue north;
- 16% Reid Highway east;
- 19% West Swan Road south,
- 20% Lord Street south,
- 5% Benara Road west,
- 20% Reid Highway west, and
- 4% Marshall Road west.

C5. Modelled Daily Traffic Flows

The modelled daily traffic flows generated by medium-term development in Dayton in these two short-term road network scenarios are illustrated in Figures C1 and C2.

Figure C1. Daily traffic generated by medium term development in Dayton (short-term road network scenario 1 – with access to West Swan Road via Coast Road and Victoria Road; no Lord St extension south of Reid Hwy)

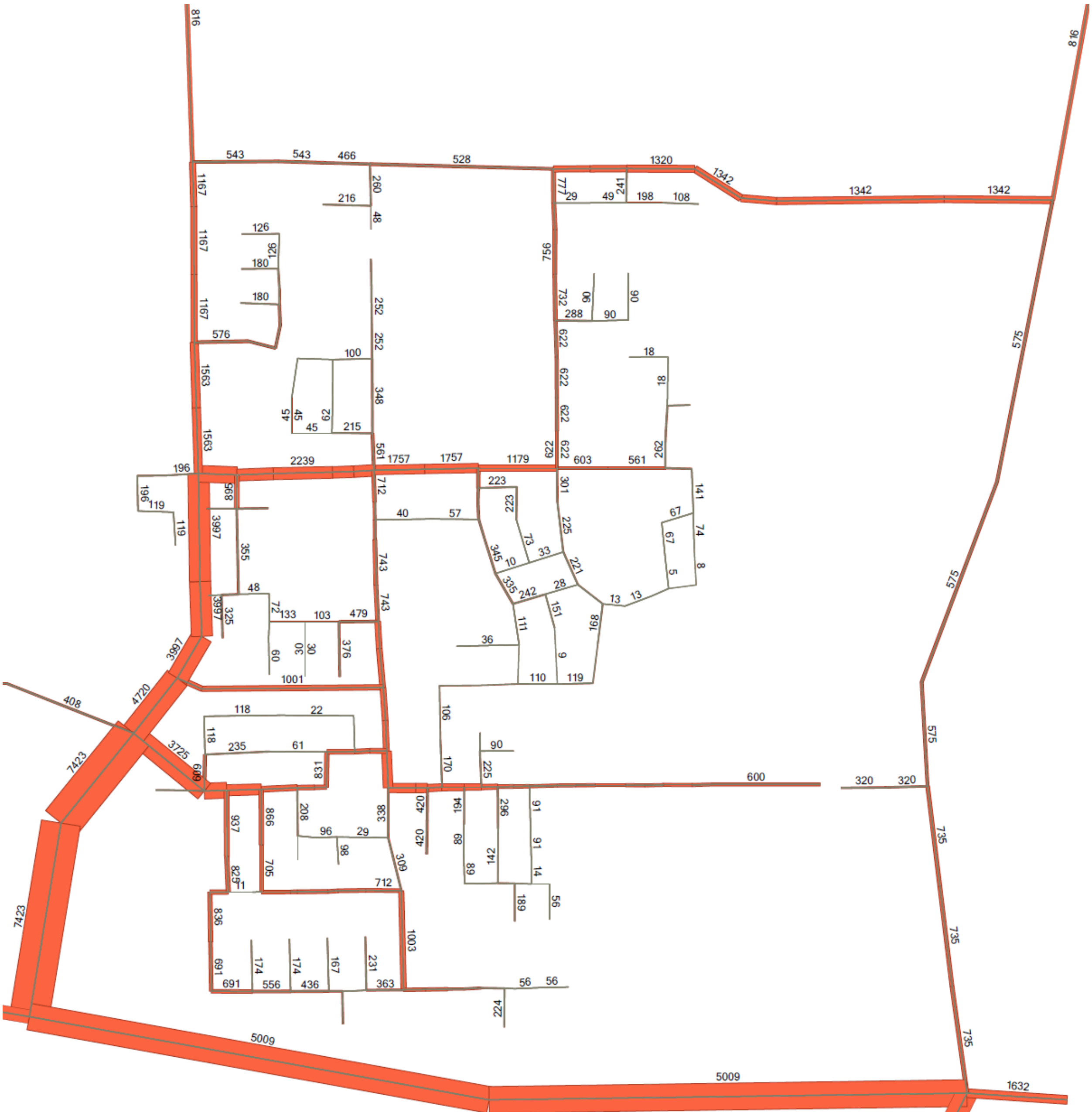


Figure C2. Daily traffic generated by medium term development in Dayton (short-term road network scenario 2 – no access to West Swan Road via Coast Road and Victoria Road; no Lord St extension south of Reid Hwy)

The existing traffic volumes on the existing road network in the Dayton area are presented in Table C1, together with the traffic generated by short to medium term development in the two short-term scenarios.

Table C1. Existing traffic volumes and total with medium term Dayton development (before extension of Lord St south of Reid Hwy)

LOCATION	SOURCE	DATE	Existing Daily Volume (vpd)	With Coast Rd & Victoria Rd access to West Swan Rd		Without Coast Rd & Victoria Rd access to West Swan Rd	
				Medium Term Dayton Traffic (vpd)	Total Traffic (vpd)	Medium Term Dayton Traffic (vpd)	Total Traffic (vpd)
Arthur Street, North of Cranleigh Street	Swan	Jul-07	60	560	600	560	600
Arthur Street, North of Marshall Road	Swan	Jul-07	210	1,730	1,900	1,090	1,300
Arthur Street, North of Coast Road	Swan	Jul-07	640	2,450	3,100	1,810	2,500
Arthur Street, North of Victoria Road	Swan	Jul-07	340	990	1,300	1,000	1,300
Blundell Street, South of Harrow Street	Swan	Mar-10	60	500	600	780	800
Coast Road, East of Arthur Street	Swan	Mar-10	480	2,980	3,500	1,730	2,200
Coast Road, West of West Swan Road	MRWA	May-11	690	3,570	4,300	-	700
Cranleigh Street, East of Lord Street	Swan	Jul-07	165	1,890	2,100	3,120	3,300
Harrow Street, East of Lord Street	Swan	Mar-10	950	460	1,400	540	1,500
Harrow Street, West of West Swan Road	MRWA	May-11	860	980	1,800	1,340	2,200
Lord Street, north of Reid Highway	MRWA	Sep-12	13,807	3,820	17,600	7,420	21,200
Lord Street, North of Marshall Road	Swan	Sep-12	15,480	2,720	18,200	4,720	20,200
Marshall Road, West of Lord Street	Swan	Sep-06	7,050	410	7,500	410	7,500
Marshall Road, East of Lord Street	Swan	Jul-07	530	310	800	1,000	1,500
Sam Rosa Place, South of Cranleigh St	Swan	Jul-07	110	250	400	300	400
Reid Highway, West of West Swan Road	MRWA	May-11	25,430	1,400	26,800	5,000	30,400
Victoria Road, West of West Swan Road	Swan	Mar-10	490	790	1,300	-	500
West Swan Road, North of Reid Hwy	Swan	Oct-12	16,848	4,340	21,200	740	17,600
West Swan Road, South of Harrow St	Swan	Sep-12	14,909	930	15,800	580	15,500

Note: Future traffic volumes rounded to nearest 100.

It should be noted that Table C1 does not take into account growth in existing traffic flows through this area that are not related to Dayton. This mainly applies to the major roads such as Lord Street, West Swan Road and Reid Highway. Future growth of the total traffic volumes on Lord Street and West Swan Road are estimated in Table C2.

Table C2. Growth of Total Traffic with medium term Dayton development (Lord Street and West Swan Road)

Year	Medium Term Dayton Dwellings	Lord St north of Reid Hwy			West Swan Rd north of Reid Hwy		
		Through traffic	Dayton traffic	Total traffic	Through traffic	Dayton traffic	Total traffic
Short term scenario 1: With Coast Rd and Victoria Rd access to West Swan Rd							
2012	200	13,300	500	13,800	16,200	600	16,800
2013	400	14,300	1,100	15,400	17,000	1,200	18,200
2014	600	15,300	1,600	16,900	17,800	1,800	19,600
2015	800	16,300	2,200	18,500	18,600	2,400	21,000
2016	1,000	17,300	2,700	20,000	19,400	3,100	22,500
2017	1,200	18,300	3,200	21,500	20,200	3,700	23,900
2018	1,400	19,300	3,800	23,100	21,000	4,300	25,300
2019	1,420	20,300	3,800	24,100	21,800	4,300	26,100
Short term scenario 2: Without Coast Rd and Victoria Rd access to West Swan Rd							
2012	200	13,300	1,000	14,300	16,200	100	16,300
2013	400	14,300	2,100	16,400	17,000	200	17,200
2014	600	15,300	3,100	18,400	17,800	300	18,100
2015	800	16,300	4,200	20,500	18,600	400	19,000
2016	1,000	17,300	5,200	22,500	19,400	500	19,900
2017	1,200	18,300	6,300	24,600	20,200	600	20,800
2018	1,400	19,300	7,300	26,600	21,000	700	21,700
2019	1,420	20,300	7,400	27,700	21,800	700	22,500

Note: All traffic volumes rounded to nearest 100.

The rationale behind the estimated future growth rates for Lord Street through traffic is as follows.

Existing traffic flows on Lord Street north of Reid Highway were 8,970 vpd in 2001/02 and increased to 10,520 vpd in 2003/04, to 13,810 in December 2007, to 14,410 vpd in Dec 2010 and were 13,810 vpd in Sept 2012. This indicates a growth rate of about 800 vpd each year up to 2007 then slowing after 2007. However, Lord Street north of Marshall Road recorded 12,850 vpd in 2007, 15,960 vpd in Dec 2010 and 15,480 vpd in Sept 2012, which implies a growth rate of approximately 1000 vpd per year to 2010 then slowing after 2010. It is anticipated that traffic growth on Lord Street (particularly between Marshall Road and Reid Hwy) has probably been restricted by the capacity of the unsignalised intersection at Reid Hwy and with right turn movements made easier at Marshall Road due to the Lord St / Marshall Rd / St Leonards Bvd roundabout some traffic may be using Marshall Road instead. It is understood that traffic signals are planned to be installed at the Reid Hwy / Lord Street intersection soon, so the observed traffic increase of 1000 vpd per year further north on Lord Street is likely to flow through to this section of Lord Street in future.

On West Swan Road (north of Reid Hwy) MRWA and City of Swan traffic counts recorded 13,095 vpd in March 2008, 15,485 vpd in May 2011 and 16,850 vpd in October 2012, which indicates a growth rate of approximately 800 vpd per year.

These annual traffic growth rates for West Swan Road and Lord Street are applied in Table C2.

C6. Analysis of Short-term Scenarios

As noted in section C1, previous analysis for LSP1 indicated that the existing West Swan Road / Coast Road and West Swan Road / Victoria Road intersections could only cope with the additional traffic from development of 290 residential lots in Dayton before major upgrading of those intersections would be required. This is the road network modelled as short-term scenario 1 in this Appendix (although the Victoria Road intersection is modelled as left-in/left-out in scenario 1).

Therefore the initial short-term access strategy for LSP1 involves access only from Lord Street. Victoria Road would be cut in the vicinity of the gas pipeline easement. Coast Road would be cut opposite the Caversham Primary School so that the school can still be accessed from both directions but through traffic movements on Coast Road and Victoria Road would be prevented. This is the road network modelled as short-term scenario 2 in this Appendix.

This initial short-term strategy was assessed in the Dayton LSP1 Transport Assessment report (April 2011) and was found to operate satisfactorily up to about 2014 with approximately 760 dwellings developed in the LSP1 area. This is equivalent to approximately 54% of the total number of dwellings in the short to medium term development scenario analysed in this Appendix. After that level of development it was found that:

- Lord Street would need to be upgraded to 4 lanes from Cranleigh Street to Reid Highway (although it is now considered that sections without direct access to driveways could remain as two lanes for longer than this, potentially until the Lord Street extension south of Reid Highway, which is planned for 2019) ;
- a roundabout would be required at the Cranleigh Street / Lord Street intersection;
- right turn movements out from Marshall Road to Lord Street would not be permitted; and
- the Lord Street / Marshall Road / St Leonards Boulevard roundabout would require upgrading (for 4 lanes on Lord Street).

Further analysis of this initial short-term strategy indicates that it will operate at a satisfactory level of service until approximately 1200 dwellings are developed in Dayton.

Therefore, development of 1200 dwellings in Dayton has been recommended as the trigger point where alternative access to the east is required.

A number of different access strategies to and from the east have been considered but there are issues requiring resolution with each one.

- Coast Road / West Swan Road intersection would require land acquisition to allow upgrading.
- Victoria Road / West Swan Road intersection is approximately 220m from the existing signalised Reid Hwy intersection. This is considered too close for this intersection to be upgraded to a signalised intersection or roundabout because of lengthy queues between the intersections.
- Marshall Road connecting to Henley Brook Avenue is the ultimate eastern access route and this report recommends that Marshall Road and Henley Brook Avenue (to a single carriageway standard southward to Reid Highway) be delivered at 1,200 lots. Both roads (including outstanding land purchases and their intersection treatment) are DCP items but they largely depend on timing / resolution of land acquisitions (Henley Brook Avenue and potentially Marshall Road) and the willingness of multiple affected landowners to subdivide their land (Marshall Road). Consequently, these roads may not be available by the time the 1200 dwelling unit trigger is reached. If those roads are not available, subdividers would either have to wait until land is available or implement interim upgrades to Coast Road and the intersection of Coast Road / West Swan Road to facilitate development. The use of Coast Road as an interim arrangement has the benefit of being an existing through connection which, in comparison with the Marshall Road option, does not require the acquisition of land, save potentially for widening around the intersection at West Swan Road and localised road carriageway upgrades to achieve a uniform width of 7 metres to accommodate the anticipated traffic volumes.
- With access provided to West Swan Road from Dayton the traffic volumes in 2019 are expected to be over 26,000 vpd (see Table C2), which is higher than the capacity of this existing two-lane road[1]. Significant upgrading of West Swan Road would be required but this is not consistent with the long-term plan to downgrade West Swan Road.
- Construction of the first 2-lane carriageway of Henley Brook Avenue from Reid Hwy to Coast Road or Marshall Road would allow Henley Brook Avenue and West Swan Road to operate as a one-way pair (i.e. northbound on Henley Brook Ave and southbound on West Swan Road) and would provide sufficient capacity for these future traffic flows. However, as noted in the third dot point above, land acquisition is still required so Henley Brook Avenue and Marshall Road may not be

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[1] The Caversham Local Structure Plan Transport Assessment (Revised September 2012) reports that City of Swan engineers calculated the capacity of West Swan Road south of Reid Hwy as 24,235 vpd at level of service E).

available in an expedient manner for development. This would present issues until the land for those roads is available or until interim upgrades are delivered and those upgrades can be implemented by a subdivider.

- Construction of the full dual carriageway of Henley Brook Avenue from Reid Hwy to Coast Road or Marshall Road would be even better as it would completely remove through traffic from this section of West Swan Road but the same land acquisition problems remain. (It is understood that the City of Swan's draft DCP for Dayton proposes construction of Henley Brook Avenue from Reid Hwy to Marshall Road by 2019.)
- Construction of the Lord Street extension south of Reid Hwy is expected to attract a significant amount of traffic away from West Swan Road, although the volume of traffic affected has not been quantified. Depending on the volume affected this would substantially relieve the problems forecast on West Swan Road when Dayton exceeds 1200 dwellings and would provide a better match between capacity and forecast traffic flows on Lord St (4 lanes) and West Swan Road (2 lanes). However, construction of the Lord Street extension south of Reid Hwy is not scheduled until 2019.

C7. Conclusions on Short-term Access for LSP2A

This Appendix documents the traffic flows that will be generated in the short to medium term development scenario represented by land ownership and developers current intentions.

Based on the assessment of interim access scenarios and the resolutions of the City of Swan there are two options for interim access.

The first option is Coast Road. Coast Road was considered at the City of Swan Council meeting of May 23rd and July 4th. The City reported and resolved that *"From the City's perspective, use of Coast Road as an interim arrangement has the benefit of being an existing through connection.......City engineering staff are satisfied that the road carriageway width of 7 metres can accommodate the anticipated traffic volumes, however localised upgrades would be required to achieve a uniform width throughout."* Consequently the City adopted this as the preferred interim arrangement and resolved to modify the Local Structure Plan as follows:

- *"Upgrade to Coast Road between Arthur Street and West Swan Road (localised widening and enhanced street lighting)"; and*
- *"Intersection of Coast Road and West Swan Road (construct priority controlled intersection)"*

In addition to the Council consideration of Coast Road, the second option includes the upgrading of Lord Street. Lord Street may be upgraded to 4 lanes from Reid Hwy to Cranleigh Street, the Lord St / Marshall Rd / St Leonards Bvd roundabout widened, a new roundabout constructed at Lord St / Cranleigh St and right turns out banned from Marshall Rd east.

This is anticipated to operate satisfactorily until development of approximately 1200 dwellings in Dayton, when capacity problems will occur on the right turn into Marshall Road east and at West Swan Rd / Coast Rd and West Swan Rd / Victoria Rd intersections.

Therefore, development of 1200 dwellings in Dayton is recommended as the trigger point where alternative access to the east is required.

No strategy for alternative access to the east has been identified yet that is acceptable and/or feasible for all parties concerned (in terms of timely implementation), so it is recommended that development in Dayton be capped at 1200 dwellings until a suitable alternative access strategy can be implemented.

Potential road network improvements that would allow development at Dayton to progress beyond 1200 dwellings (in addition to improvements identified after 760 dwellings) include:

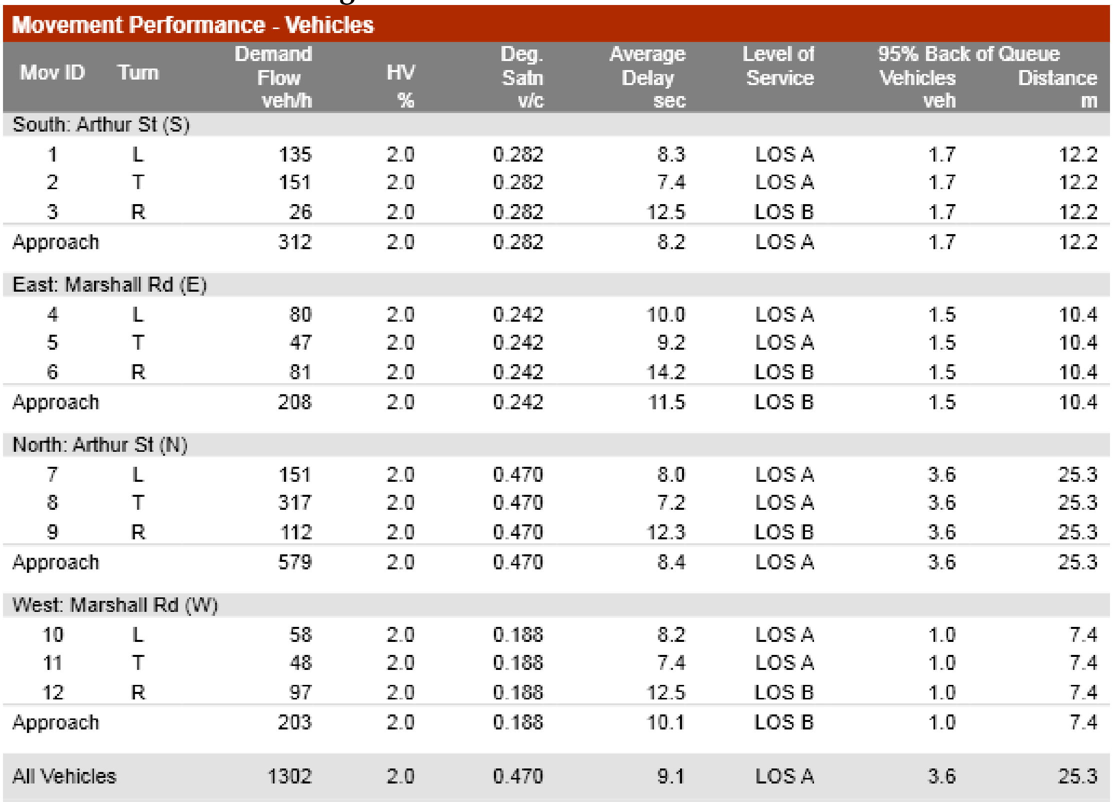
- Intersection improvements to address right turn capacity at Lord St / Marshall Rd east intersection; and
- Land acquisition and two-lane carriageway constructed for Henley Brook Avenue from Reid Hwy to Coast Rd; or
- West Swan Road upgrading from Reid Hwy to Coast Road, including Coast Rd and Victoria Rd intersections; or
- Lord Street extension south of Reid Hwy constructed (currently scheduled for 2019).

These arrangements are in addition to the interim access arrangements regarding Coast Road as resolved by Council and mentioned above. These are presented as interim options that a subdivider (or the City and WAPC through a condition of subdivision) can investigate and implement to facilitate their development. These options are not required once the ultimate eastern access arrangement (Marshall Road & Henley Brook Avenue) is constructed. What these interim options highlight is the difficulties of delivering timely access solutions in highly fragmented areas. An ongoing collaborative approach between landowners, local and state agencies is needed to effect satisfactory traffic outcomes until the ultimate eastern access arrangement is constructed.

APPENDIX D

SIDRA INTERSECTION ANALYSIS

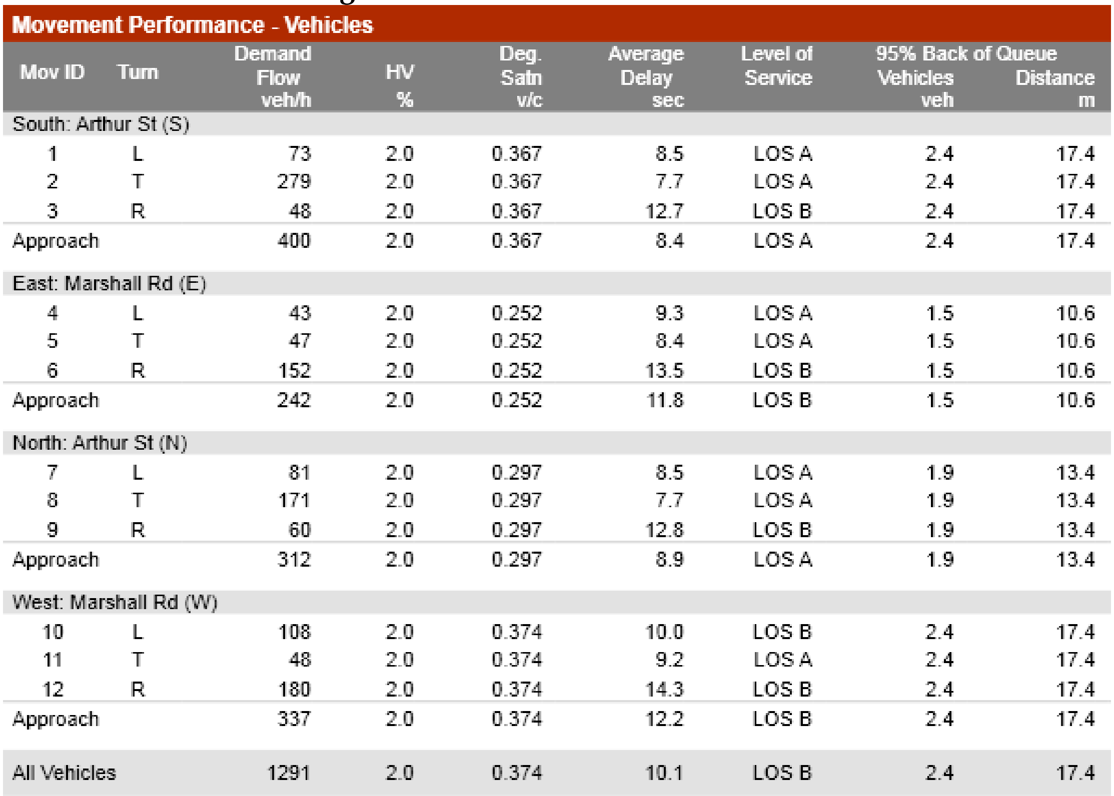
Table D1(a). SIDRA results – Arthur St / Marshall Rd roundabout – AM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: Arthur St (S)								
1	L	135	2.0	0.282	8.3	LOS A	1.7	12.2
2	T	151	2.0	0.282	7.4	LOS A	1.7	12.2
3	R	26	2.0	0.282	12.5	LOS B	1.7	12.2
Approach		312	2.0	0.282	8.2	LOS A	1.7	12.2
East: Marshall Rd (E)								
4	L	80	2.0	0.242	10.0	LOS A	1.5	10.4
5	T	47	2.0	0.242	9.2	LOS A	1.5	10.4
6	R	81	2.0	0.242	14.2	LOS B	1.5	10.4
Approach		208	2.0	0.242	11.5	LOS B	1.5	10.4
North: Arthur St (N)								
7	L	151	2.0	0.470	8.0	LOS A	3.6	25.3
8	T	317	2.0	0.470	7.2	LOS A	3.6	25.3
9	R	112	2.0	0.470	12.3	LOS B	3.6	25.3
Approach		579	2.0	0.470	8.4	LOS A	3.6	25.3
West: Marshall Rd (W)								
10	L	58	2.0	0.188	8.2	LOS A	1.0	7.4
11	T	48	2.0	0.188	7.4	LOS A	1.0	7.4
12	R	97	2.0	0.188	12.5	LOS B	1.0	7.4
Approach		203	2.0	0.188	10.1	LOS B	1.0	7.4
All Vehicles		1302	2.0	0.470	9.1	LOS A	3.6	25.3

Table D1(b). SIDRA results – Arthur St / Marshall Rd roundabout – PM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: Arthur St (S)								
1	L	73	2.0	0.367	8.5	LOS A	2.4	17.4
2	T	279	2.0	0.367	7.7	LOS A	2.4	17.4
3	R	48	2.0	0.367	12.7	LOS B	2.4	17.4
Approach		400	2.0	0.367	8.4	LOS A	2.4	17.4
East: Marshall Rd (E)								
4	L	43	2.0	0.252	9.3	LOS A	1.5	10.6
5	T	47	2.0	0.252	8.4	LOS A	1.5	10.6
6	R	152	2.0	0.252	13.5	LOS B	1.5	10.6
Approach		242	2.0	0.252	11.8	LOS B	1.5	10.6
North: Arthur St (N)								
7	L	81	2.0	0.297	8.5	LOS A	1.9	13.4
8	T	171	2.0	0.297	7.7	LOS A	1.9	13.4
9	R	60	2.0	0.297	12.8	LOS B	1.9	13.4
Approach		312	2.0	0.297	8.9	LOS A	1.9	13.4
West: Marshall Rd (W)								
10	L	108	2.0	0.374	10.0	LOS B	2.4	17.4
11	T	48	2.0	0.374	9.2	LOS A	2.4	17.4
12	R	180	2.0	0.374	14.3	LOS B	2.4	17.4
Approach		337	2.0	0.374	12.2	LOS B	2.4	17.4
All Vehicles		1291	2.0	0.374	10.1	LOS B	2.4	17.4

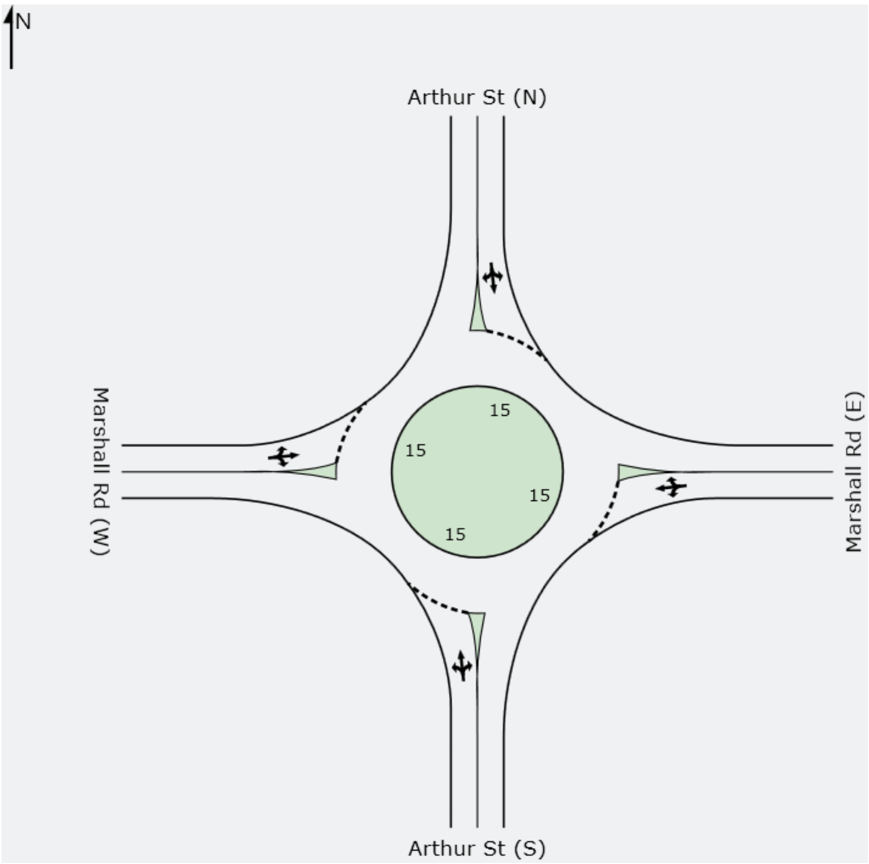
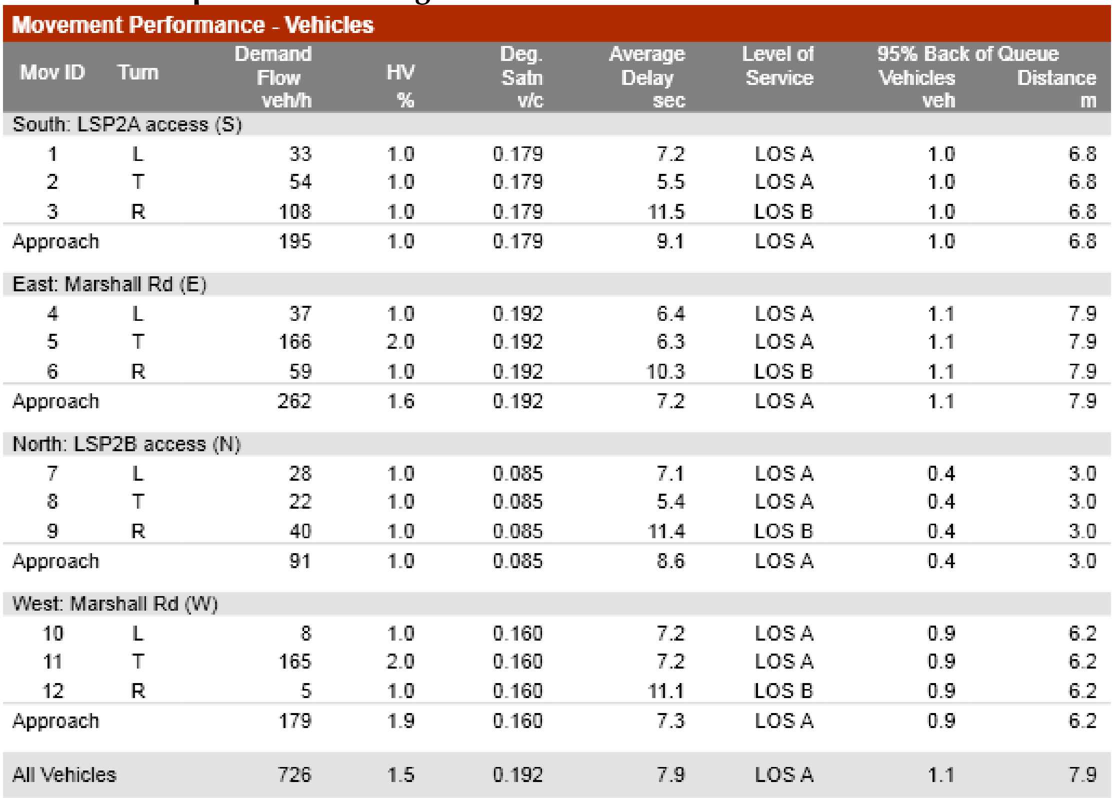


Figure D1. Arthur St / Marshall Rd roundabout layout analysed in SIDRA

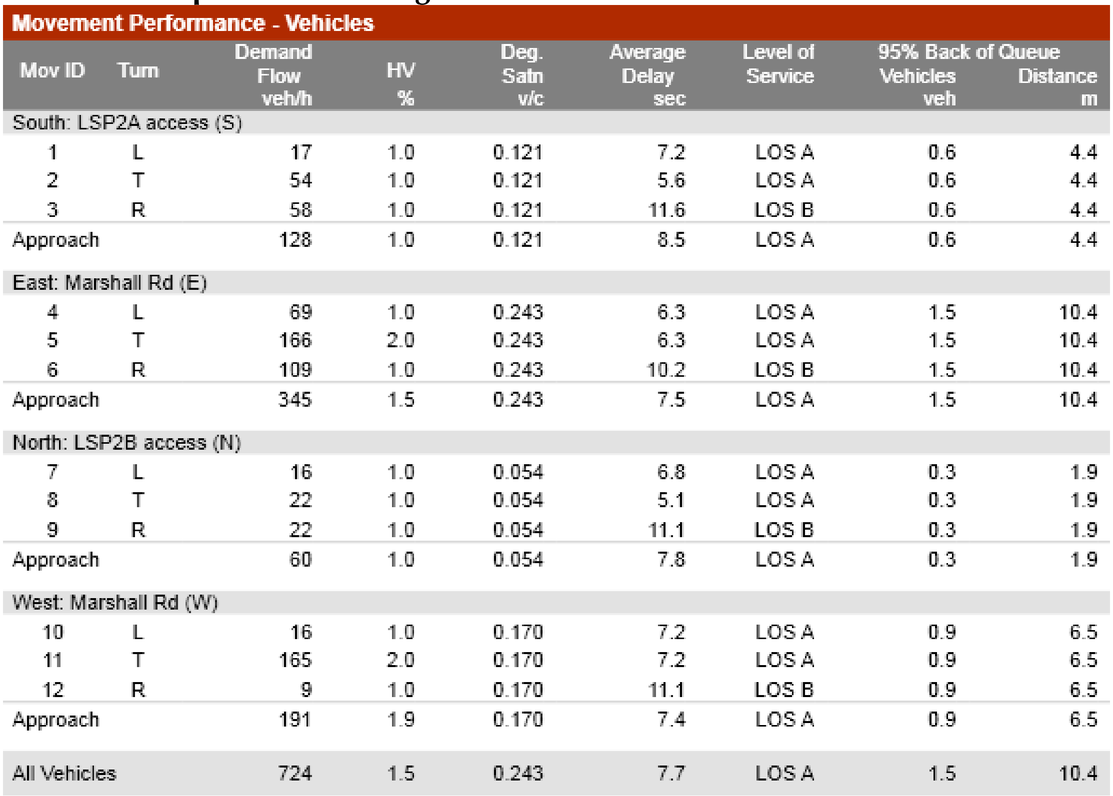
Table D2(a). SIDRA results – Marshall Rd / LSP2A / LSP2B roundabout – AM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: LSP2A access (S)								
1	L	33	1.0	0.179	7.2	LOS A	1.0	6.8
2	T	54	1.0	0.179	5.5	LOS A	1.0	6.8
3	R	108	1.0	0.179	11.5	LOS B	1.0	6.8
Approach		195	1.0	0.179	9.1	LOS A	1.0	6.8
East: Marshall Rd (E)								
4	L	37	1.0	0.192	6.4	LOS A	1.1	7.9
5	T	166	2.0	0.192	6.3	LOS A	1.1	7.9
6	R	59	1.0	0.192	10.3	LOS B	1.1	7.9
Approach		262	1.6	0.192	7.2	LOS A	1.1	7.9
North: LSP2B access (N)								
7	L	28	1.0	0.085	7.1	LOS A	0.4	3.0
8	T	22	1.0	0.085	5.4	LOS A	0.4	3.0
9	R	40	1.0	0.085	11.4	LOS B	0.4	3.0
Approach		91	1.0	0.085	8.6	LOS A	0.4	3.0
West: Marshall Rd (W)								
10	L	8	1.0	0.160	7.2	LOS A	0.9	6.2
11	T	165	2.0	0.160	7.2	LOS A	0.9	6.2
12	R	5	1.0	0.160	11.1	LOS B	0.9	6.2
Approach		179	1.9	0.160	7.3	LOS A	0.9	6.2
All Vehicles		726	1.5	0.192	7.9	LOS A	1.1	7.9

Table D2(b). SIDRA results – Marshall Rd / LSP2A / LSP2B roundabout – PM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: LSP2A access (S)								
1	L	17	1.0	0.121	7.2	LOS A	0.6	4.4
2	T	54	1.0	0.121	5.6	LOS A	0.6	4.4
3	R	58	1.0	0.121	11.6	LOS B	0.6	4.4
Approach		128	1.0	0.121	8.5	LOS A	0.6	4.4
East: Marshall Rd (E)								
4	L	69	1.0	0.243	6.3	LOS A	1.5	10.4
5	T	166	2.0	0.243	6.3	LOS A	1.5	10.4
6	R	109	1.0	0.243	10.2	LOS B	1.5	10.4
Approach		345	1.5	0.243	7.5	LOS A	1.5	10.4
North: LSP2B access (N)								
7	L	16	1.0	0.054	6.8	LOS A	0.3	1.9
8	T	22	1.0	0.054	5.1	LOS A	0.3	1.9
9	R	22	1.0	0.054	11.1	LOS B	0.3	1.9
Approach		60	1.0	0.054	7.8	LOS A	0.3	1.9
West: Marshall Rd (W)								
10	L	16	1.0	0.170	7.2	LOS A	0.9	6.5
11	T	165	2.0	0.170	7.2	LOS A	0.9	6.5
12	R	9	1.0	0.170	11.1	LOS B	0.9	6.5
Approach		191	1.9	0.170	7.4	LOS A	0.9	6.5
All Vehicles		724	1.5	0.243	7.7	LOS A	1.5	10.4

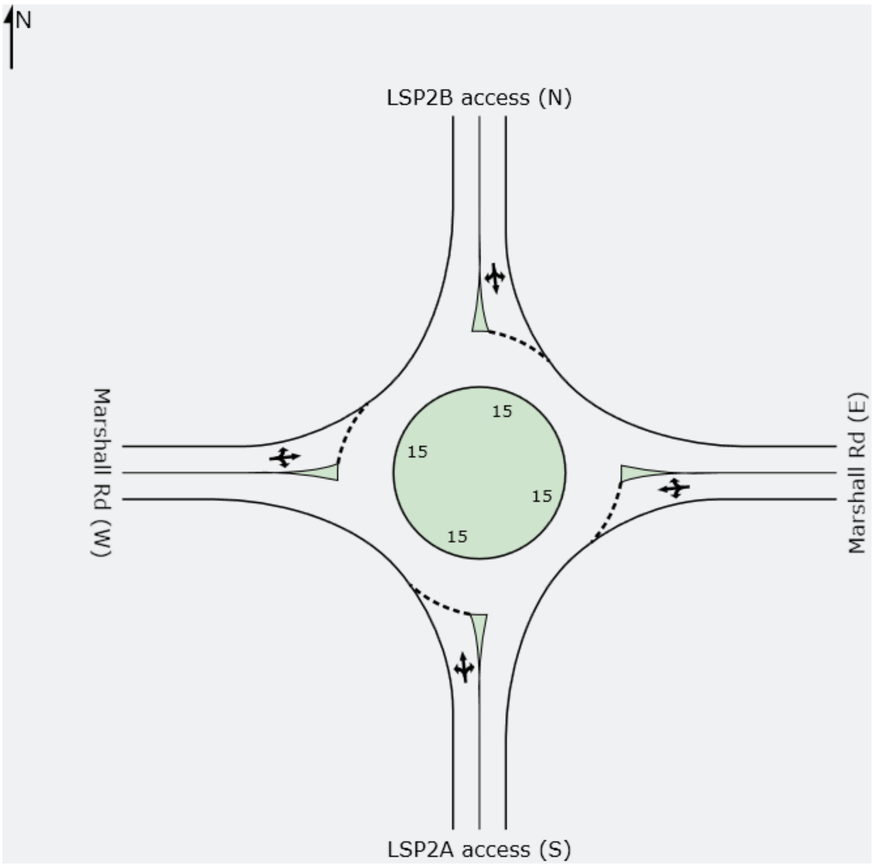
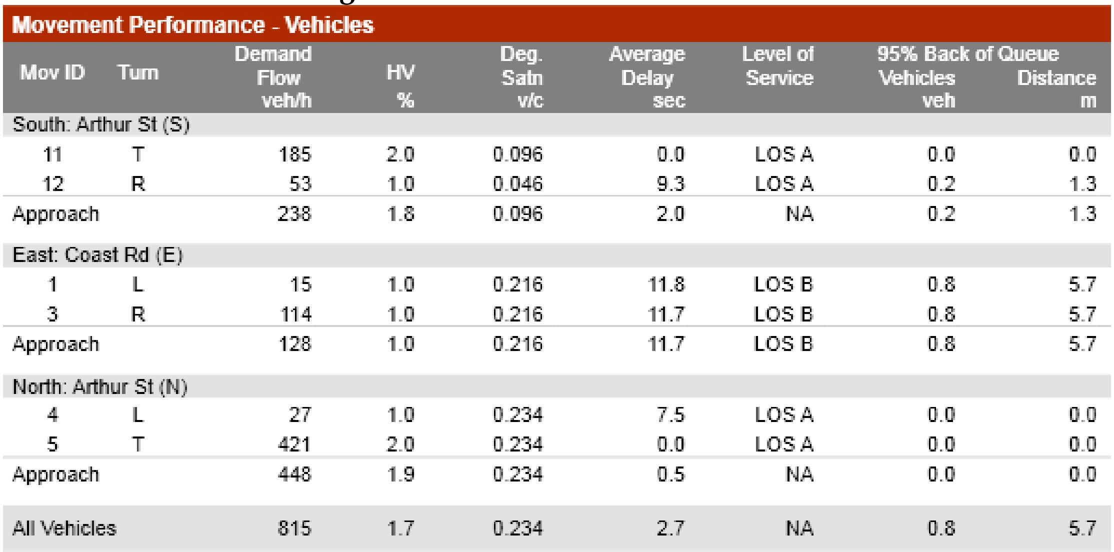


Figure D2. Marshall Rd/LSP2A/LSP2B roundabout layout analysed in SIDRA

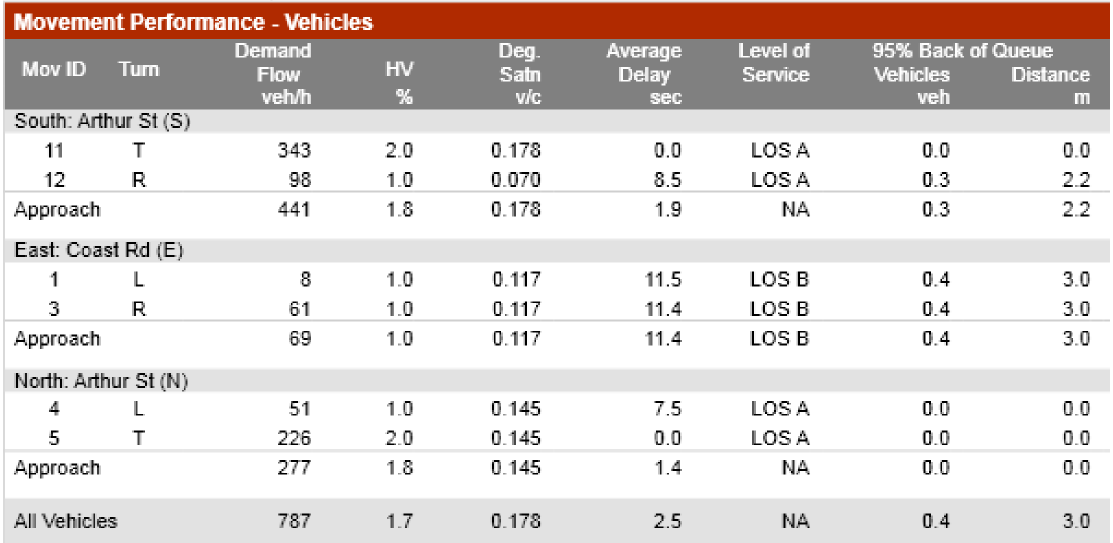
Table D3(a). SIDRA results – Arthur St / Coast Rd intersection – AM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue	
							Vehicles veh	Distance m
South: Arthur St (S)								
11	T	185	2.0	0.096	0.0	LOS A	0.0	0.0
12	R	53	1.0	0.046	9.3	LOS A	0.2	1.3
Approach		238	1.8	0.096	2.0	NA	0.2	1.3
East: Coast Rd (E)								
1	L	15	1.0	0.216	11.8	LOS B	0.8	5.7
3	R	114	1.0	0.216	11.7	LOS B	0.8	5.7
Approach		128	1.0	0.216	11.7	LOS B	0.8	5.7
North: Arthur St (N)								
4	L	27	1.0	0.234	7.5	LOS A	0.0	0.0
5	T	421	2.0	0.234	0.0	LOS A	0.0	0.0
Approach		448	1.9	0.234	0.5	NA	0.0	0.0
All Vehicles		815	1.7	0.234	2.7	NA	0.8	5.7

Table D3(b). SIDRA results – Arthur St / Coast Rd intersection – PM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue	
							Vehicles veh	Distance m
South: Arthur St (S)								
11	T	343	2.0	0.178	0.0	LOS A	0.0	0.0
12	R	98	1.0	0.070	8.5	LOS A	0.3	2.2
Approach		441	1.8	0.178	1.9	NA	0.3	2.2
East: Coast Rd (E)								
1	L	8	1.0	0.117	11.5	LOS B	0.4	3.0
3	R	61	1.0	0.117	11.4	LOS B	0.4	3.0
Approach		69	1.0	0.117	11.4	LOS B	0.4	3.0
North: Arthur St (N)								
4	L	51	1.0	0.145	7.5	LOS A	0.0	0.0
5	T	226	2.0	0.145	0.0	LOS A	0.0	0.0
Approach		277	1.8	0.145	1.4	NA	0.0	0.0
All Vehicles		787	1.7	0.178	2.5	NA	0.4	3.0

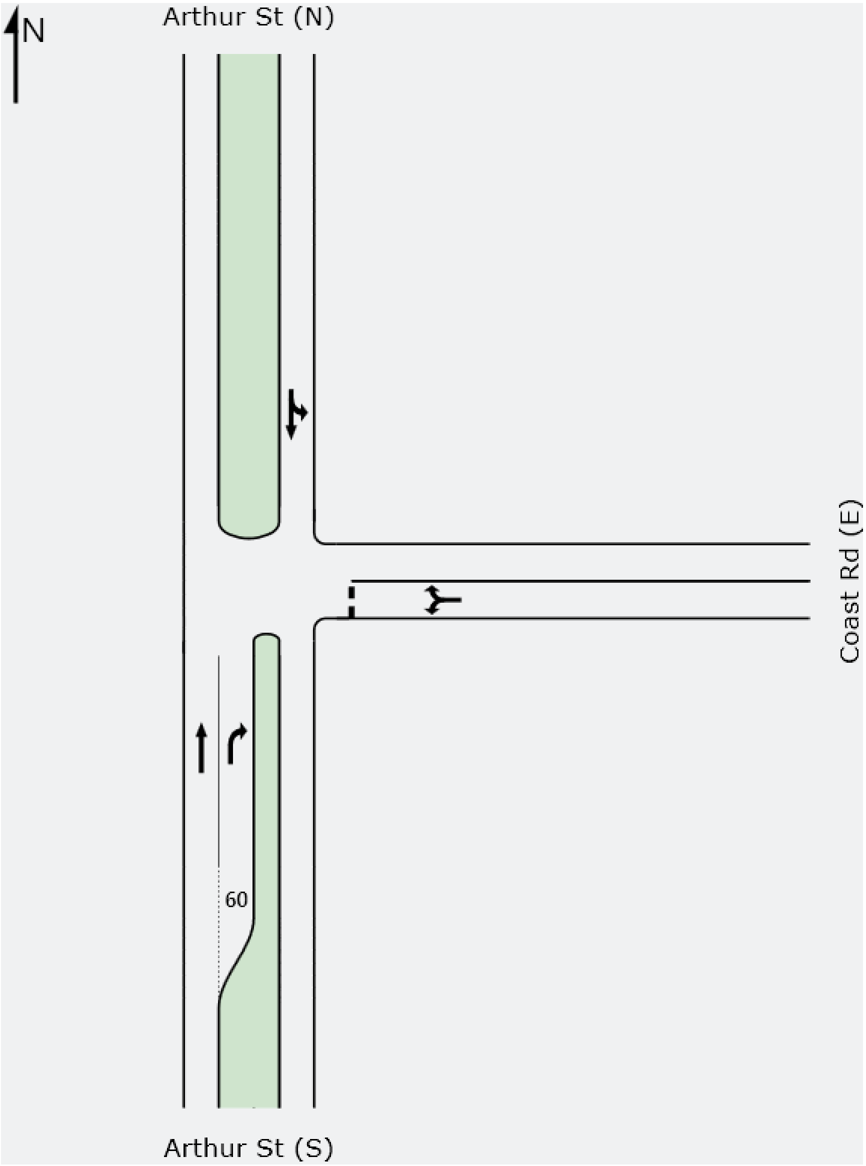
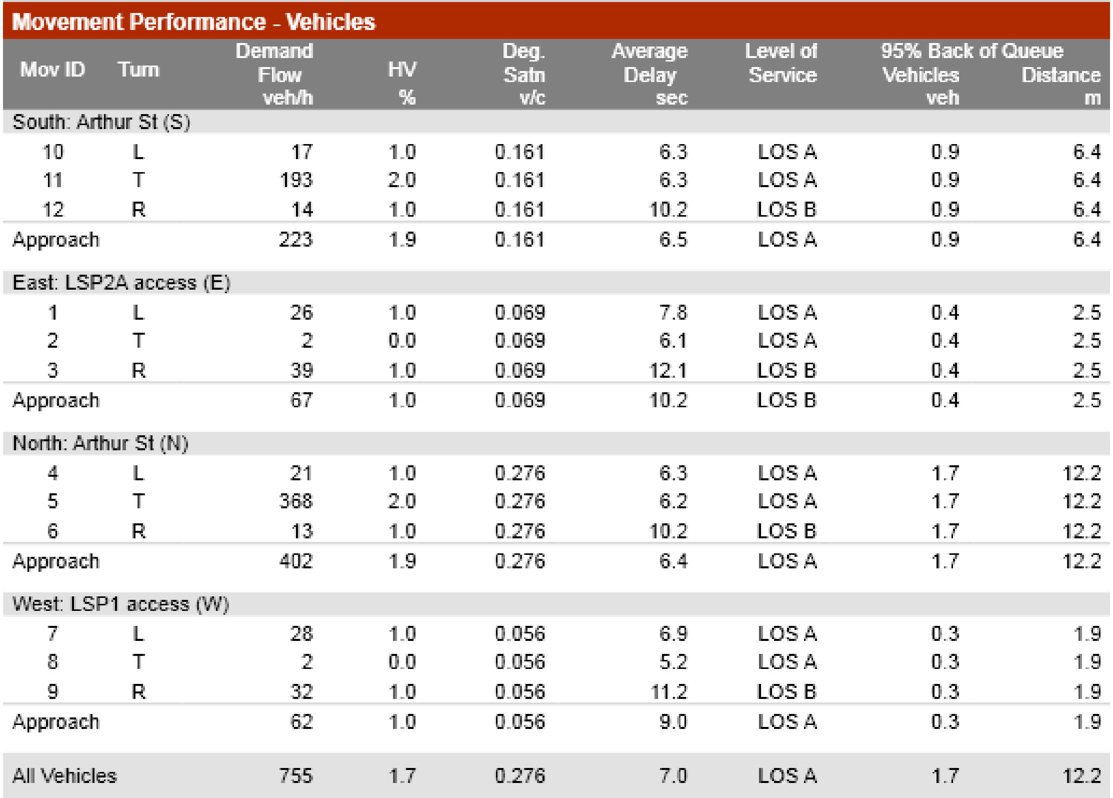


Figure D3. Arthur St / Coast Rd intersection layout analysed in SIDRA

Table D4(a). SIDRA results – Arthur St / LSP1 / LSP2A roundabout – AM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: Arthur St (S)								
10	L	17	1.0	0.161	6.3	LOS A	0.9	6.4
11	T	193	2.0	0.161	6.3	LOS A	0.9	6.4
12	R	14	1.0	0.161	10.2	LOS B	0.9	6.4
Approach		223	1.9	0.161	6.5	LOS A	0.9	6.4
East: LSP2A access (E)								
1	L	26	1.0	0.069	7.8	LOS A	0.4	2.5
2	T	2	0.0	0.069	6.1	LOS A	0.4	2.5
3	R	39	1.0	0.069	12.1	LOS B	0.4	2.5
Approach		67	1.0	0.069	10.2	LOS B	0.4	2.5
North: Arthur St (N)								
4	L	21	1.0	0.276	6.3	LOS A	1.7	12.2
5	T	368	2.0	0.276	6.2	LOS A	1.7	12.2
6	R	13	1.0	0.276	10.2	LOS B	1.7	12.2
Approach		402	1.9	0.276	6.4	LOS A	1.7	12.2
West: LSP1 access (W)								
7	L	28	1.0	0.056	6.9	LOS A	0.3	1.9
8	T	2	0.0	0.056	5.2	LOS A	0.3	1.9
9	R	32	1.0	0.056	11.2	LOS B	0.3	1.9
Approach		62	1.0	0.056	9.0	LOS A	0.3	1.9
All Vehicles		755	1.7	0.276	7.0	LOS A	1.7	12.2

Table D4(b). SIDRA results – Arthur St / LSP1 / LSP2A roundabout – PM peak hour – long term ultimate scenario

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue	
							Vehicles veh	Distance m
South: Arthur St (S)								
10	L	32	1.0	0.290	6.3	LOS A	1.8	12.7
11	T	366	2.0	0.290	6.2	LOS A	1.8	12.7
12	R	26	1.0	0.290	10.2	LOS B	1.8	12.7
Approach		424	1.9	0.290	6.5	LOS A	1.8	12.7
East: LSP2A access (E)								
1	L	14	1.0	0.033	6.8	LOS A	0.2	1.1
2	T	2	0.0	0.033	5.1	LOS A	0.2	1.1
3	R	21	1.0	0.033	11.1	LOS B	0.2	1.1
Approach		37	0.9	0.033	9.2	LOS A	0.2	1.1
North: Arthur St (N)								
4	L	39	1.0	0.184	6.2	LOS A	1.0	7.2
5	T	199	2.0	0.184	6.2	LOS A	1.0	7.2
6	R	24	1.0	0.184	10.2	LOS B	1.0	7.2
Approach		262	1.8	0.184	6.6	LOS A	1.0	7.2
West: LSP1 access (W)								
7	L	15	1.0	0.035	7.7	LOS A	0.2	1.2
8	T	2	0.0	0.035	6.0	LOS A	0.2	1.2
9	R	17	1.0	0.035	12.0	LOS B	0.2	1.2
Approach		34	0.9	0.035	9.7	LOS A	0.2	1.2
All Vehicles		757	1.7	0.290	6.8	LOS A	1.8	12.7

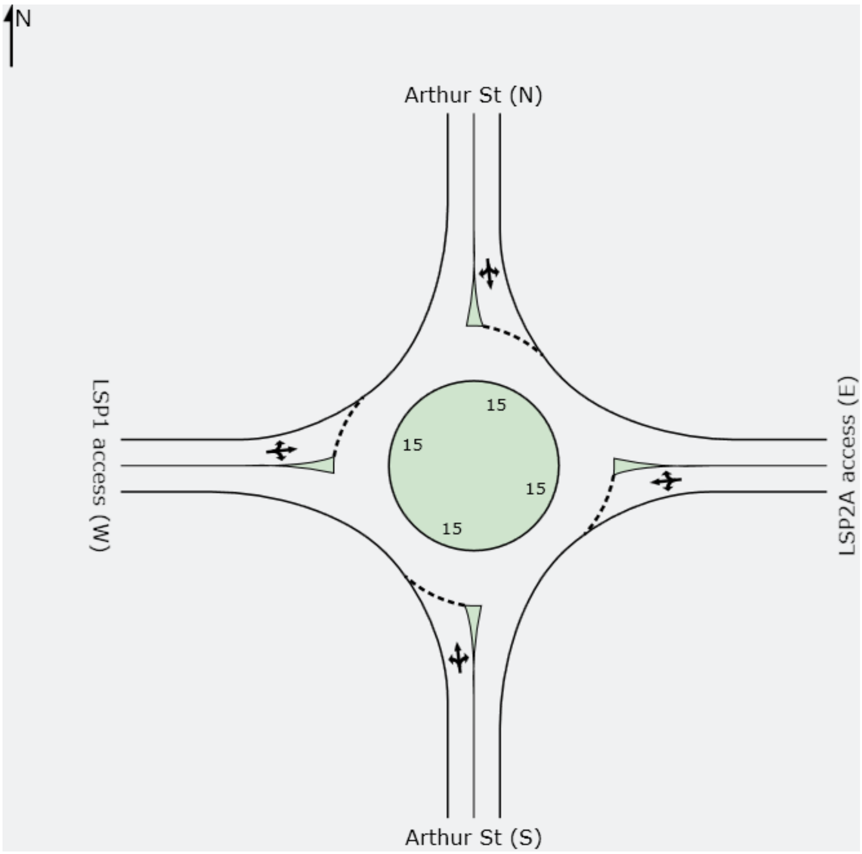
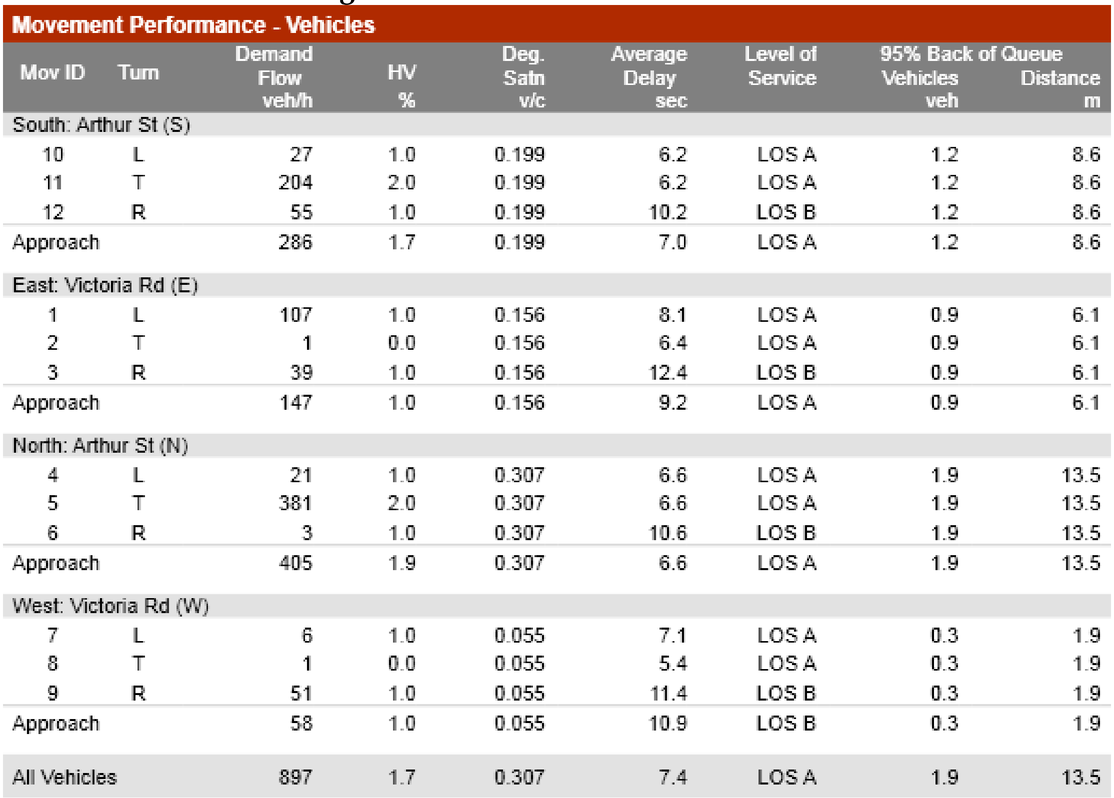


Figure D4. Arthur St / LSP1 / LSP2A roundabout layout analysed in SIDRA

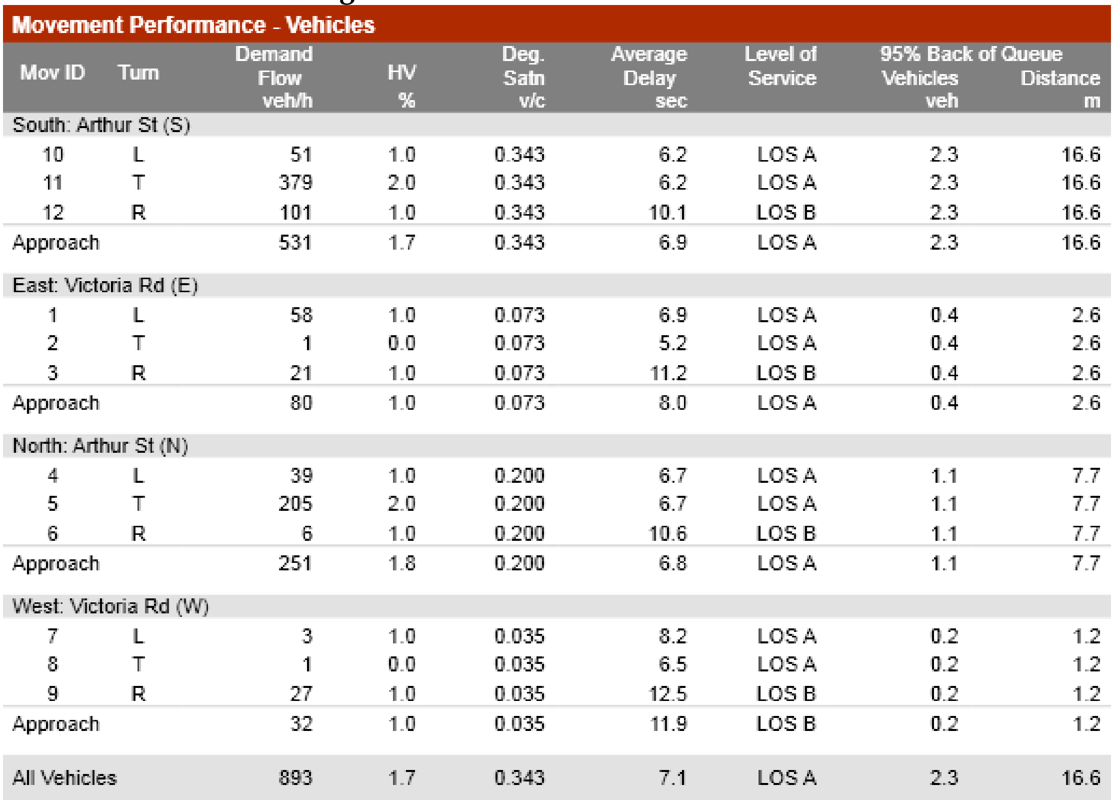
Table D5(a). SIDRA results – Arthur St / Victoria Rd roundabout – AM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: Arthur St (S)								
10	L	27	1.0	0.199	6.2	LOS A	1.2	8.6
11	T	204	2.0	0.199	6.2	LOS A	1.2	8.6
12	R	55	1.0	0.199	10.2	LOS B	1.2	8.6
Approach		286	1.7	0.199	7.0	LOS A	1.2	8.6
East: Victoria Rd (E)								
1	L	107	1.0	0.156	8.1	LOS A	0.9	6.1
2	T	1	0.0	0.156	6.4	LOS A	0.9	6.1
3	R	39	1.0	0.156	12.4	LOS B	0.9	6.1
Approach		147	1.0	0.156	9.2	LOS A	0.9	6.1
North: Arthur St (N)								
4	L	21	1.0	0.307	6.6	LOS A	1.9	13.5
5	T	381	2.0	0.307	6.6	LOS A	1.9	13.5
6	R	3	1.0	0.307	10.6	LOS B	1.9	13.5
Approach		405	1.9	0.307	6.6	LOS A	1.9	13.5
West: Victoria Rd (W)								
7	L	6	1.0	0.055	7.1	LOS A	0.3	1.9
8	T	1	0.0	0.055	5.4	LOS A	0.3	1.9
9	R	51	1.0	0.055	11.4	LOS B	0.3	1.9
Approach		58	1.0	0.055	10.9	LOS B	0.3	1.9
All Vehicles		897	1.7	0.307	7.4	LOS A	1.9	13.5

Table D5(b). SIDRA results – Arthur St / Victoria Rd roundabout – PM peak hour – long term ultimate scenario



Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m
South: Arthur St (S)								
10	L	51	1.0	0.343	6.2	LOS A	2.3	16.6
11	T	379	2.0	0.343	6.2	LOS A	2.3	16.6
12	R	101	1.0	0.343	10.1	LOS B	2.3	16.6
Approach		531	1.7	0.343	6.9	LOS A	2.3	16.6
East: Victoria Rd (E)								
1	L	58	1.0	0.073	6.9	LOS A	0.4	2.6
2	T	1	0.0	0.073	5.2	LOS A	0.4	2.6
3	R	21	1.0	0.073	11.2	LOS B	0.4	2.6
Approach		80	1.0	0.073	8.0	LOS A	0.4	2.6
North: Arthur St (N)								
4	L	39	1.0	0.200	6.7	LOS A	1.1	7.7
5	T	205	2.0	0.200	6.7	LOS A	1.1	7.7
6	R	6	1.0	0.200	10.6	LOS B	1.1	7.7
Approach		251	1.8	0.200	6.8	LOS A	1.1	7.7
West: Victoria Rd (W)								
7	L	3	1.0	0.035	8.2	LOS A	0.2	1.2
8	T	1	0.0	0.035	6.5	LOS A	0.2	1.2
9	R	27	1.0	0.035	12.5	LOS B	0.2	1.2
Approach		32	1.0	0.035	11.9	LOS B	0.2	1.2
All Vehicles		893	1.7	0.343	7.1	LOS A	2.3	16.6

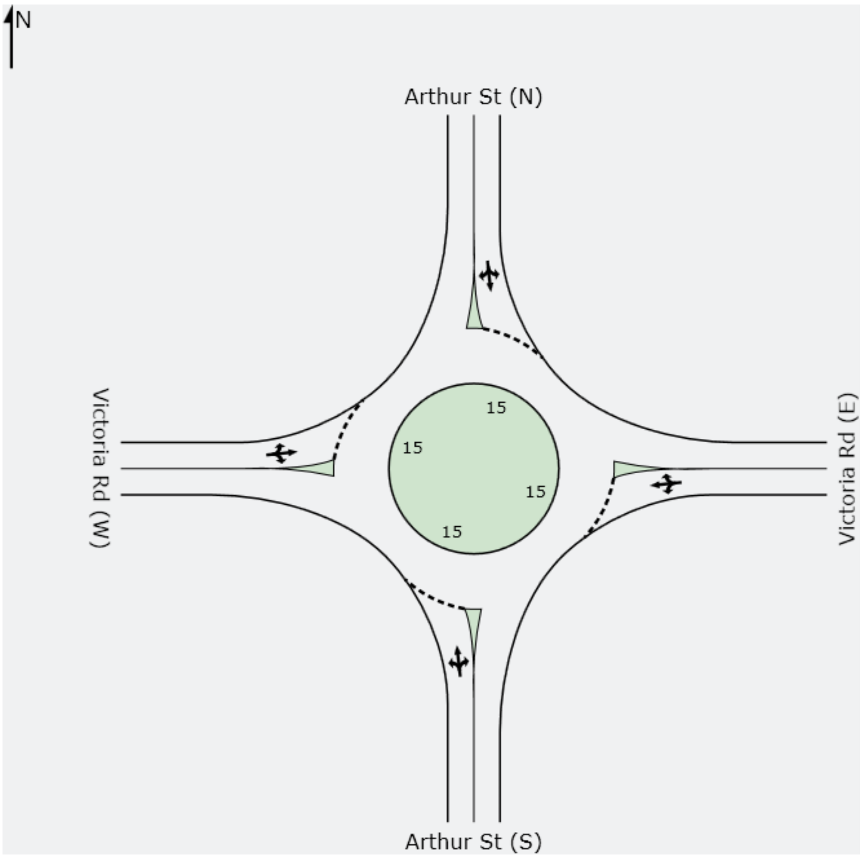


Figure D5. Arthur St / Victoria Rd roundabout layout analysed in SIDRA

APPENDIX E

ALTERNATIVE ROAD NETWORK WITH REALIGNMENT OF THE PERTH-DARWIN NATIONAL HIGHWAY

APPENDIX E

ALTERNATIVE ROAD NETWORK WITH REALIGNMENT OF THE PERTH-DARWIN NATIONAL HIGHWAY

In 2012 Main Roads WA reintroduced the idea of realigning the planned Perth-Darwin National Highway to the western side of Whiteman Park instead of the alignment on the eastern side of Dayton that is currently shown in the Metropolitan Region Scheme (MRS).

Main Roads WA and the City of Swan have subsequently prepared a concept plan for a district distributor road of dual carriageway standard on the current MRS PDNH alignment. (Referred to as the 'western distributor' in this Appendix.)

As this would be a lower standard road than the PDNH it would not require grade separation at Marshall Road and offers the potential for additional road connections from adjacent areas. It is understood that a connection from Harrow Street to this western distributor road has been included in the road network modelled in this work.

During this period the Department of Planning, in consultation with the City of Swan, has investigated intersection requirements on the planned Henley Brook Avenue. The department has subsequently advised that current planning indicates signalised four-way intersections on Henley Brook Avenue at Harrow Street and Marshall Road in the Dayton area and no connection to Coast Road on either side.

Previous analysis for Dayton local structure plans has indicated that Victoria Road / Henley Brook Ave would not be able to operate satisfactorily as a full movement unsignalised intersection and Main Roads WA would not support a signalised intersection there due to its proximity to the future Henley Brook Ave / Reid Hwy grade-separated interchange, so Victoria Road is assumed to be restricted to left in / left out at Henley Brook Avenue in future.

Main Roads WA has subsequently provided a limited amount of information on the future traffic volumes on the regional road network around Dayton for one particular road network scenario to assist planning within the Dayton area.

The EMME traffic model prepared by Transcore for Dayton has therefore been used to model a similar scenario, which may be considered to represent a likely future road network outcome. Particular features of this road network scenario include:

- Western distributor / Marshall Rd – full movement 4-way intersection
- Western distributor / Harrow St – full movement 3-way intersection
- Lord St / Harrow St – full movement 4-way intersection
- Henley Brook Ave / Harrow St – full movement 4-way intersection
- West Swan Rd / Harrow St – full movement 3-way intersection

- Henley Brook Ave / Marshall Rd – full movement 4-way intersection
- West Swan Rd / Marshall Rd – full movement 3-way intersection
- Henley Brook Ave / Victoria Rd – Victoria Road left in / left out only
- Arthur Street – no connection across Reid Hwy.

The resulting modelled traffic volumes for this scenario are illustrated in Figure E1.

One feature that should be noted is that Lord Street south of Harrow Street is not expected to carry very much through traffic in this scenario due to the Harrow Street link to the western distributor, so basically only traffic from within Dayton is likely to use this section of Lord Street in this scenario.

The forecast traffic volumes on West Swan Road east of Henley Brook Avenue are consistent with its current single carriageway standard.

The projected traffic volumes shown on Henley Brook Avenue and the western distributor are consistent with planning for these to be dual carriageway roads with two lanes in each direction.

The modelled traffic flows confirm that Marshall Road should be planned to the Integrator B standard proposed in this transport assessment.

Figure E1. 2031 Daily traffic flows at Dayton with a western distributor road instead of PDNH

APPENDIX 6

INFRASTRUCTURE AND SERVICING STRATEGY

TABEC
Civil Engineering Consultants

DAYTON DSP INFRASTRUCTURE REPORT – LSP 2A

FOR ST LEONARDS PRIVATE ESTATE PTY LTD

AUGUST 2012 – REV C

TABLE OF CONTENTS

INTRODUCTION

TABEC have been requested to provide an infrastructure assessment for the Dayton Local Structure Plan 2A Area landholdings held by St Leonards Private Estate Pty Ltd. This area is bounded by Arthur Street to the west, Reid Hwy to the south, the Dampier to Bunbury Natural Gas and Parmelia Gas Pipeline Corridor to the east, and the Marshall Road reservation to the north.

This document will form the basis of the engineering input into the overall submission for the Dayton Local Structure Plan 2A Area, which will be compiled by the nominated planner, Burgess Design Group. The document will aim to satisfy the requirements of the WAPC, Department of Planning and other relevant regulatory authorities in the planning process.

This infrastructure assessment is based upon Burgess Design Group's structure plan drawings current to September 2012.

1 EXISTING COMMUNITY AND ENVIRONMENT

1.1 Environmental

This section examines the existing site topography, vegetation and other natural or man-made features which are known to be within LSP 2A. The aim of this section is to clarify any potential issues and discuss the mitigation strategies which will be used in the delivery of the proposed residential land uses.

1.1.1 Topography and Landform

The site is generally flat and comparatively low lying with a high point at approximately RL18.0m AHD in the west of the LSP area around Arthur St and Kennedia Ent intersection, falling generally to the east / south-east to an existing open drains or approximate RL14.0m AHD.

The site has been extensively cleared in the past for agricultural usages and housing. There are minimal pockets of natural remnant vegetation within the LSP 2A area.

There are a number of existing houses, buildings and workshops within the subject area. The condition of these varies from inhabited to some part-demolished structures in yard areas. All demolition works required will be undertaken in accordance with the relevant Australian Standards, the relevant occupational health and safety requirements and the relevant regulatory authority requirements. A series of buildings have been successfully demolished within LSP 1, with clearance granted by our nominated environmental consultant on works.

There is visual evidence of some minor pockets of uncontrolled fill on properties within the area. Any areas with uncontrolled fill will be tested and approved for usage within the development, or remediation at an approved landfill site by a qualified environmental consultant.

The management of stormwater drainage and the importation fill will be a key factor for success in this development, particularly in the south-eastern corner of LSP 2A. Tabec and JDA will continue their close-working relationship in the formulation of drainage strategies for LSP 2A.

1.1.2 Soils and Geomorphology

Based on the 1:50,000 scale Environmental Geology Series Mapping (Perth Sheet) and Coffey Geosciences report (P7174.02-AA-Rev2 dated 21 August 2006), titled “Residential Subdivision, West Swan – Report on Preliminary Geotechnical Investigation”, it is anticipated that the subsurface profile of the site can generally be subdivided into three different formations. The first includes an area of thin Bassendean Sand over Guildford Formation in the southeast corner of LSP 2A. In accordance with Australian Standard AS2870-1996, it is anticipated that “A” site classifications can be achieved for these areas with additional importation of clean sand fill. The second formation is a relatively small area of swamp deposits in the north-eastern portion of LSP 2A that will have to be excavated and removed from the site due to both environmental and geotechnical requirements and subsequently replaced with imported fill, after which it is anticipated that “A” lot site classifications would be achieved. The final formation, which covers the remainder of the site, is that of Guildford Formation alluvium and if a minimum of 1.2m of existing or imported sand fill is achieved over these areas then it is anticipated that "S" lot site classifications could be achieved, otherwise "M" lot site classifications are likely. The occurrence of layers of weakly cemented dark brown silty sand and well (iron)-cemented silty sand or "coffee rock" is also likely.

It is noted that the geotechnical investigation referred to above is preliminary in nature and comprehensive geotechnical investigations will be carried out for each of the proposed subdivision areas.

All earthworks will be carried out in accordance with the provisions of Australian Standard AS3798-1996 "Earthworks for Residential and Commercial Development".

1.1.3 Surface Hydrology and Groundwater

The West Swan Estate Local Water Management Strategy (LWMS) prepared by Jim Davies & Associates "*proposes a Controlled Groundwater Level (CGL) approach to water table control, to minimise the requirement for imported fill*". This would include the installation of subsoil drainage within all road reserves serving lots with design / finished pad levels that are less than 1.5 metres above Average Annual Maximum Groundwater Levels (AAMGL's).

According to the July 2012 LWMS, it is expected that the majority of LSP 2A has depth from natural surface to groundwater of approximately 0.7 metre on average. As a result there is a significant imported fill requirement for land within LSP 2A. Where possible suitable material may be cut from areas where there is more than 1.5 metres of existing sand fill above the AAMGL's, however other factors such as minimising depth of services across the site, maintaining existing topography character and vegetation need to be considered.

The LSP2A area, south of Coast Road, generally drains south-east toward Victoria Road, which conveyed runoff further east towards West Swan Road via two roadside table drains. Ultimately this drain connected back to Bennett Brook downstream.

The LSP2A area, north of Coast Road, generally drains north-east towards Marshall Road Drain, then ultimately connecting to the Swan River approximately 7km directly east.

1.2 SERVICE INFRASTRUCTURE

This section documents the locations of existing services infrastructure pertinent to the development of the subject site. Commentary regarding the suitability of services for connection to the site, and likely extension / upgrade requirements is documented in Section 2 of this report.

1.2.1 Sewerage System

Existing sewer infrastructure is available as follows: -

- Existing deep sewer is available in Arthur Street for the connection of LSP2A western half, pending construction of regional infrastructure by the Water Corporation. This is expected to be completed and commissioned by the end of 2013.

- An existing temporary pumping station in Bennett Street between Suffolk Street and Benara Road with excess capacity to service approximately 500 lots, located approximately 2.5 kilometres south of the subject site, dependent upon the route chosen.
- An existing rising main from the temporary pumping station in Bennett Street heading north toward the intersection of Suffolk Street.
- An existing gravity main in the vicinity of the intersection of Bennett Street and Suffolk Street, approximately 1 kilometre south of the subject site.

Prior to the completion of the LSP process, sewer infrastructure for the expansion of LSP 2A was constructed in Coast Road for St Leonards Estate Stage 1J of St Leonards (located approximately 100 metres east of Arthur Street).

1.2.2 Water Supply

Existing water infrastructure is available within and adjacent to LSP 2A as follows: -

- 250mm-diameter main on the western side of Arthur Street
- 150mm-diameter main on the northern side of Coast Road in the vicinity of Stage 1J (approved for release under the Early Release approval)

1.2.3 Electricity

Existing power services are available within the vicinity of the site as follows: -

- Existing aerial LV is available on a number of roads within the subject area including Arthur Street, Victoria Road, and Coast Road.
- Existing underground LV and HV is available in the vicinity of the subject area with reticulation in: -
    - Arthur Street for Stages 1A and 1B
    - Grandis Street (formerly Victoria Rd) near the intersection of Arthur Street
    - Coast Road in the vicinity of Stage 1J

Western Power requires the submission of a Design Information Package prior to the confirmation of staging requirements. The requirements for a Zone Sub Station are being finalised with Western Power as part of the development requirements for the full DSP area.

More information is detailed in Appendix A – Servicing Report for Site Electrical Services LSP 2A & 2B.

1.2.4 Telecommunications

Telstra Network:

Existing telecommunications services are available within the vicinity of the site as follows: -

- Arthur Street (north and south of the Reid Highway) – optical fibre on the western side of the existing road carriageway.
- Arthur Street – local cable (some nominated as dead) on the western side of the existing road carriageway.

- Victoria Road and Coast Road – local cable on the northern side of the existing road carriageway.

NBN Network:

Several completed subdivisional developments adjacent to LSP2A are ready to be service by NBN Co.'s fibre. St Leonards Estate Stage 1D, 1E, and 1F are believed to be service via a Fibre Access Node at the Telstra Bassendean Exchange.

1.2.5 Gas

WA Gas Networks recently provided a pressure reduction valve on the existing high pressure gas main in Marshall Road near the intersection of Arthur Street. This PRV provides the connection point for gas services in the area.

Prior to completion of the LSP process, some underground infrastructure have been provided along Coast Road for the connection of St Leonards Estate Stage 1J, 36 lots Development (approximately 100 metres east of Arthur Street).

2 DAYTON STRUCTURE PLAN AREA – PROPOSED SERVICING

This section documents the expected infrastructure upgrades required to service the proposed subdivision of the LSP 2A area. It is based upon an assessment of the existing infrastructure, its proximity to the site and our experience with similar projects.

2.1 Engineering

This section summarises the infrastructure requirements for the future residential population of the Dayton LSP 2A Structure Plan area.

2.1.1 Earthworks

Most areas subject to development are expected to require modification to the topography to suit the change in land usage from agricultural uses to residential purpose, due to the proximity of the AAMGL and the existing ground surface.

The site offers a number of key issues in the earthworks phase, namely: -

- Dust control requirements during earthworking in drier periods.

The use of water carts and wind fencing has been successful in the suppression of dust during dry periods in the development of LSP 1 landholdings over the past 2 years. These methods will be continued into the future in all developments within the Dayton DSP areas. Where practical it is beneficial to commence earthworks fill contracts in the wetter months.

- Groundwater / saturated conditions in wetter periods.

Areas of high natural groundwater are likely to exist in LSP 2A, similar to pockets which existed within LSP 1. Temporary groundwater management measures such as trench dewatering and spear dewatering around deep manhole excavations will be required for some sections of deep sewer and / or stormwater drainage, however the sections of deep excavation are likely to be confined to short runs and are highly manageable.

- Removal of some areas of imported debris and fill.

Removal of imported debris and fill has been managed under an approved management plan in LSP 1 to the requirements of the Department of Environment. Imported fill materials into sites will be reviewed for their compliance with current environmental regulations. Where possible the materials will be used in an approved manner within the site as is preferred under the current regulations, with any unsuitable materials “screened” and taken to an appropriate landfill site.

- Removal of some areas of remnant floodplain materials with potential (albeit minimal) acid sulphate risks and / or general deleterious materials such as peats.

Remnant floodplain areas have been mapped in LSP 1 and 2A and have been the subject of extensive potential acid sulphate soils reporting by Bioscience. In general, the presence of acid sulphate soils within the subject area is limited to depths greater than 5 metres as has been evidenced in studies completed thus far. It is expected there will be minimal excavation required around these depths within the LSP 2A area, particularly given the amount of imported fill required for land development in the area.

Any proposed sewer or stormwater drainage routes with expected excavation depths greater than 3 metres will be reviewed for PASS in accordance with current management plan requirements.

2.1.2 Stormwater Management

The subdivision drainage within the subject area will need to be constructed in accordance with the City of Swan's subdivision "Guidelines and Standards" and Jim Davies and Associates' West Swan Estate Local Water Management Strategy July 2012 (LWMS).

Particular reference is made to Section 4.3 on Surface Water Management within the LWMS for further detail on drainage treatment and regional & local flood management. In short for the regional flood management this concludes that there is *no flow entering the West Swan East cell from external areas*, and that *the study area is well above* the 100 year flood levels of Bennett Brook and Swan River floodplain.

In accordance to the LWMS, stormwater drainage system will be designed and using a major/minor approach adhering to DWMS flow criteria. The minor drainage system will convey runoff for storm events up to 1 in 5 Years ARI, via road gutter, and pits & pipes system. The major drainage system will be convey runoff for storm events greater than 5 years ARI, via roads network, drainage reserves, detention basins, and POS.

Effectively the LWMS emphasises the use of Water Sensitive Urban Design (WSUD) principles and in particular a treatment train approach for the area and management of water quality. The latest LWMS divided LSP2A into two catchment areas utilising Marshall Road and Victoria Street drainage system as arterial conveyance route to direct runoff towards the Swan River and Bennett Brook, respectively.

Development areas within LSP2A, north of Coast Road, will be graded north-east toward Marshall Road Drain, and then continue directly eastward towards the Swan River. Currently, 40% of Marshall Road Drain within the LSP2A area has been upgraded in conjunction with St Leonards Estate Stage 1K subdivisional development (within LSP2B). The remaining developments within this northern catchment area of LSP2A, will required to upgrade the adjacent section of Marshall Road Drain and provide onsite detention basin of 0.39ha for 5 Year ARI events, and 0.49ha for 100 Year ARI events, in accordance to the latest drainage modelling by JDA.

Development areas within LSP2A, south of Coast Road, will be generally graded south-east, towards the allocated POS/Drainage Reserve area. Stormwater will be detained within the POS prior to being conveyed via Victoria Street, continuing towards Reid Highway, West Swan Road, and finally looping back toward Bennett Brook through the Caversham Structure Plan area. JDA latest drainage modelling indicated that this catchment area will require 1.65ha and 1.82ha of detention area for 5 year ARI and 100 year ARI storm events, respectively.

The cost per lot to install the subdivision drainage system is expected to be relatively high when compared to conventional development as a result of the following: -

- The likelihood that many of the drainage lines deeper than 2 metres below finished surface may require dewatering during the construction phase.
- The DEC potentially requiring trench backfill to be neutralised with lime and the dewatering treated with a lime dosing unit where there is some evidence of potential and / or actual acid sulphate soils (as previously discussed, there has been minimal evidence of PASS within LSP 1 and LSP 2A within 5 metres of the natural surface.)
- The requirement for subsoil drainage in low-lying areas of the site, particularly expected close to POS areas and the tributary in the south-eastern corner of the LSP 2A area near Reid Hwy and in the vicinity of the DBNGP and Parmelia Pipeline Easement.
- The requirement for direct lot connections where the depth to clay, or clay equivalent soil types with low infiltration qualities from design levels is less than 2.0 metres.
- The requirement for Outlet Structures with trash racks and potentially significant retention basins.
- The likelihood of fragmented developments that do not have direct access to the local POS/Drainage Reserve area. As a result, temporary drainage basin must be created to detain the predevelopment flow onsite, until the Local POS/Drainage Reserve is finalised.

2.1.3 Roadworks

There are significant major roadworks and transportation links planned for the long term within the vicinity of the site.

The following transportation improvements have been catered for in the LSP 1 design process, with Tabec providing some preliminary design information for some components in consultation with MRWA and the Department for Planning and Infrastructure: -

- A major freeway-style interchange at the intersection of Reid Highway / Perth to Darwin Highway;
- Designs for flyovers and associated batters and drainage infrastructure on Arthur Street (over Reid Hwy) and Marshall Road (over the Perth to Darwin Highway) – completed by Tabec;
- Extension of Henley Brook Drive to the east of the St Leonards landholdings;
- It is worth noting that PTA have withdrawn the strategy for a heavy rail or light rail line, and have opted for busway corridor on the eastern side of the Lord Street carriageway, with a transit station located near the intersection of Lord Street and Reid Hwy.

The status and land requirement of these infrastructure upgrades will be considered in the short term, with commentary provided on the likely opportunities and constraints and any risks which require mitigation.

The subdivision roads within the subject area will be constructed in accordance with the City of Swan's subdivisional "Guidelines and Standards" and in accordance with Liveable Neighbourhoods guidelines. Road cross-sections configuration will be as per Transcore Transport Assessment Report.

The majority of paving will be black asphalt with entry statements, intersections, traffic calming devices and designated car-parking areas in red asphalt or brick paving. Additional parking will be placed around POS areas in consultation with the City of Swan where agreed.

Mountable and semi-mountable kerbing will bound the roads with flush kerbing adjacent to POS areas to allow runoff into grassed areas, (with bollards or similar to City of Swan approval provided to prevent vehicular access into the POS and anti-social behaviour).

Dual Use Paths and footpaths will also be provided in accordance with the guidelines and the Department for Planning and Infrastructure requirements and additional footpath links may be provided in other areas as required.

It is not anticipated that any of the existing roads within the site will be able to be maintained as they are in effect rural roads with inappropriate longitudinal and / or horizontal gradients. In many areas they will also need to be raised significantly to suit the post development finished levels due to the groundwater levels requirements.

The proposed Arthur Street Flyover (over Reid Hwy) will have significant effect on earthworks and development cost to subdivisional developments in the southwest corner of LSP2A. Significant amount of import fill may be required to lift Lots level in this area to avoid the lot product being over shadowed by the Flyover, and Victoria Road may need to be lift to tie-in with the Flyover. Overhead power line (132kV) and fibre optic cable will need to be reconstructed as part of the Flyover construction.

2.1.4 Water Supply

The Water Corporation recently completed the installation of a DN600 water main (2690m) from the intersection of Benara and Altone Roads to the intersection of Suffolk Street and Lord Street extension. In conjunction is installation of a DN250 water main along Suffolk Street then along Arthur Street (1650m), which has also been completed.

This has improve the supply of water to residential areas in Caversham and Dayton, and which will act as an initial water supply for early stages of the Dayton Structure Plan area.

Future development of the Dayton DSP area requires construction of a 600mm diameter water main north along the Lord Street road reservation to the intersection of Lord Street and Marshall Road. The timing of this is still to be confirmed with the Water Corporation.

The full development of LSP2A will required the construction of a water ring main DN200 to DN250, along Victoria Rd, the future most eastern roads of LSP2A, and along Marshall Road.

The provision of water services is an iterative process and will be confirmed with the Water Corporation, and further dialogue is expected.

All lots will be provided with connections in accordance with Water Corporation requirements via the installation of water reticulation within the development within the common trench, along with other essential services.

2.1.5 Waste Management

This section on waste management will focus on three phases of the waste management process: -

- **The initial capacity expansion for approximately 500 additional lots**

  Construction and commissioning of a Type 40 pumping station on Brookleigh Estate, adjacent to Suffolk Street near the low point of the site. In addition, a rising pressure sewer main to connect into an existing gravity sewer near the intersection of Suffolk and Bennett Streets.

  This section has been constructed in full.

- **The ultimate capacity expansion to service the entire West Swan (East) catchment plus other developments in Caversham**

  This requires the construction of a Type 180 Pumping Station (Eden Hill Pump Station B) near the intersection of Benara Road and Bennett Street. Following various meetings in 2011 between the Water Corporation, the major Developers, and Engineering Consultancies operating in the Caversham and Dayton area, the Water Corporation are committed to advancing the development of the Eden Hill PS B and the associated infrastructures.

  The infrastructure includes the construction of a rising main connecting the proposed pump station to infrastructure approximately 4 kilometres away near the intersection of Benara Road and Tonkin Highway.

  The Pump Station and the associated pressure main are being delivered via the Water Corporation Capital Works Program, and planned for completion and commissioning at the end of 2013.

- **The internal servicing**

The Water Corporation's current planning allows for two sewerage catchment areas within the overall West Swan (East) Structure Plan area. These include: -

- A larger catchment including the developable area south of Reid Highway immediately adjacent to the St Leonards subject site and east to Bennett Brook as well as land to the west of the site, which is the West Swan (West) Structure Plan area.
- A smaller catchment located on the eastern boundary of the structure plan area that is contained entirely within the LSP 2A and LSP 2B.

The eastern portion of LSP 2A will drain into the 2nd smaller catchment nominated above, requiring construction of a Type 40 Pumping Station (Eden Hill F). This pumping station will pump into the western catchment, discharging via the same route as the remainder of the Dayton DSP area. Eden Hill F (Type 40) is currently proposed to be located near the intersection of Coast Road and the Dampier to Bunbury Natural Gas and Parmelia Gas Pipeline Corridor, within the development proposed POS area.

In conjunction, to the Eden Hill F Pump Station, a sewer pressure main is required to be constructed, running parallel to the 'Dampier to Bunbury Natural Gas and Parmelia Gas Pipeline Corridor', from Coast Road to Reid Highway (approx. 800m), and a DN225 gravity sewer main continuing directly southward towards Suffolk Street, then continuing eastward along Suffolk Street, and linking to the existing system on Arthur Street (approx. 920m).

The above infrastructure works related to, and including the Type 40 Pump Station is currently not under the Water Corporation Works Program, and there is no plan to deliver these infrastructures in the near future. As the proposed works will require crossing multiple landowners' boundaries and Reid Highway, it can be envisaged that the implementation of these works will be challenging.

The western portion of LSP 2A will drain directly into existing sewer assets in Arthur Street.

All proposed lots will be provided with connections in accordance with Water Corporation requirements.

The cost per lot to install the internal sewerage reticulation will take into account the following: -

- The likelihood that some of the sewer lines deeper than approximately 2.5 metres below finished surface level may need to be dewatered.

- The DEC potentially requiring trench backfill to be neutralised with lime and the dewatering treated with a lime dosing unit where there is some evidence of potential and / or actual acid sulphate soils where excavation depths exceed 3 metres.
- The potential for deep sewer lines due to the relatively flat nature of the site.

In summary, LSP 2A will utilise both a gravity system flowing toward Arthur Street, with the eastern third of this landholding requiring a pumping station to be constructed with pressure main infrastructure discharging to the existing system in Arthur Street. For LSP 2A to be fully developable, this will require the completion and commissioning of the Type 180 Pump Station (Eden Hill B), and Type 40 Pump Station (Eden Hill F), and the associated sewer mains.

2.1.6 Power Supply

Power Supply and Electrical Services are detailed in Appendix A.

2.1.7 Telecommunications

Communication networks, including Telstra and NBN are detailed in Appendix B.

2.1.8 Gas Supply

For the development of the area bounded by Lord Street, Marshall Road, Arthur Street and Reid Hwy, St Leonards Estates Pty Ltd provided a Pressure Reduction Valve (PRV) to existing Medium Pressure WestNet Gas assets in Marshall Road. This connection has been confirmed as sufficient for supply to all proposed land uses in LSP 1 and will be utilised for incremental development within LSP 2A.

PROJECT:

ST LEONARDS ESTATE – LSP 2A & 2B
RESIDENTIAL DEVELOPMENT

SERVICING REPORT FOR:

SITE ELECTRICAL SERVICES

DOCUMENT NO: 3E12109G-R-01

CIVIL ENGINEERS:

TABEC

DOCUMENT PREPARED BY:

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Document History and Status

Revision	Date issued	Author	Reviewed by	Approved by	Revision Description
A	5/10/12	JH	DLJ	DLJ	Preliminary
B	29/11/12	JH	VH	DLJ	Issued for Information

SECTION 1 EXISTING POWER NETWORK

1.1 DISTRIBUTION

The existing Western Power (WP) Distribution infrastructure in the vicinity of and throughout the site comprises of a mix of High Voltage (HV) aerial lines, and underground cables. The aerial infrastructure is many years old, while the cable network has generally been installed through the initial stages of recent development. The voltage of the HV network is 22kV, and is a three phase network.

The HV network is fed from the Beechboro Zone substation, approximately 5km to the West. Three of the HV feeders emanating from this Substation end up at the development area, after passing through and servicing much of the developed area in between, as well as continuing beyond and servicing other areas. There is currently no dedicated HV feeder from a Substation to the development site.

One of the feeders (BCH506) feeds much of the area immediately north east of the Zone substation through a cable network which heads towards the estate, crossing the Reid Hwy at Arthur st and entering the estate. It feeds the HV aerials at Arthur st, and therefore currently feeds much of the recently developed estate.

The second of the feeders (BCH509) takes a route generally along Beechboro Rd, Bennet Springs Dr, Marshall Rd and then Cranleigh st, reaching the western edge of the development area at an isolation point near Lord st. It therefore does not currently feed any of the estate.

The other feeder (BCH518) takes a route along Benara rd, then up West Swan rd, before heading back towards the development area along Cranleigh st, meeting the first feeder at a HV isolation point just east of Arthur st. It also currently does not feed any of the estate.

Please refer to the extract of WP's SpiderWeb system in the WP feasibility report in the appendix.

WP's feasibility report states that feeders BCH506 and BCH509 are both close to their capacity. It states that BCH518, however, has some spare capacity and therefore may feed initial stages of LSP2A & LSP2B development.

From Western Power's public Network Capacity Mapping Tool, some limited information on the capacity of the Beechboro Zone Substation can be found. Currently there is in excess of 20MVA capacity in the Substation. Within ten years, this is expected to diminish to less than 5MVA, due to growth in the area surrounding it.

1.2 TRANSMISSION

Crossing the estate is both a 330kV Transmission line and a 132kV Transmission line. These overhead Transmission lines do not directly service the development, but do carry easements and therefore have an effect on the land usage of the areas immediately adjacent to them.

The 330kV line is an East-West line on the south side of Marshall rd, which traverses the entire estate. It is covered by a 60m easement.

The 132kV line runs next to the 330kV line from Lord st along Marshall rd, south of the road, but north of the 330kV line. It then turns South at Arthur st, where it then continues on the West side of Arthur st, and then crosses the Reid Hwy. The 132kV line is covered by an 18m easement.

SECTION 2 POWER SUPPLY SCENARIO

2.1 LIKELY LOAD

The combined potential lot yield for the LSP 2A & 2B areas is 1300 lots, with LSP 2A potentially yielding 900 lots, and LSP 2B 400 lots. The expected power load requirement for these combined areas, at Western Power’s standard 4.7kVA ADMD value, is approximately 6.5MVA.

The expected development rate of planned development under the scope of this report is as follows.

Within the LSP 2A area, approximately 240 lots will be developed within the period starting in 18 months and finishing in 24 months. This will add approximately 1.2MVA on to the network.

Within the LSP 2B area, approximately 60 lots will be developed within the period starting in 6 months, and finishing in 18 months. This will add approximately 300kVA on to the network.

Subsequent to these above timeframes is less certain, with an approximation of 120 lots per year per area used as basis for load growth estimates. On this basis we would anticipate this area reaching the 6.5MVA load estimate by 2020.

2.2 LIKELY POWER SUPPLY SCENARIO

Western Power requires that all new developments are to be serviced by underground three phase power. Western Power also require any existing HV and LV aerials adjacent to the land being subdivided to be undergrounded and any existing consumers affected will have to have their consumer mains reconnected to the network.

Completed stages have been serviced with new underground infrastructure, as above, and are supplied by the BCH506 HV Feeder as mentioned in section one. It is anticipated that LSP2A & LSP2B will initially be fed from BCH518 this HV feeder will only be able to service one or two more stages, consisting of 120 or so lots.

To utilise the spare capacity on the BCH518 HV feeder, some network upgrade or extension works could be required to facilitate this, depending on the development staging. This could be completed in stage if the construction staging suited the location of the existing network - Stage 1L would be ideal in accessing this HV feeder in terms of location and expected timing. If not, they could be performed out-of-stage which would be slightly more difficult (access to land for new ground mounted switchgear issues etc).

As confirmed in the WP Feasibility report – at some stage, given the extent of the load of the planned development, and the expected limited capacity of the three existing HV feeders, a new dedicated feeder will be required to be installed from a Zone Substation to the development site. WP has advised that they will complete the design and construction of this HV feeder, as it is outside of the development site. The need for this feeder will simply be triggered by an application for a stage of development which, in their assessment, by its timing will be suitable for the HV feeder to be associated with.

2.3 BUDGET ESTIMATES

Typical costs for supplying power to residential lots is $8,000 - $10,000 (ex GST) per lot. This can vary depending on what works are associated with the stage such as new HV substations, roundabout lighting, existing Distribution aerial removal and Transmission asset relocations etc. More detailed cost estimates can be created for each stage once detailed design is complete. This cost estimate excludes trenching, cable laying, use of decorative street lighting, design fees and HV headworks associated with bringing power to the development site.

The WP feasibility report has stated that the cost of the new HV dedicated feeder to be in the order of $4.2M. While the feeder will be a dedicated feeder to the area, and may be driven by development within LSP 2A & 2B, it may also supply other developments in the immediate area. The estimate load of this site (6.5MVA) makes up only a portion of the total capacity of the proposed feeder, which is typically in the order of 10MVA. The remaining capacity can be used to supply the growth in these adjacent developments. As such, the cost of this feeder will be shared across those developments that access the feeder.

So based the estimates above, the cost of the feeder that will be attributed to the lots released by St Leonards Estate in LSP2A & LSP2B will be $2.8M.

--- End of Report ---

APPENDIX A – WP Feasibility Report & Estimate

westernpower

Electricity Networks Corporation
ABN 18 540 492 861
Locked Bag 2520 Perth WA 6001

Enquiries

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TTY 1800 13 13 51

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enquiry@westernpower.com.au
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Your reference:	3E12109G
Request reference:	MF010126
Fax:	9225 2073

29 October 2012

3E Consulting Engineers Pty Ltd
Suite 1 Level 2, 22 St Georges Terrace
PERTH WA 6000

Attention: James Hutton

Dear James,

ST LEONARDS ESTATE - LSPSA & 2B
WESTERN POWER REF: MF010126, WAPC No: N/A

In response to your request for a Feasibility Study, I am pleased to provide you with the attached report.

Our Tax Invoice will be sent to you in due course. The amount due includes the standard fee of $775.00.

The following is an estimated cost of the high voltage distribution works to provide electricity distribution capacity to your proposed development. This estimate is based on a desktop review of your requirements and the existing electrical network.

FEASIBILITY ESTIMATE

The estimated cost of the reinforcement works for the installation of 7.5km of HV feeder cable and associated zone sub works to your proposed development is $4,180,520.00, including GST.

Please note the following important information about this estimated cost:

- It is an indicative figure only, to assist you to plan and make decisions about your project.
- The final quoted cost may be higher or lower than this estimate. In some cases, final quotes are significantly higher than estimates, because of ground conditions and other impediments identified during the site visit and / or fluctuations in the cost of materials and labour etc.
- This estimated cost is non-binding.

DISCLAIMER

- This information is based on information available today.
- Western Power cannot reserve any capacity to accommodate the proposed development unless a quotation is offered and accepted.
- Western Power accepts no responsibility for any consequences resulting from decisions made on the basis of information provided in this response.

ANY QUESTIONS?

If you have any questions, please telephone our Customer Contact Centre on 13 10 87 during business hours.

Yours faithfully

Simon Bradbrook
Connections Manager
Customer Assist

enc: Terms and Conditions

westernpower

Electricity Networks Corporation
ABN 18 540 492 861

FEASIBILITY STUDY TERMS AND CONDITIONS

1. Terms and Conditions

These terms and conditions shall form part of the contract unless specifically excluded in writing by an authorised representative of Western Power.

2. Consequential Loss

Damages shall be limited to damages for direct and foreseeable loss attributable to breach or default under this Agreement. The rights of either party to damages for indirect or consequential loss are hereby excluded. Neither party shall be liable to the other for any loss of profit suffered by a party to this Agreement or any other person.

3. Modification

A purported modification, variation or amendment of this Agreement including the scope of works or any waiver of any rights of any party or any approval or consent shall have no effect unless in writing and signed by the party to be charged, and may attract a subsequent fee.

4. Application of Acts and By-Law

Nothing contained in these Terms and Conditions shall in any way limit the operation or effect of the Electricity Corporation Act 1994, Energy Corporations (Powers) Act 1994, Energy Corporations (Transitional and Consequential Provisions) Act 1994, or any Regulations, By-Laws or Orders made pursuant thereto.

5. Ownership of Works

The whole of the electricity extension that forms the works carried out in accordance with the proposal is the property of Western Power and Western Power has the right to connect additional customers to any part of the extension.

6. Indicative Estimate

This indicative estimate of the cost of electrical distribution [and transmission] works is ONLY AN INDICATIVE ESTIMATE.

7. Assumptions

Western Power has calculated the indicative estimate on the basis of a "desktop study" only which includes information readily available at the time and certain assumptions regarding the project and costs. The information and assumptions may turn out to be incorrect or incomplete.

8. Fluctuations

Construction costs, including materials and labour, are subject to fluctuation and may change significantly over time. The final quoted cost may be higher or lower. In some cases final quoted costs are SIGNIFICANTLY HIGHER than indicative estimates.

9. Liability

Western Power has calculated the indicative estimate in good faith however Western Power, to the extent permitted by law, accepts no liability for any errors or omissions or for any discrepancy between the indicative estimate and the final quoted cost, if any.

FEASIBILITY STUDY

St Leonards Estate – LSP2A & 2B

Work Request Number: ***MF010126***

1. Introduction

Western Power has been requested to conduct a feasibility study to supply St Leonards Estate – LSP2A & 2B. Based on the request, the approximate max total load increase is 6110kVA.

This feasibility study looks at a new proposed subdivision in the suburb of Dayton. The stage for the load take up timing is approximately 2021. Details of the project are as follows:

Project Name:	St Leonards Estate – LSP2A & 2B
Consultant:	3E Consulting Engineers Pty Ltd
Customer's Name:	Mr James Hutton
Number of Stages:	N/A
Proposed Max total Load Increase:	6110 kVA (1300 Lots)

2. Existing Infrastructure

The proposed load increase could be supplied from 22kV Beechboro Zone Substation. The max total load increase of 6110kVA on the 22kV distribution network would represent approximately 160.35A increase on the HV feeder.

The site is approximately 5.2km away from the Beechboro Zone Substation as shown in the figure below.

The closest feeder to the proposed subdivision is BCH518 – 122 Benard Rd which is supplied from Beechboro Zone Substation.

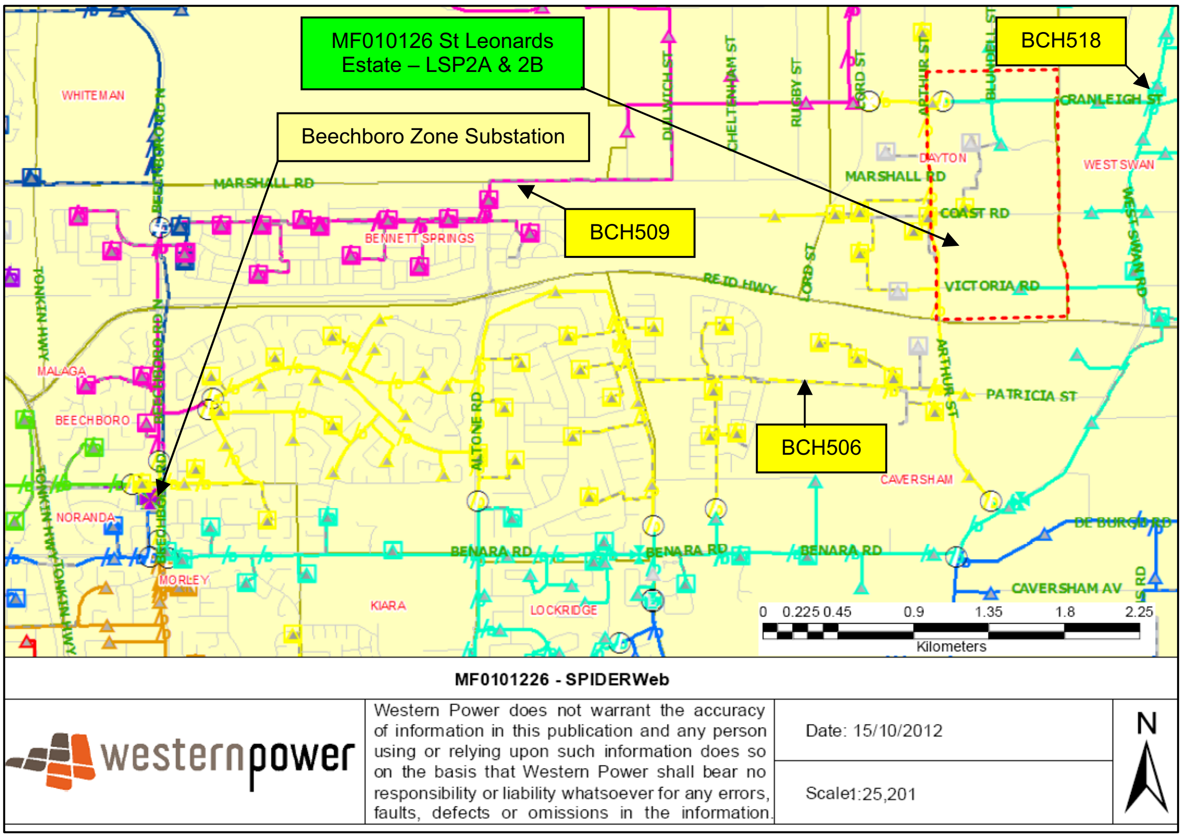


Figure 1

3. Study Details

Please be advised that the feasibility study was conducted considering load requests for other surrounding developments in the region.

As per the application (refer to appendix A), development of St Leonards Estate – LSP2A & 2B will create a residential of 1300 lots. Following customer advice, it is separated into 2 sections which are LSP2A and LSP2B.

LSP2A will have 900 lots in total. From approximate May 2014 to May 2015, 240 lots will be created. After that an estimate of 120 lots will be created per year. LSP2B will have 400 lots in total. From approximate May 2013 to May 2014, 60 lots will be created. After that an estimate of 120 lots will be created per year.

As it is a residential development, each lot will be 4.7kVA. Therefore the total load required for this development will be approximately 6110kVA

Table below is the summary of load(KVA) increase in each year.

	LPS 2A		LPS 2B		LPS 2A & 2B	
Year	Lots	Load	Lots	Load	Lots	Load
May2013-May2014	0	0	60	282	60	282
May2014-May2015	240	1128	120	564	360	1692
May2015-May2016	120	564	120	564	240	1128
May2016-May2017	120	564	100	470	220	1034
May2017-May2018	120	564	0	0	120	564
May2018-May2019	120	564	0	0	120	564
May2019-May2020	120	564	0	0	120	564
May2020-May2021	60	282	0	0	60	282
Total	900	4230	400	1880	1300	6110

Based on the 2012 Summer Peak Load and number of projects that are currently still under construction, BCH506 feeder and BCH509 feeder are reaching their full capacity. Fortunately, there is spare capacity on the BCH518 feeder. Based on the time frame of the commencement date for the development, BCH518 will be able to initially supply the load. Some reconducting of low rated conductor may be needed on the feeder backbone. However, it will not be able to handle the entire load. Therefore, a new feeder at some point in time is required to supply the development. The exact time is uncertain due to underline growth, new developments or lots taken up. In addition, Beechboro Zone Substation is of outdoor 22KV construction, thus the 22KV busbar augmentation could be required in order to add a new feeder circuit. As a result, the new feeder construction could take up to 18 months.

Disclaimer: The timing of the above is highly dependent on the load uptake of other developments, and also the future load growth in the surrounding area. Please note that a formal request is required to be submitted before a detailed analysis is conducted to determine the exact requirements.

4. Conclusion

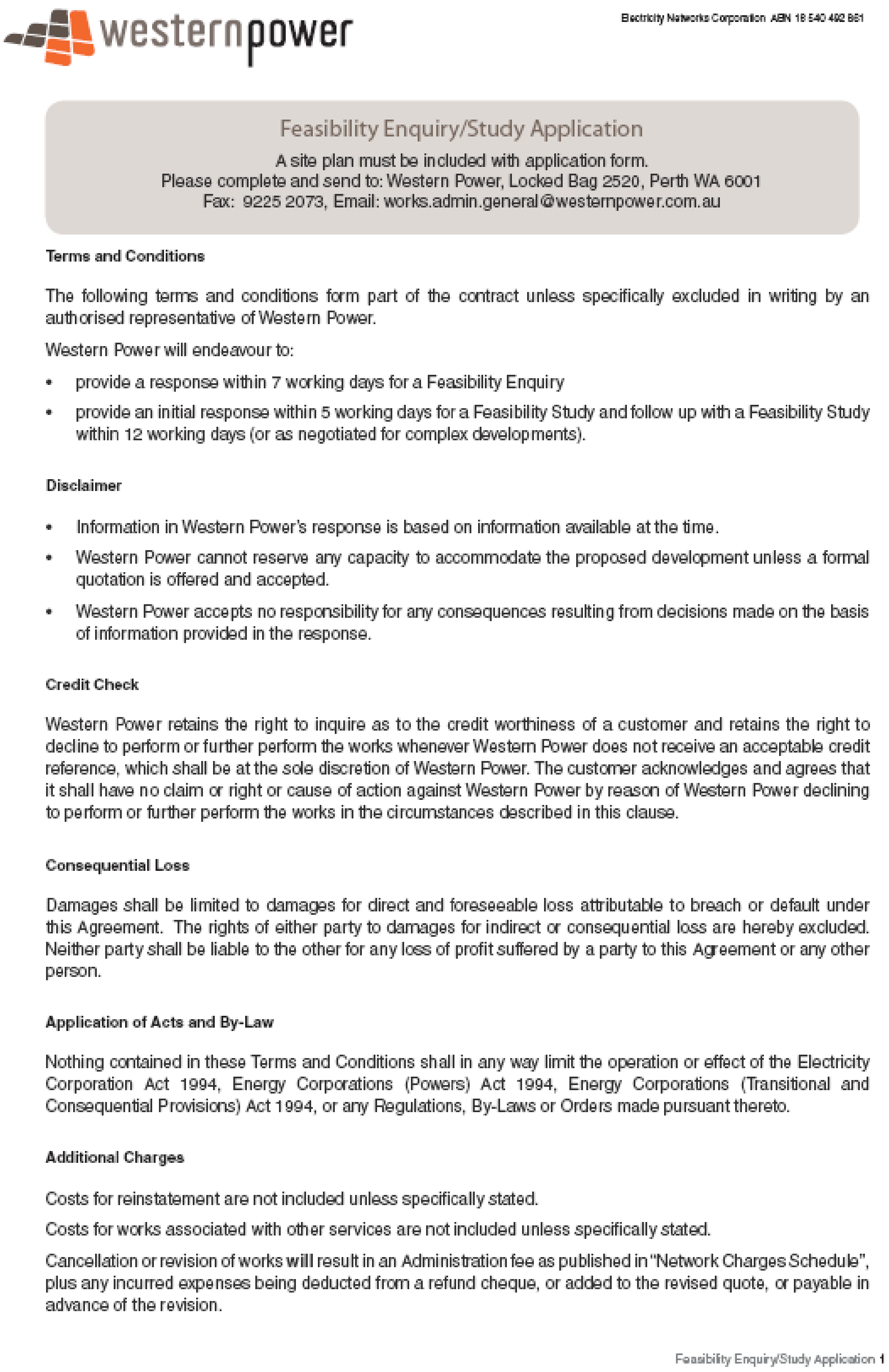
Based on the study and the existing HV distribution network infrastructure surrounding the development, BCH518 - 122 Benard Rd Feeder should have sufficient spare capacity to accommodate an initial load increase. However, due to the total load request, a new feeder is needed to supply the development at some point in time.

5. General Assessment

The timing mentioned in this study is highly dependent on the load growth in the region and may change. The details in this feasibility enquiry report are only indicative. Further in-depth study and analysis will be required to determine the exact requirement of the connection works once a formal application to Western Power has been lodged. It would be appreciated that at the time of the initial application, a staging plan with expected take up dates be provided to Western Power.

Western Power can neither reserve capacity nor guarantee supply to this development without a formal request being lodged. In order to provide a firm connection proposal and cost, a formal application to Western Power will have to be made, in accordance with our connection policies.

Appendix A



Electricity Networks Corporation ABN 18 540 492 861

Feasibility Enquiry/Study Application

A site plan must be included with application form.
Please complete and send to: Western Power, Locked Bag 2520, Perth WA 6001
Fax: 9225 2073, Email: works.admin.general@westernpower.com.au

Terms and Conditions

The following terms and conditions form part of the contract unless specifically excluded in writing by an authorised representative of Western Power.

Western Power will endeavour to:

- provide a response within 7 working days for a Feasibility Enquiry
- provide an initial response within 5 working days for a Feasibility Study and follow up with a Feasibility Study within 12 working days (or as negotiated for complex developments).

Disclaimer

- Information in Western Power's response is based on information available at the time.
- Western Power cannot reserve any capacity to accommodate the proposed development unless a formal quotation is offered and accepted.
- Western Power accepts no responsibility for any consequences resulting from decisions made on the basis of information provided in the response.

Credit Check

Western Power retains the right to inquire as to the credit worthiness of a customer and retains the right to decline to perform or further perform the works whenever Western Power does not receive an acceptable credit reference, which shall be at the sole discretion of Western Power. The customer acknowledges and agrees that it shall have no claim or right or cause of action against Western Power by reason of Western Power declining to perform or further perform the works in the circumstances described in this clause.

Consequential Loss

Damages shall be limited to damages for direct and foreseeable loss attributable to breach or default under this Agreement. The rights of either party to damages for indirect or consequential loss are hereby excluded. Neither party shall be liable to the other for any loss of profit suffered by a party to this Agreement or any other person.

Application of Acts and By-Law

Nothing contained in these Terms and Conditions shall in any way limit the operation or effect of the Electricity Corporation Act 1994, Energy Corporations (Powers) Act 1994, Energy Corporations (Transitional and Consequential Provisions) Act 1994, or any Regulations, By-Laws or Orders made pursuant thereto.

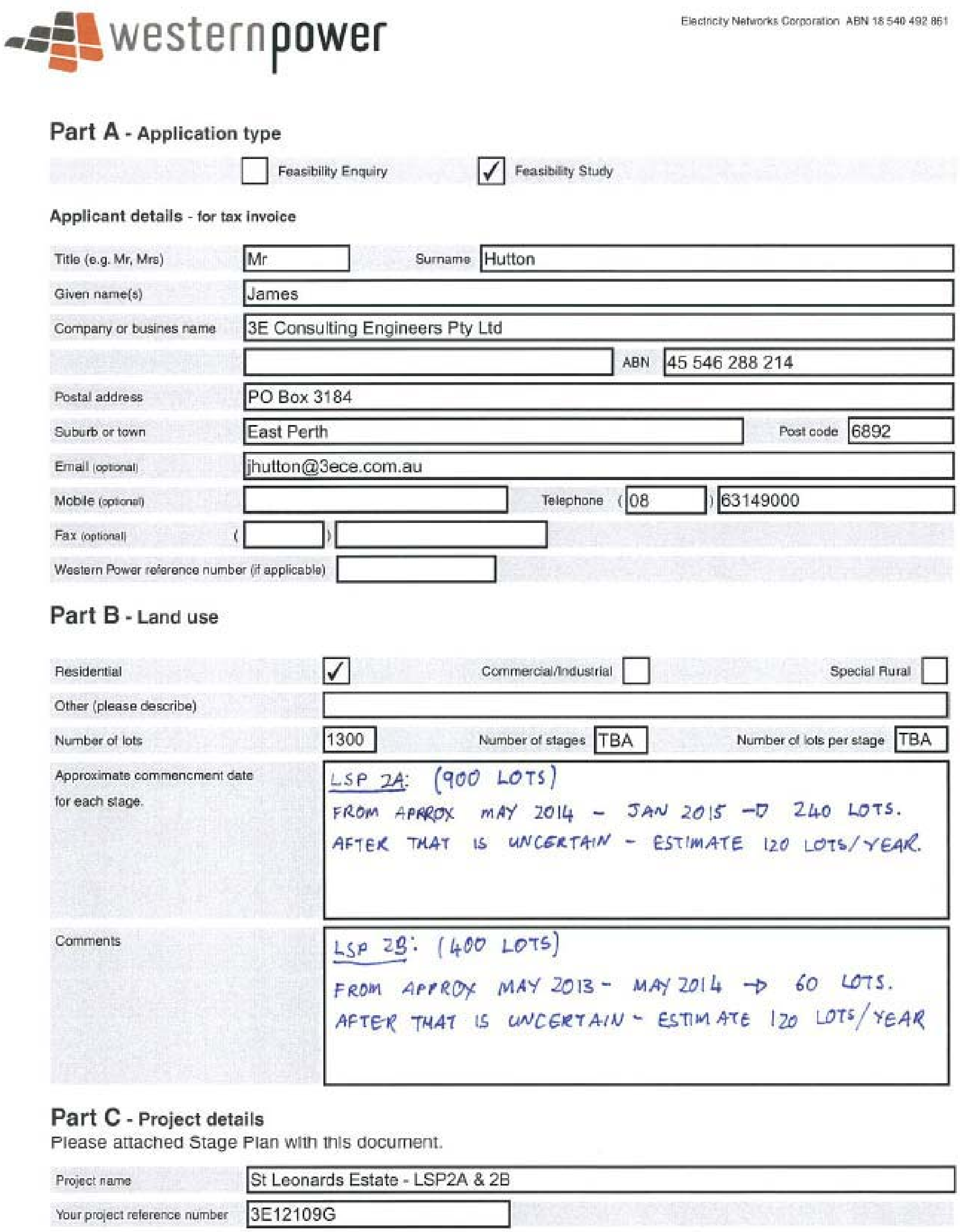
Additional Charges

Costs for reinstatement are not included unless specifically stated.

Costs for works associated with other services are not included unless specifically stated.

Cancellation or revision of works will result in an Administration fee as published in "Network Charges Schedule", plus any incurred expenses being deducted from a refund cheque, or added to the revised quote, or payable in advance of the revision.

Feasibility Enquiry/Study Application 1



westernpower

Electricity Networks Corporation ABN 18 540 492 861

Part A - Application type

☐ Feasibility Enquiry ☑ Feasibility Study

Applicant details - for tax invoice

Title (e.g. Mr, Mrs)	Mr	Surname	Hutton
Given name(s)	James		
Company or busines name	3E Consulting Engineers Pty Ltd		
		ABN	45 546 288 214
Postal address	PO Box 3184		
Suburb or town	East Perth	Post code	6892
Email (optional)	jhutton@3ece.com.au		
Mobile (optional)		Telephone	(08) 63149000
Fax (optional)	( )		
Western Power reference number (if applicable)			

Part B - Land use

Residential	☑	Commercial/Industrial	☐	Special Rural	☐
Other (please describe)					
Number of lots	1300	Number of stages	TBA	Number of lots per stage	TBA

Approximate commencment date for each stage.

LSP 2A: (900 LOTS)
FROM APPROX MAY 2014 - JAN 2015 → 240 LOTS.
AFTER THAT IS UNCERTAIN - ESTIMATE 120 LOTS/YEAR.

Comments

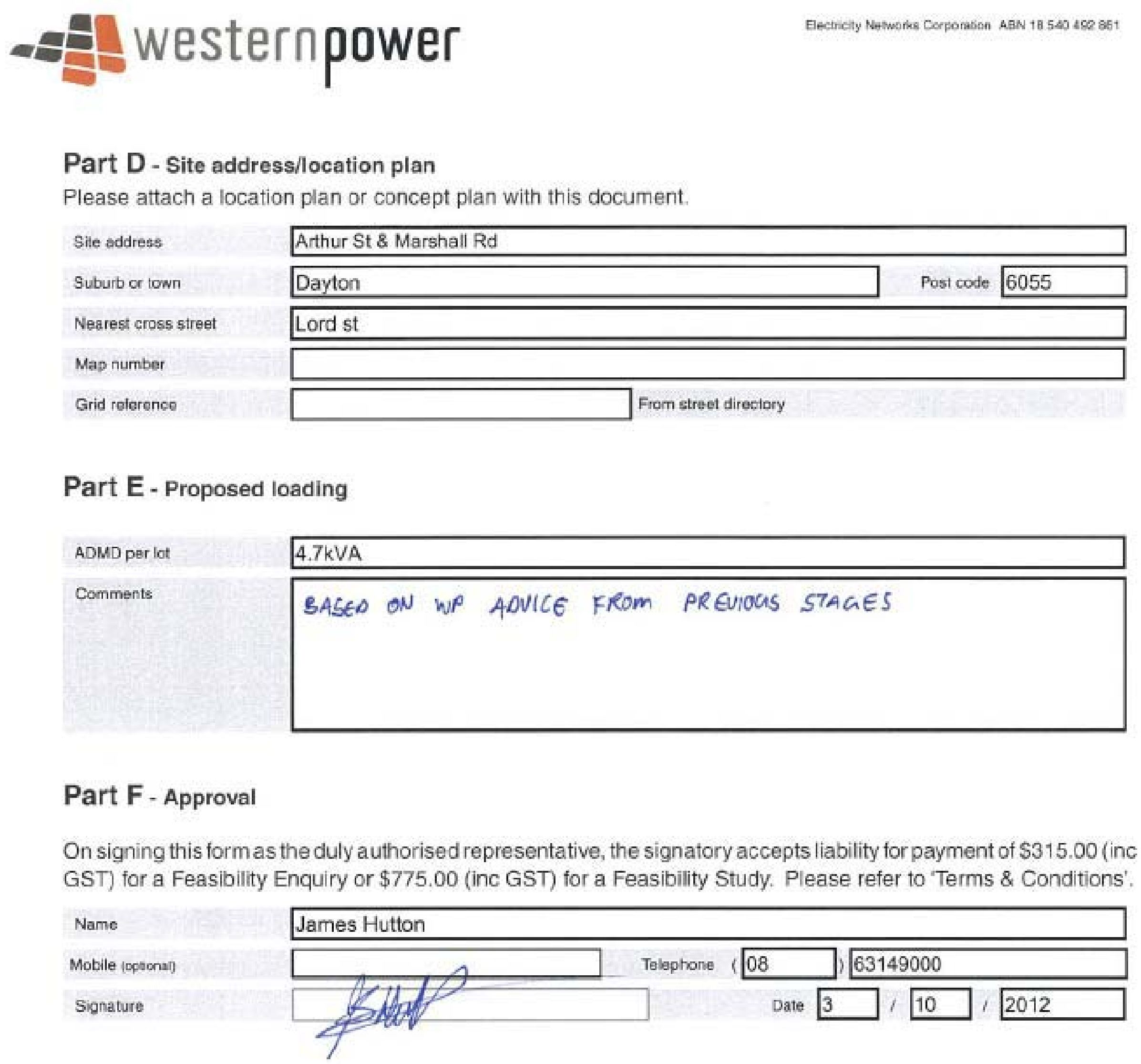
LSP 2B: (400 LOTS)
FROM APPROX MAY 2013 - MAY 2014 → 60 LOTS.
AFTER THAT IS UNCERTAIN - ESTIMATE 120 LOTS/YEAR

Part C - Project details

Please attached Stage Plan with this document.

Project name: St Leonards Estate - LSP2A & 2B

Your project reference number: 3E12109G



westernpower

Electricity Networks Corporation ABN 18 540 492 861

Part D - Site address/location plan

Please attach a location plan or concept plan with this document.

Site address	Arthur St & Marshall Rd		
Suburb or town	Dayton	Post code	6055
Nearest cross street	Lord st		
Map number			
Grid reference		From street directory	

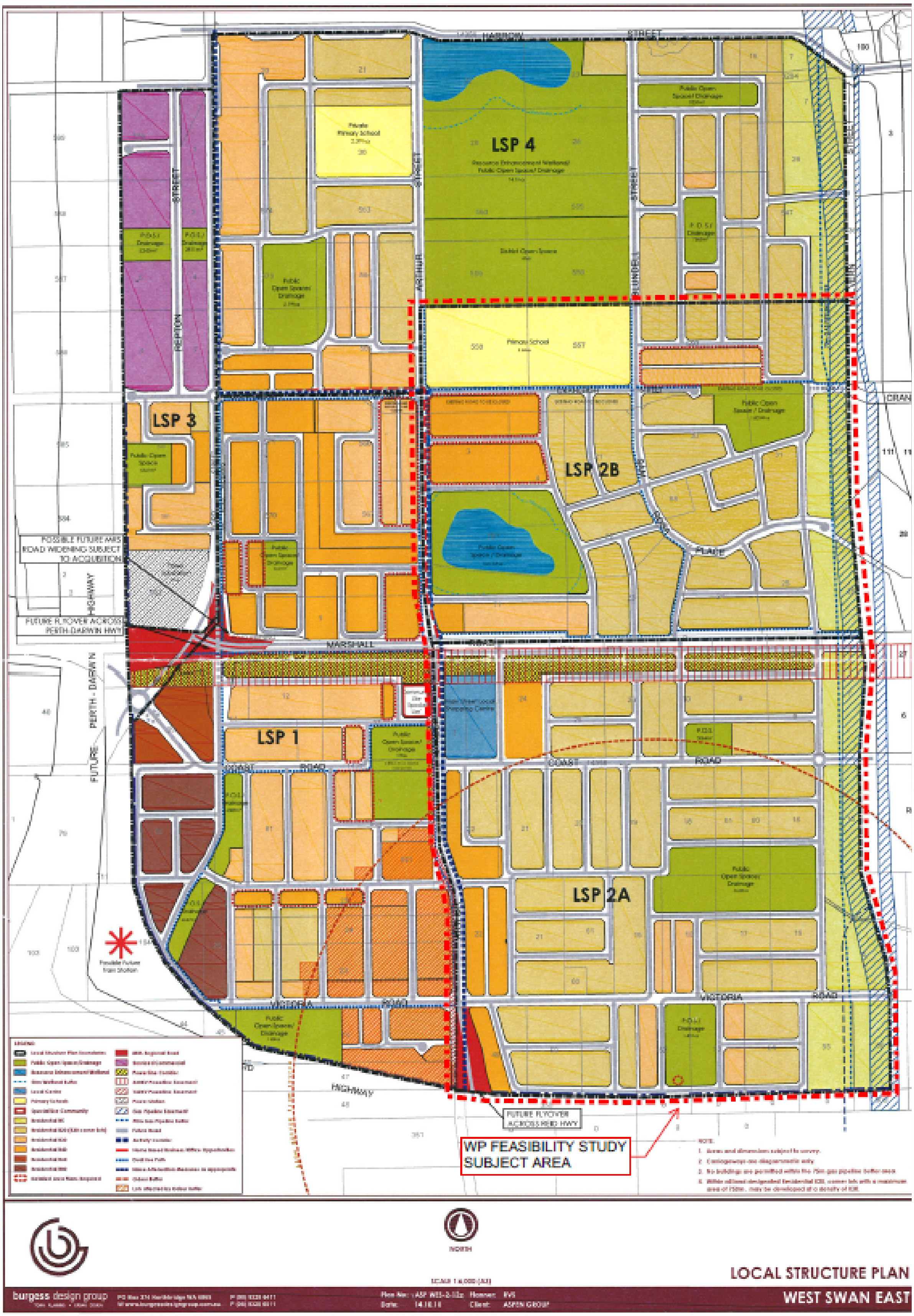
Part E - Proposed loading

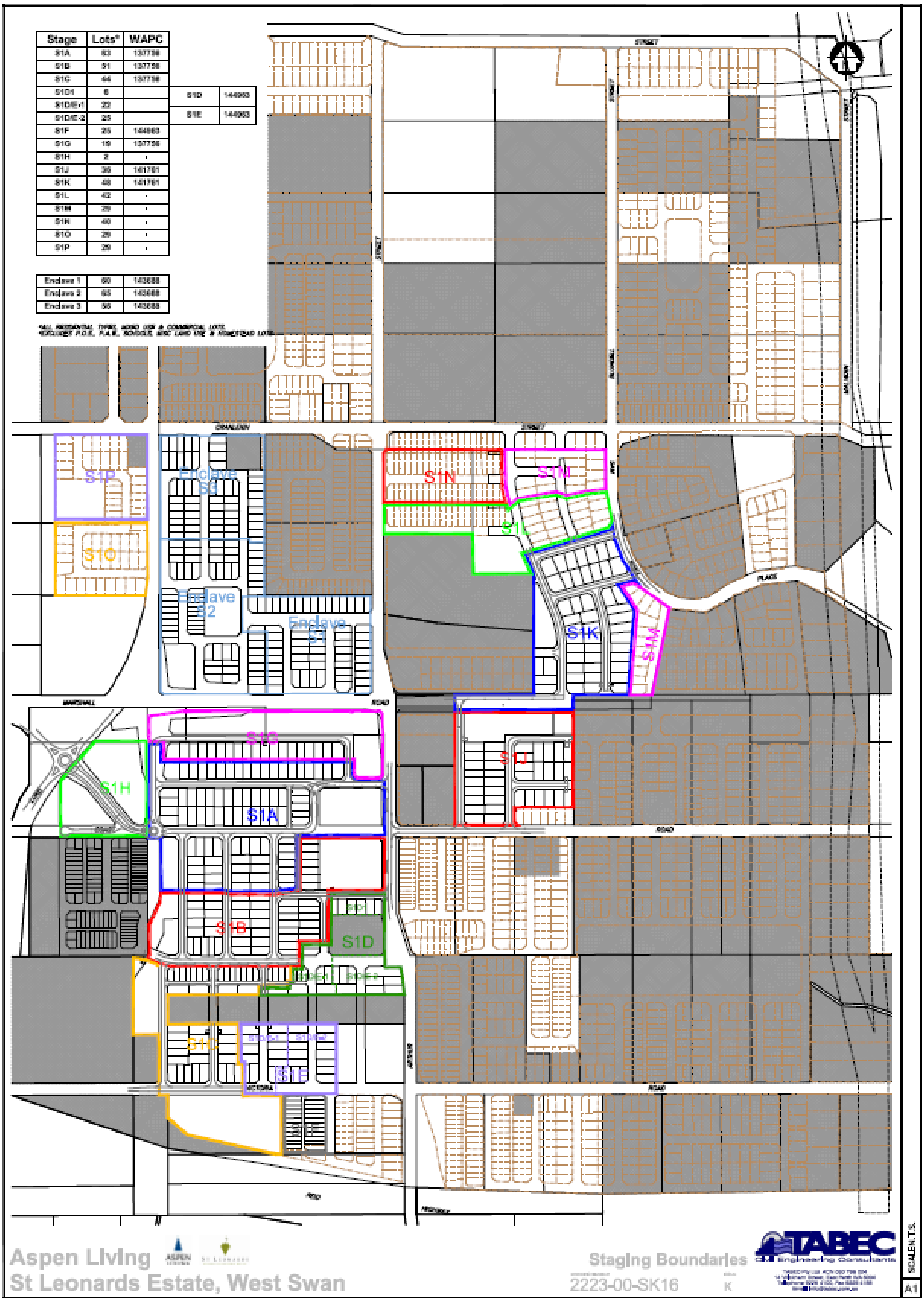
ADMD per lot	4.7kVA
Comments	BASED ON WP ADVICE FROM PREVIOUS STAGES

Part F - Approval

On signing this form as the duly authorised representative, the signatory accepts liability for payment of $315.00 (inc GST) for a Feasibility Enquiry or $775.00 (inc GST) for a Feasibility Study. Please refer to 'Terms & Conditions'.

Name	James Hutton		
Mobile (optional)		Telephone	(08) 63149000
Signature		Date	3 / 10 / 2012


HARROW STREET
LSP 4
Resource Enhancement Wetland/ Public Open Space/ Drainage
District Open Space
Private Primary School
Public Open Space/ Drainage
Primary School
LSP 3
LSP 2B
LSP 1
LSP 2A
ARTHUR STREET
REPTON STREET
MARSHALL ROAD
COAST ROAD
VICTORIA ROAD
PLACE
POSSIBLE FUTURE MRS ROAD WIDENING SUBJECT TO ACQUISITION
FUTURE FLYOVER ACROSS PERTH-DARWIN HWY
FUTURE PERTH - DARWIN HIGHWAY
Possible Future Train Station
HIGHWAY
FUTURE FLYOVER ACROSS REID HWY
WP FEASIBILITY STUDY SUBJECT AREA
LEGEND
NOTE:
NORTH
LOCAL STRUCTURE PLAN
WEST SWAN EAST
burgess design group
ASPEN GROUP



Stage	Lots*	WAPC		
S1A	63	137756		
S1B	51	137756		
S1C	44	137756		
S1D1	6		S1D	144963
S1D/E-1	22			
S1D/E-2	25		S1E	144963
S1F	25	144963		
S1G	19	137756		
S1H	2	-		
S1J	36	141781		
S1K	48	141781		
S1L	42	-		
S1M	29	-		
S1N	40	-		
S1O	29	-		
S1P	29	-		

Enclave 1	60	143688
Enclave 2	65	143688
Enclave 3	56	143688

*ALL RESIDENTIAL TYPES, MIXED USE & COMMERCIAL LOTS.
EXCLUDES P.O.S., P.A.W., SCHOOLS, MISC LAND USE & HOMESTEAD LOTS.

APPENDIX B – LSP 2A & 2B HV Concept Drawings

LEGEND

SCHEME BDY.	▬ · ▬ · ▬
CABLES	
400mm2 HV	🟪 - - - -
35mm2 HV	🟩 - - - -
EXISTING OVERHEAD HV	▬▬
330kV TRANSMISSION	— · — · ·
132kV TRANSMISSION	— · — · ·

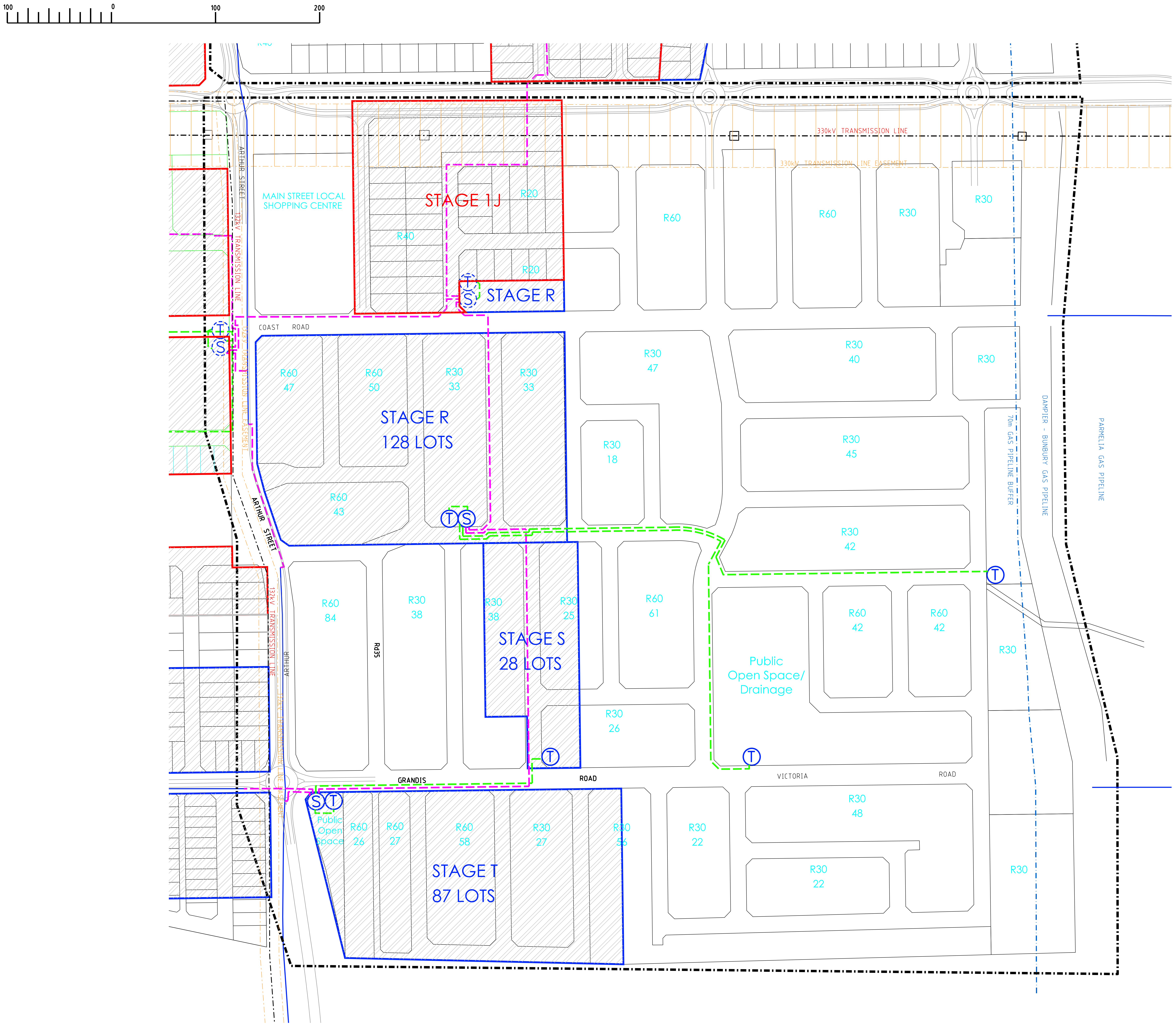
TRANSFORMERS		SWITCHGEAR
Ⓣ	PROPOSED	Ⓢ
Ⓣ	EXISTING	Ⓢ

LOTS CURRENTLY OWNED BY DEVELOPER RED - CURRENT STAGE BLUE - FUTURE STAGE	▨
330kV TRANSMISSION EASEMENT	▯▯▯

NOTES:

1. THIS DRAWING IS A CONCEPT ONLY. ALL CABLE ROUTES & GROUND MOUNTED INFRASTRUCTURE LOCATIONS SUBJECT TO INPUT FROM ALL RELEVANT STAKEHOLDERS AS WELL AS DETAILED DESIGN, AND AS SUCH ARE INDICATIVE ONLY.
2. INCOMING HV FEEDER CABLE ROUTES SUBJECT TO WP DESIGN.
3. CABLE ROUTES SHOWN HAVE BEEN SELECTED TO FOLLOW NEW ROADS WHERE POSSIBLE.
4. HV RMU LOCATIONS SHOWN HAVE BEEN SELECTED TO SUIT STAGING AND OPEN SPACE AREAS AND ARE SUBJECT TO SUITABILITY INVESTIGATIONS IN TERMS OF WP CIVIL REQUIREMENTS.
5. AN ADMD OF 4.7kVA/LOT HAS BEEN ASSUMED

Dimensions and scales to be checked prior to measuring cable lengths



REV	DESCRIPTION	DATE	DRAWN	CHKD
1	ISSUED TO CLIENT FOR COMMENT	---	DA	JH

REV	DESCRIPTION	DATE	DRAWN	CHKD

3E CONSULTING ENGINEERS PTY LTD

Electrical Engineering Excellence

Suite 1, Level 2, Condor Tower
22 St George's Tce, Perth WA 6000
PO Box 3184 Perth WA 6832
Tel: 08 6314 9000 Fax: 08 9325 3351
Email: admin@3ece.com.au

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N
LAT 31° 51' 22" S
LONG 115° 58' 44" E

Scale	1:2000	@ A1 Original Paper Size	
Base File Date	N/A	Design Date	23-08-2011
Designed	JH	Drawn	DA
Checked	JH	Approved	DLJ
Western Power Reference No.	TBA	WAPC No.	N/A
Local Authority	CITY OF SWAN		
Civil Consultant	TABEC		

ST LEONARD'S ESTATE
LSP 2A
HV NETWORK CONCEPT

Sheet	Of	3E Drawing Number	Revision
1	1	3E12109G-01	1

LEGEND

SCHEME BDY.	▬ · ▬ · ▬
CABLES	
400mm2 HV	- - - -
35mm2 HV	- - - -
EXISTING OVERHEAD HV	▬▬
330kV TRANSMISSION	— · — · ·
132kV TRANSMISSION	— · — · ·

TRANSFORMERS		SWITCHGEAR
Ⓣ	PROPOSED	Ⓢ
Ⓣ	EXISTING	Ⓢ

LOTS CURRENTLY OWNED BY DEVELOPER RED - CURRENT STAGE BLUE - FUTURE STAGE	▨
330kV TRANSMISSION EASEMENT	▥

NOTES:

1. THIS DRAWING IS A CONCEPT ONLY. ALL CABLE ROUTES & GROUND MOUNTED INFRASTRUCTURE LOCATIONS SUBJECT TO INPUT FROM ALL RELEVANT STAKEHOLDERS AS WELL AS DETAILED DESIGN, AND AS SUCH ARE INDICATIVE ONLY.
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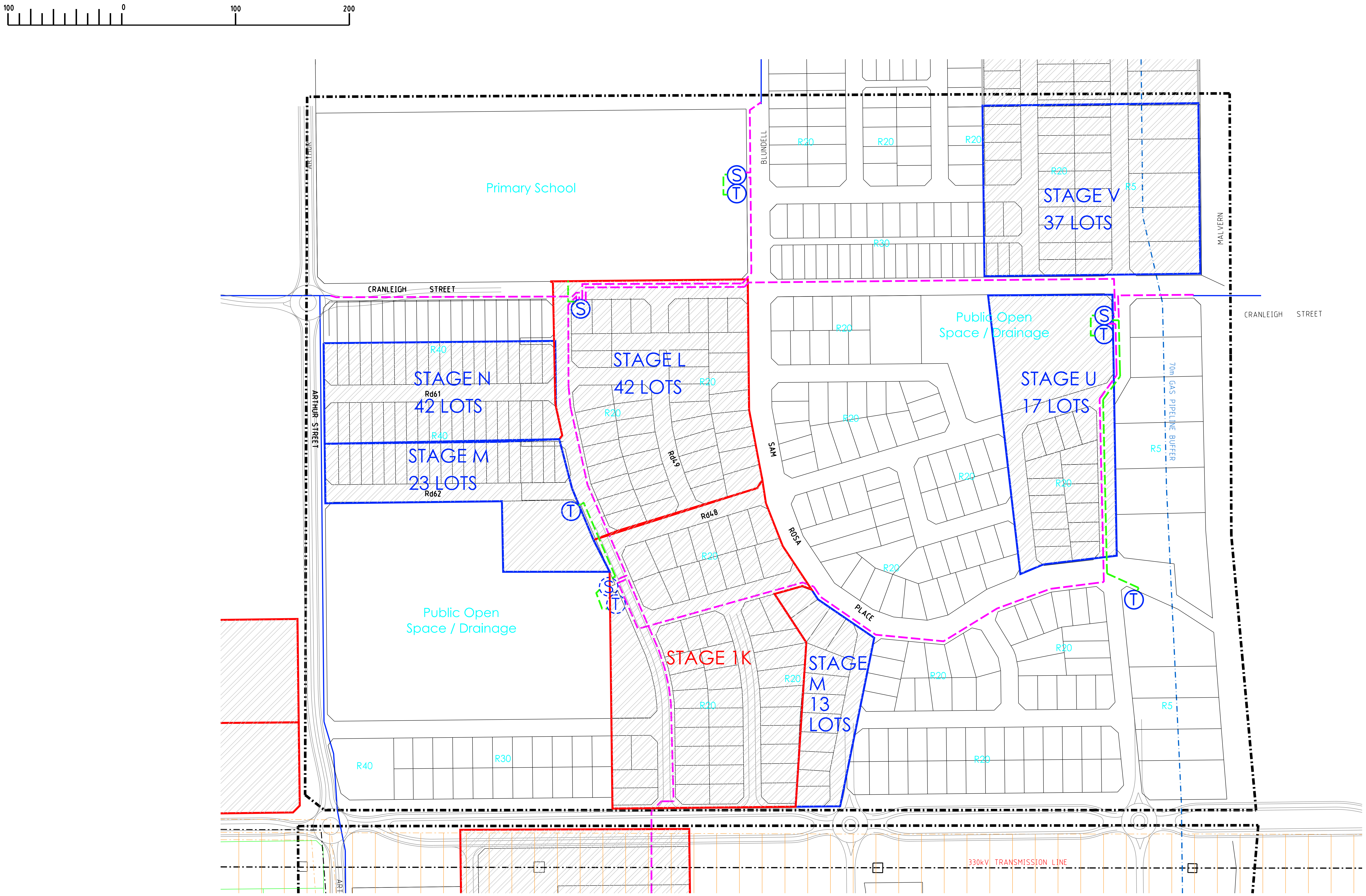

REV	DESCRIPTION	DATE	DRAWN	CHKD	REV	DESCRIPTION	DATE	DRAWN	CHKD
1	ISSUED TO CLIENT FOR COMMENT	---	DA	JH					

3E CONSULTING ENGINEERS PTY LTD

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Checked	JH	Approved	DLJ
Western Power Reference No.	TBA	WAPC No.	N/A
Local Authority	CITY OF SWAN		
Civil Consultant	TABEC		

ST LEONARD'S ESTATE
LSP 2B
HV NETWORK CONCEPT

Sheet	Of	3E Drawing Number	Revision
1	1	3E12109G-02	1

PROJECT:

ST LEONARDS ESTATE – LSP 2A & 2B RESIDENTIAL DEVELOPMENT

SERVICING REPORT FOR:

SITE COMMUNICATIONS SERVICES

DOCUMENT NO: 3E12109G-R-11

CIVIL ENGINEERS:

TABEC

DOCUMENT PREPARED BY:

3E Consulting Engineers Pty Ltd
Tel: +61 8 6314 9000
Fax: +61 8 9325 3351

Document History and Status

Revision	Date issued	Author	Reviewed by	Approved by	Revision Description
A	8/10/12	BB	DLJ	DLJ	Preliminary

SECTION 1 EXISTING COMMUNICATIONS NETWORK

1.1 TELSTRA NETWORK

Distribution to the LSP 2A area is currently provided by a Telstra copper network from a multiplexer located near the corner of Victoria and West Swan Rd's whilst the mains network is fed by fibre to from the Midland exchange, some 5.4Km – see attached plan. The current copper network has limited capacity to Coast and Victoria Rd's – a total of 100 pairs. The Midland Telstra exchange currently has substantial spare broadband port capacity (~ 2000 ports). Telephony is readily available to the area however broadband on copper at bit rates < 8Mbps (ADSL1) is currently available to customers on Coast Rd and at bit rates < 20 Mbps (ADSL 2+) to customers on Victoria Rd.

St Leonards Estate Greenfields developments to the west of Arthur St, have been serviced by Telstra Velocity in recent times but are now being serviced by NBN Co fibre. Telstra Velocity plans offer download allowances of 2GB -> 500GB at bit rates of up to 100/20 Mbps downstream/upstream.

1.2 NBN NETWORK

A number of Developers have subdivisions adjacent to LSP 2A currently being serviced by NBN Co fibre. It is understood that these networks will parent on a Fibre Access Node (FAN) at the Telstra Bassendean exchange rather than routing to the Midland exchange.

SECTION 2 PROPOSED NBN NETWORK

2.1 FUTURE DEVELOPMENT

The lot yield for land bounded by the proposed Perth - Darwin Highway to the west, Reid Highway to the south, Bush Forever to the north and Dampier/Parmelia gas pipelines to the east is expected to be in the vicinity of 2,700 lots (LSAP 1, 2A, 2B, 3 and 4). Current plans for the LSP 2A & 2B areas propose ~1300 lots, with LSP 2A potentially yielding 900 lots, and LSP 2B 400 lots.

NBN distribution occurs via Fibre Distribution Hubs (FDH's) which typically service ~200 lots, although actual experience suggests that somewhat lower utilisation of 170 lots may be achieved in practice. Five FDH's are proposed to service LSP 2A and three to service LSP 2B with fibre. In the interim NBN Co are parenting FDH's on Temporary Fibre Access Nodes (TFAN's) pending the availability of floor space and other ancillary equipment at the permanent FAN sites – in this case Bassendean exchange. NBN Co policy is to install TFAN's within Brownfields developments to avoid potential rollout delays that could arise were they to be located in Greenfields developments.

The Gigabit Passive Optical Network (GPON), the international standard upon which the NBN network is based, will permit FDH’s to be located typically 15Km from their parent FAN. St Leonards worst case distances from Bassendean exchange ie to the mid point of the most distant FDH are of the order of 9Km, well within then allowable optical power budget.

NBN Co propose to utilise a ring architecture to enable the highest service level restoration standards to be met. However, due to resource and network availability constraints NBN Co are electing to utilise a star architecture in the short term. Network availability and restoration times under the star architecture would not be as high as proposed under the ring architecture.

Although customer data rates are typically doubling every year, the NBN network will effectively future proof the network for many decades to come – maybe up to five decades.

2.2 FUTURE SERVICES

The NBN Co network, being and open access and non- discriminatory, will permit Retail Service Providers(RSP’s) to provide a range of Voice, Data, Video and TV services to consumers.

Typical product offerings available from RSP’s deliver 20 –> 500GB download capacity at speeds of 12/1 Mbps up to 100/40 Mbps, downstream/upstream.

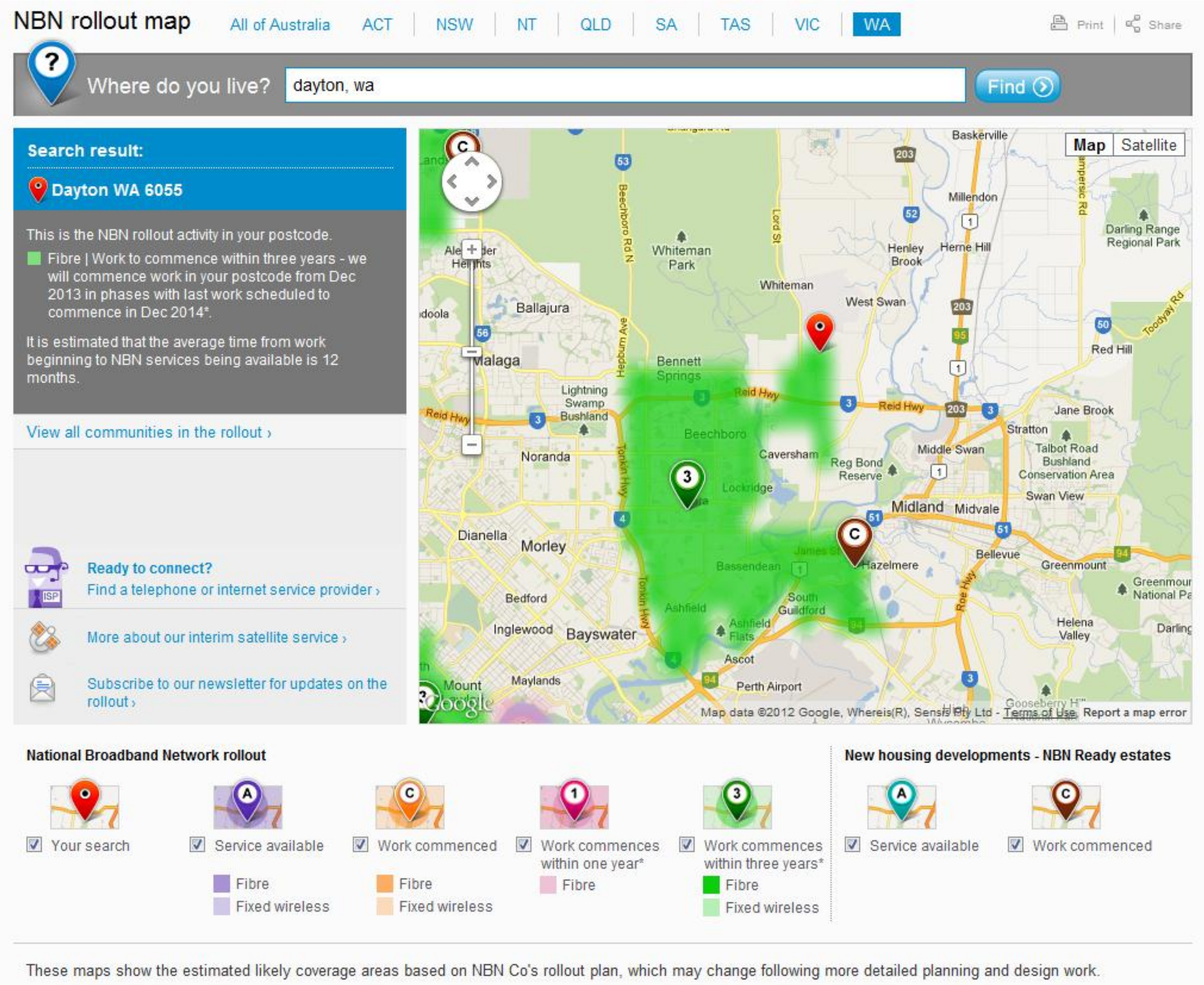
The NBN Co Brownfields rollout will provide service to existing customers in the vicinity of Arthur St, by the end of 2015 - see rollout map below. NBN Co are not obliged, under the most recent Government policy announcements, to provide service to existing fibred premises where that is already “adequately served”.

2.3 BUDGET ESTIMATES

Whist NBN Co are the Wholesale infrastructure Provider of Last Resort (for developments over 100 lots over 3 years), most Developers elect to service with NBN Co fibre. Under Government policy, Developers provide pit and pipe at their expense, which typically costs ~$900/lot (excl GST) in metro urban areas with lot frontages below 20m. Regardless of whether or not a Developer utilises NBN Co or a Fibre to the Home competitor, all pit and pipe network installed must be NBN fibre ready.

Existing Telstra Network

NBN Brownfields Rollout



Where do you live? dayton, wa

Search result:

Dayton WA 6055

This is the NBN rollout activity in your postcode.

🟩 Fibre | Work to commence within three years - we will commence work in your postcode from Dec 2013 in phases with last work scheduled to commence in Dec 2014*.

It is estimated that the average time from work beginning to NBN services being available is 12 months.

View all communities in the rollout ›

Ready to connect?
Find a telephone or internet service provider ›

More about our interim satellite service ›

Subscribe to our newsletter for updates on the rollout ›

National Broadband Network rollout

- ☑ Your search
- ☑ Service available
  - 🟪 Fibre
  - ▨ Fixed wireless
- ☑ Work commenced
  - 🟧 Fibre
  - ▨ Fixed wireless
- ☑ Work commences within one year*
  - ▨ Fibre
- ☑ Work commences within three years*
  - 🟩 Fibre
  - ▨ Fixed wireless

New housing developments - NBN Ready estates

- ☑ Service available
- ☑ Work commenced

These maps show the estimated likely coverage areas based on NBN Co's rollout plan, which may change following more detailed planning and design work.

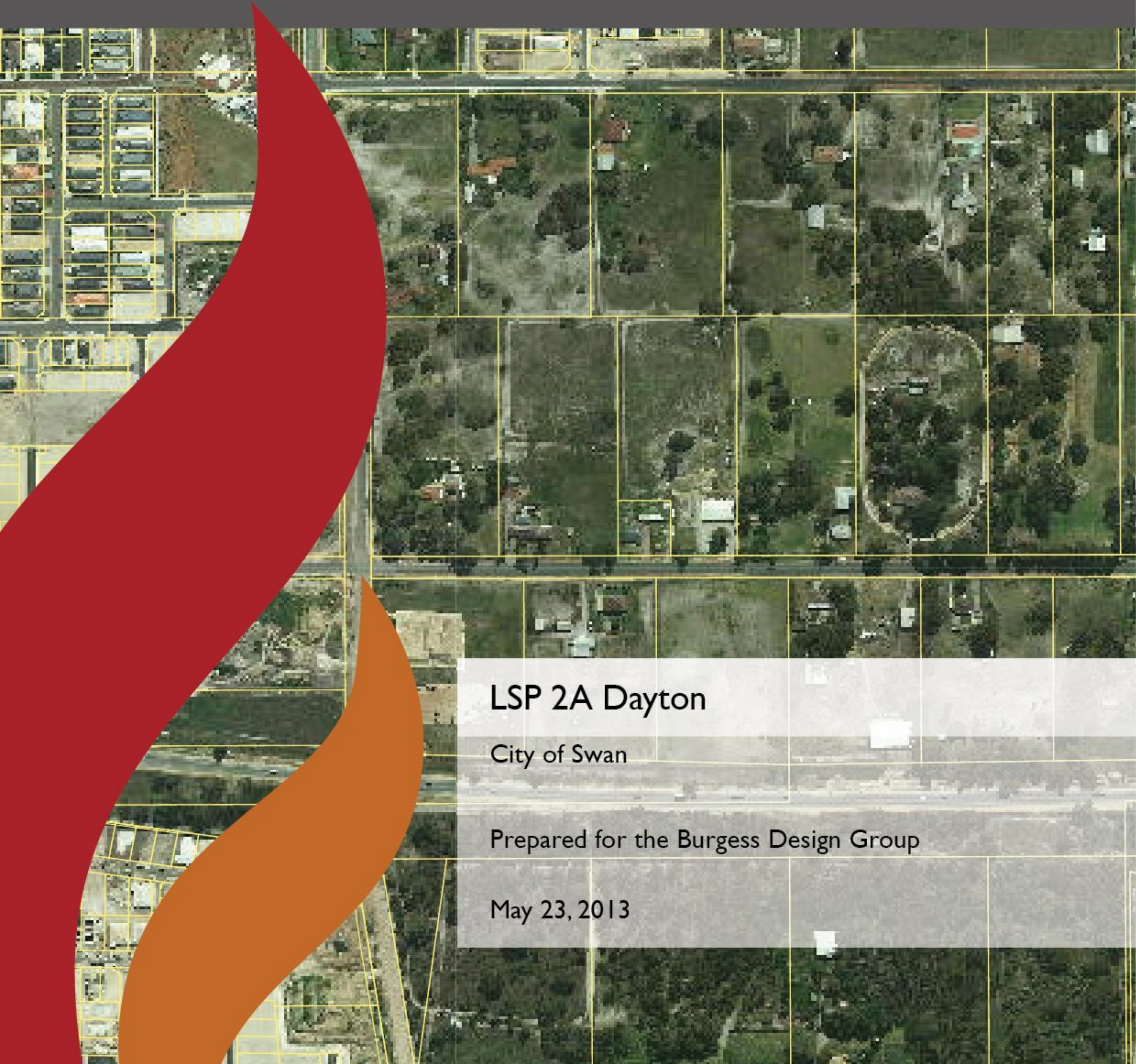
--- End of Report ---

APPENDIX 7

BUSHFIRE MANAGEMENT PLAN

Bushfire Safety
CONSULTING

Bushfire Management Plan



LSP 2A Dayton

City of Swan

Prepared for the Burgess Design Group

May 23, 2013

Dayton Local Structure Plan 2A
City of Swan

Front Cover Photo: Aerial photograph of development site

Prepared for: Burgess Design Group

Report prepared by:

Rohan Carboon B. App. Sci. G. Cert. (Bushfire Protection)
Managing Director
Bushfire Safety Consulting Pty Ltd
P O Box 84
STONEVILLE WA 6081

Mobile: 0429 949 262
Email: enquiries@bushfiresafety.net
Website: www.bushfiresafety.net

Disclaimer

Table of Contents

Executive Summary

This Bushfire Management Plan (BMP) has been prepared following the assessment of the Dayton LSP 2A area which broadly encompasses various lots between Reid Highway, Arthur Street, Marshall Road and the Dampier Bunbury Gas Pipeline Easement in Dayton.

The BMP has been prepared to support a Local Structure Plan (LSP) and respond to a request from the City of Swan.

The development site has been assessed for vegetation class and bushfire hazard rating levels. **It has been determined that the proposed development will fall within the acceptable level of risk**. Areas of classified vegetation have been clearly identified on and surrounding the site, which require AS3959 construction standards for residential dwellings.

This Plan includes a table on page 32 showing responses to the Performance Criteria outlined in the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

Currently, the site's bushfire hazard level is rated as predominantly low due to the its predominant agricultural land use. Some small areas of remnant forest and woodland vegetation exist on the site, although they are highly degraded. Areas of Public Open Space will retain mature eucalypt trees however it will become fully landscaped parkland and reserves. The residual hazard external to the site will pose the greatest threat to the development. A perimeter Building Protection Zone will ensure the predicted radiant heat flux exposure levels remains below BAL-12.5.

Access and egress from the site will adequately service the development.

Reticulated water is available at the site and hydrants will be spaced according to Department of Fire and Emergency Services (DFES) and Water Corporation Standards.

Both the City of Swan and DFES have a public education program to raise the community's awareness to its responsibilities regarding preparing homes for a bushfire attack and what to do if an event occurs.

If there is a bushfire within or near the site, implementing this BMP will reduce the threat to residents, visitors and fire fighters.

1. Introduction

The subject land covers 61.30 hectares and comprises 68 separate lots. The site is generally bounded by Arthur Street to the West, Marshall Road to the North, the Dampier Bunbury Gas Pipeline easement to the East, and Reid Highway to the South. The site is located 16 kilometres north-east of the Perth CBD and 8 kilometres north of Midland Regional Centre (Appendix A).

The site is zoned Urban under the Metropolitan Region Scheme. The City of Swan and Local Planning Scheme No. 17 zone the site and surrounding Dayton area as" Special Use – West Swan"

This BMP has been prepared on behalf of St Leonards Estate Pty Ltd in consultation with Burgess Design Group. St Leonards Estate Pty Ltd is the registered landowner of several lots within the Local Structure Plan (LSP) area.

The LSP is the third structure plan to be developed as part of the ongoing planning of Dayton and surrounding suburbs.

1.1 Statutory and Policy Framework

Relevant key legislation, policy and guidelines include the following:

1.1.1 Bush Fires Act

The Act sets out provision to reduce the dangers resulting from bushfires; prevent, control and extinguish bushfires; and for other purposes. The Act addresses various matters including prohibited burning times, enabling Local Government to require landowners and/or occupiers to plough or clear fire breaks, to control and extinguish bushfires and establish and maintain Bush Fire Brigades.

1.1.2 State Planning Policy No. 3.4 Natural Hazards and Disasters

The objectives of this Policy are to:

- Include planning for natural disasters as a fundamental element when preparing all statutory and non-statutory planning documents, specifically town planning schemes and amendments, and local planning strategies, and;
- Use these planning instruments to minimise the adverse effects of natural disasters on communities, the economy and the environment.

The Policy determines those areas that are most vulnerable to bushfire and where development is appropriate and not appropriate. The provisions and requirements contained in Planning for Bush Fire Protection Guidelines - Edition 2 (WAPC et al. 2010) are used in this determination.

1.1.3 Planning for Bush Fire Protection Guidelines (2010)

DFES, the Western Australian Planning Commission (WAPC) and the Department of Planning prepared these Guidelines. The document is the foundation for fire risk management planning on private land in Western Australia.

The document addresses important fire risk management and planning issues and sets out performance criteria and acceptable solutions to minimise the risk of bushfires in new subdivisions and developments. It addresses management issues including location, design, the development site, vehicular access and water.

2. Aim

The aim of the fire management plan is to reduce the occurrence of, and minimise the impact of bushfires, thereby reducing the threat to life, property and the environment.

3. Objectives

The Dayton West Swan LSP2A provides a guide to future development of the site. It creates a framework for the future urban subdivision development of an anticipated 928 residential lots at densities ranging from R20 to R60, facilitating lot sizes from 180 m² to 500 m². Four Public Open Space (POS) areas totalling 4.298 hectares will accommodate the community's recreational needs and site drainage requirements. A 2.0 ha local centre is also proposed (Appendix B).

All areas of POS will be landscaped and managed as parkland and reserves. Indicatively, the development will include 7 stages with Stage 1 starting in the north-west corner (Appendix C).

In correspondence to Burgess Design Group in March 2013 the City of Swan noted:

- Structure plans will be able to amend the “Bushfire Prone Area” in LPS17, and
- Our broad brush mapping showed most of LSP2A as a “Bushfire Prone Area” and this risk needs to be managed accordingly.

The City of Swan also requested:

- A Bushfire Management Plan (BMP) be prepared in accordance with WAPC’s *“Planning for Bushfire Protection Guidelines (May 2010)”*
- To depict on LSP2A, those areas where AS3959 applies and any other recommendations of the FMP that are to be implemented; and
- To update part one to specify those other recommendations accordingly.

The BMP has been prepared to satisfy this request for the LSP process. It achieves this by providing responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

The LSP has evolved from higher level structure planning including; the sub regional structure plan for the Swan Urban Growth Corridor that was endorsed by the Western Australian Planning Commission (WAPC) in 2009 and the West Swan East (Dayton) District Structure Plan that was endorsed by the WAPC’s in early 2012.

Community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals. The planning and building controls outlined in this Plan, when implemented, will reduce the risk to people and property. How people interpret the risk, prepare and maintain the property and buildings and what decisions and actions they take (i.e. evacuate early or stay and defend or other) greatly influence the outcome in a bushfire.

The aim of this BMP is to address bushfire management issues within the proposed development including the LSP. If there is a bushfire within or near the site, implementing the BMP will reduce the threat to residents, property and emergency response personnel.

Achievable and measurable goals of this Plan include ensuring:

- The development is located in an area where the bushfire hazard does not present an unreasonable level of risk to life and property;
- Vehicular access to the development is safe if there is a bushfire occurring;

- Water is available to the development so that life and property can be protected from bushfire;
- The development is sited to minimise the effects of a bushfire; and
- The development design will minimise the effects of a bushfire.

This document sets out the roles and responsibilities of the developer, residents and tenants, the City of Swan and DFES. It is important that the measures and procedures outlined in this BMP are reviewed as necessary.

This BMP includes:

- A description of the site, the surrounding area, fire climate and bushfire history;
- A summary of research into the related effects of a bushfire;
- A bushfire hazard assessment;
- Means of addressing vehicular access;
- Siting of buildings to include building protection and hazard separation zones;
- Water supply; and
- Maps and plans of fire reduction measures.

4. Description of the Area

4.1 General

Dayton suburb was gazetted in May 2011, is part of the City of Swan's urban growth corridor and is bounded by Lord Street, Harrow Street, Malvern Street, Reid Highway and the Dampier to Bunbury natural gas pipeline easement.

The City of Swan and the Department of Planning, in consultation with key landowners and other government agencies, prepared the Sub-Regional Structure Plan for the Swan Urban Growth Corridor. This includes land located between Midland and Ellenbrook. The Sub-Regional Plan is designed to guide the coordinated growth and development of the Swan Urban Growth Corridor. Over 30,000 new residents and associated infrastructure have been projected in this document.

The site and surrounding areas have been predominantly cleared and grazed, and more recently, converted to rural-residential and rural-lifestyle uses. Residential subdivisions are occurring North and West of the site in approved LSP areas. The Caversham Primary School is situated north-east of the site.

4.2 Climate and Fire Weather

The behaviour of bushfires is significantly affected by weather conditions and they burn more aggressively when high temperatures combine with low humidity and strong winds. In Perth and surrounding coastal areas, the fire risk is greatest from summer through autumn when the moisture content in vegetation is low. Summer and autumn days with high temperatures, low humidity and strong winds are particularly conducive to the spread of fire. This threat is increased if thunderstorms develop, accompanied by lightning and little or no rain.

Research indicates that virtually all house losses occur during severe, extreme or catastrophic conditions (i.e. when the Fire Danger Index is over 50) (Blanchi et al. 2010).

The Bureau of Meteorology website[1] states that extreme fire weather conditions in the Perth region typically occur with strong easterlies or north-easterly winds associated with a strong high to the south of the state and a trough offshore. Easterly winds represent about 60 per cent of extreme fire weather days (events) compared to less than 5 per cent associated with southerly winds. About 15 per cent of Perth events occurred in a westerly flow following the passage of a trough.

Very dangerous fire weather conditions often follow a sequence of hot days and easterly winds that culminate when the trough deepens near the coast and moves inland. Winds can change from easterly to northerly and then to westerly during this sequence of climatic events.

Data from the RAAF Pearce Bureau of Meteorology weather station (19 kilometres north of the study site) indicate the area experiences warm dry summers and cool wet winters (Figure 1), and is classified as a Mediterranean climate. Mean maximum temperatures vary from 31 degrees Celsius in February to 19 degrees Celsius in July.

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[1] www.bom.gov.au/weather/wa/sevwx/perth/bushfires.shtml

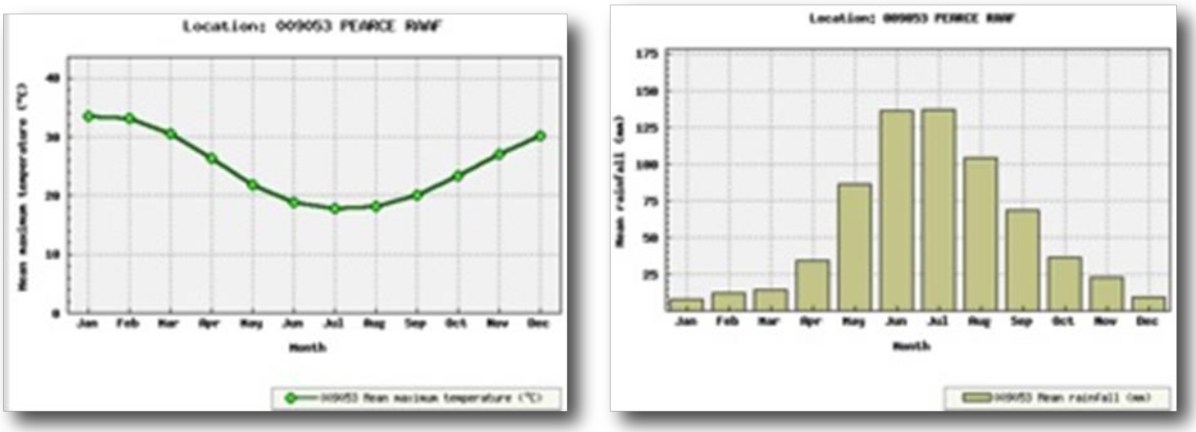

Figure 1: Mean maximum recorded temperatures and mean rainfall for RAAF Pearce Bureau of Meteorology Station between 1940 and 2012

Data from the RAAF Pearce Bureau of Meteorology weather station indicate that the predominant winds in the summer months at 3pm near the study site are south-westerly (Figure 2). Easterly and south-easterly winds are more common in February. Wind strength, direction and frequency from the south-west is dominant and occurs 70 to 80% of the time.

The majority of the extreme bushfire hazard is located south of Reid Highway. The prevailing winds could blow embers into the southern portion of the site.

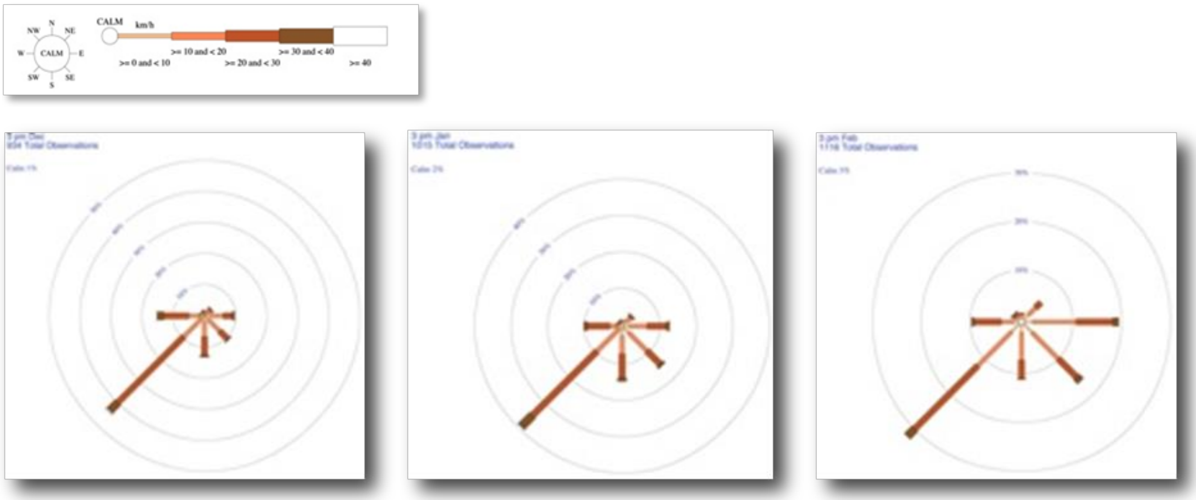

Figure 2: Rose of wind direction and wind speed in km/hr for December, January and February between 1937 and 2011 at the RAAF Pearce Meteorology Station

Interpreting Figure 2 - Wind speed vs Direction Plot
Wind roses summarize the occurrence of winds at a location, showing their strength, direction and frequency. The percentage of calm conditions is represented by the size of the centre circle - the bigger the circle, the higher is the frequency of calm conditions. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness and colour, which represent wind speed ranges in that direction. Speed ranges of 10 km/hr are used. The length of each segment within a branch is proportional to the frequency of winds blowing within corresponding range of speeds from that direction (BOM 2010).

4.3 Topography

The landscape is generally flat with slopes achieving 2° in the south east corner. The site generally drains to the south-east.

4.4 Bushfire Fuels

The study site is vegetated predominantly with managed grassland vegetation. The grass fuels are predominantly managed by the grazing of livestock and horses.

Vegetation surrounding dwellings are maintained as gardens and irrigated lawns.

There are scattered woodland trees throughout the site but predominantly located in the central area, the south-east corner and the north-western portion of the site. The woodland trees are predominantly isolated from the grassland fuels by a complete lack of intermediate and elevated fuel layers. It is a degraded vegetation type due to the land-use which is occurring.

Vegetation to the west, north and east of the site are managed similarly to those that occur on the site. Grassland is the dominant fuel and the land-use determines the quantity of grass fuels that occur on individual properties.

South of Reid Highway an area of woodland and open forest vegetation occurs. This vegetation type is more intact and the fuel layers that exist include intermediate banksia fuels, elevated shrub and scrub fuels and near surface heath and grassland fuels. This area poses the greatest hazard and threat to the development area.

4.5 Land Use

The subject land contains numerous rural-residential and rural-lifestyle lots and a number of dwellings and outbuildings.

The site is extensively grazed by sheep, cattle and horses. Some remnant woodland and forest trees exist in isolated areas. They are very degraded environmentally and have minimal intermediate and elevated fuel layers.

One aboriginal heritage site has been identified within the LSP area which will be protected in a proposed area of POS.

4.6 Assets

When the site is fully developed it will contain over 900 residential dwellings and one shopping centre complex. Assets under greatest threat from a bushfire will be those within 100 metres of classified vegetation as defined by the Australian Standard AS 3959. This includes essentially a strip of dwellings that will be located on the southern interface with Reid Highway.

4.7 Access

The site, when fully developed will be extensively serviced by public roads including a main highway such as Reid Highway and larger roads such as Victoria Road, Leonards Road and Arthur Street. The number of smaller loop neighbourhood roads will interconnect the residential lots providing extensive access throughout the entire site.

The LSP outlines a total of 6 road intersections with existing surrounding public roads.

Residents and fire fighters will have a minimum of two access ways available at all times.

4.8 Water Supply

Reticulated water will be provided to the entire development. Fire hydrants will be spaced to Water Corporation and DFES standards and provide emergency services access to an adequate water supply.

5. Fire Problem

5.1 Bushfire History

Fires have been common on the Swan Coastal Plain for thousands of years, the anthropological and historical evidence suggests that Aborigines regularly burnt this area (Hallam 1975, Abbott 2003).

Bushfires and grassfires are common in the City of Swan including areas such as Whiteman Park and local brigades respond to many bushfires annually. A recent bushfire in the nearby area includes:

- On 21 January 2010, a bushfire started near Houghton's property and threatened two houses. Three hectares were burnt and arson was suspected as the cause. Twenty fire fighters, two helitacs and one type 1 helicopter supported ground crews to control the fire. At 8.10 pm, the Bushfire "All Clear" was issued for residents in and near Dale Road.

Areas of native vegetation adjacent to residential estates are susceptible to frequent bushfires due to the high risk of arson and great potential for accidental ignitions (Walker 1981, Burrows and Abbott 2003).

Given that bushfires are common in the City of Swan, this BMP plays a critical role in ensuring that the development of the land is appropriately mitigated from fire risk and threat.

5.2 Bushfire Risk

The risk management process described in the Australian Standard AS/NZS ISO 31000:2009 is a systematic method for identifying, analysing, evaluating and treating emergency risks.

Bushfire risk is determined by assessing the bushfire hazard (i.e. vegetation), the threat level (i.e. proximity of the hazard to assets and people), the vulnerability of the asset, the consequence rating (i.e. a rating for the potential outcome once the ‘incident’ has occurred) and the likelihood rating (i.e. the chance of something happening).

It is beyond the scope of this report is to detail a comprehensive bushfire risk assessment as per the Australian Standard AS/NZS ISO 31000:2009, however a comprehensive bushfire hazard assessment is outlined in Section 5.3 Bushfire Hazard. The threat level is assessed in later sections by determining the Bushfire Attack Levels for exposed areas of development.

The vulnerability of assets such as dwellings is impacted by several factors. Some relate to the way a bushfire behaves at a site, others to the design and construction materials in the building and siting of surrounding elements. Infrastructure, utilities and human behaviour are also factors. Leonard (2009) identified the following factors:

- Terrain (slope);
- Vegetation - overall fuel load, steady state litter load, bark fuels, etc;
- Weather (temperature, relative humidity and wind speed);
- Distance of building from unmanaged vegetation;
- Individual elements surrounding the building that are either a shield or an additional fuel source;
- Proximity to surrounding infrastructure;
- Building design and maintenance;
- Human behaviour - ability to be present and capacity to fight the fire;
- Access to the building and how that influences human behaviour;
- Water supply for active and/or passive defence; and
- Power supply.

It is likely that buildings are lost because of their vulnerability to the mechanisms of bushfire attack. Buildings constructed to Australian Standard (AS 3959) are more likely to survive a bushfire compared to buildings with no construction standards however, building survival is not guaranteed.

The vulnerability of people is determined by several factors, some of which are: age, fitness levels, gender, levels of preparation, number of occupants who can actively defend a property. The entire development includes the construction of residential dwellings, there are no vulnerable assets such as schools, day care centres or aged care centres proposed.

Vulnerability, consequence and likelihood ratings are all determined using a risk assessment matrix which is beyond the scope of this report.

5.3 Bushfire Hazard

Assessing bushfire hazards at a strategic level takes into account the predominant class of vegetation on the site and surrounding area for a minimum of 100 metres. The vegetation class map for the site and surrounding area for a minimum of 100 metres is shown in Appendix D. Fuel layers in a typical forest environment can be broken-down into five segments as shown in Figure 3. These defined fuel layers are used in the following descriptions regarding vegetation types, fuel structure and bushfire hazard levels.

Figure 3: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

5.3.1 Vegetation Type and Structure

The site assessment undertaken for this study identified 5 broad vegetation types on and surrounding the site as shown and mapped in Appendix D.

The vegetation on the site reflects its current and previous land uses. The land-use on the existing rural-residential lots varies from a hobby farm with sheep and cattle grazing through to equine properties with horses and ponies. All of the vegetation is highly degraded. Where remnant trees exist they usually have minimal intermediate or elevated fuels.

Introduced grasses make up the dominant fuel type on the site. They are managed over most of the site through the grazing of livestock or horses (Figure 4). Grass fuels are also managed by mowing and maintenance of vegetation around dwellings. On some lots the grass fuels appear unmanaged (Figure 5), and achieve heights up to 50 cm. This reflects the landowners' property maintenance levels and whether they have livestock or not grazing on their property.

Two small areas of degraded open forest occur in the central part of the site. Both areas are managed either with the grazing of sheep or horses. However there are heavy fuel litter loads and elevated unmanaged grass fuels in these areas (Figure 6). The sites are long unburnt, evidenced by the depth of the leaf litter material. Degraded woodland also occurs in several isolated sites where the total foliage cover is between 10 and 30%. Similar to the degraded open forest there are minimal intermediate and elevated fuels in the woodland (Figure 7).

North of the site, the power line easement contains grass fuels. They are managed in the eastern portion of the site by the grazing of cattle. In the western portion, the grass fuels are unmanaged. There is a small area of Melaleuca scrub north of the site adjacent to a new residential development (Figure 8). East of the site and north of Coast Road, all of the grass fuels are managed by the grazing of sheep and cattle. This results in very low grass fuel loads (Figure 9). South of St Leonards Boulevard (formerly Coast Road) and east of the site a small area of degraded woodland occurs on the Perth to Bunbury gas line easements. Tree canopies are widely spaced and there are minimal intermediate and elevated fuels but there is a heavy near surface grass fuel layer (Figure 10).

South of the site in the Reid Highway road reserve most of the grass fuels are managed by slashing by Main Roads of Western Australia. This results in a managed grass fuel layer (Figure 11). In one small area remnant forest vegetation occurs providing an isolated patch of heavier bushfire fuels (Figure 12). South of Reid Highway, there are heavier bushfire fuels found in the open forest vegetation, patches of degraded woodland, scrub and unmanaged grassland areas. The open forest vegetation is dominated by Banksia and Sheoak species with some eucalypt trees (Figure 13). The canopy heights are low at approximately 10-12 metres.

West of the site in the approved LSP 1 Area, residential development is currently under way. In one small area, sand and soil is being stockpiled and some unmanaged grass fuels and scrub plants are growing. This area will be developed in September 2013 and the hazard will be removed prior to any residential development on the site.

Figures 4 and 5: Grazing paddocks are common within the site (left) and unmanaged grassland occurs on properties devoid of livestock (right)

Figures 6 & 7: Small areas of degraded open forest occur with heavy fuel litter levels (left) and areas of degraded woodland have either managed or unmanaged grass fuels (right).

Figures 8 & 9: A small patch of scrub occurs within 100 metres north of the site (left) and cattle grazed paddocks on the east side of the site (right)

Figures 10 &11: Unmanaged grass fuels in an area of degraded woodland south-east of the site (left) and the slashed grass fuels in the Reid Highway Road Reserve (right)

Figures 12 &13: A small area of open forest between the Site and Reid Highway (left) and the more extensive area of open forest south of Reid Highway (right)

5.3.2 Slope

The site is generally flat and about 14 to 18 metres above Australian Height Datum (AHD). The general direction of drainage flow is to the south-east. This reflects the gentle topography, with slopes achieving 1° in the south-east corner. There is a change of 4 metres elevation across the entire site and the slope will have minimal influence on predicted bushfire behaviour.

South of Reid Highway in the open forest vegetation, the effective slope increases to 2 degrees downslope.

5.3.3 The Bushfire Hazard Assessment Levels

The vegetation class map (Appendix D) outlines the dominant vegetation types on the study site and in the surrounding area (for a minimum of 100 metres). Descriptions of the vegetation types, structure and fuel layers are outlined in Section 5.1 Vegetation Type and Structure.

The bushfire hazard assessment levels were determined using Appendix 1 of the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010). The study site has bushfire hazard ratings of low and moderate. Some extreme hazard occurs where remnant mature trees exist and where degraded woodland or open forest vegetation is identified.

Low bushfire hazard areas occur where grass fuels are the dominant vegetation type and where they are highly managed through the grazing of livestock or through the maintenance of fuel loads around residential dwellings by mowing grass et cetera. Moderate hazard essentially occurs where the grass fuels are unmanaged and livestock is either not present or the property owners simply do not maintain their properties in as good a condition. All areas of moderate and extreme hazard on the site can be readily reduced by the removal and management of grass fuel loads and management of the minimal shrub and leaf litter that occurs. This will happen when the development staging occurs so internal hazard will be reduced along with the potential for a fire to be carried across the site. The current bushfire hazard rating map for the site is outlined in Appendix E.

All areas of proposed POS within the site (See Appendix B) will be managed landscapes, parkland and reserves and essentially become low threat vegetation. Landscaping plans have been developed for each area of POS which are extensive areas of irrigated turf and recreation areas.

Immediately north of the site under the power line easement the unmanaged grass fuels which make up the moderate hazard will be landscaped according to the landscape drawings in Appendix F. This will result in a managed parkland and reserves environment which will not pose any permanent hazard adjacent to the development. Permanent residual bushfire hazard will remain south of Reid Highway in the open forest vegetation and in a small area in the south-east corner of the site where unmanaged fuels adjoin the property.

As land clearing and earthworks commence for Stage 1 of the development, the vegetation will be removed or managed in areas of POS and the bushfire hazard will fall to low. Fuel loads within 100 metres of development stages will be reduced to ensure an appropriate buffer exists around each stage as the entire site is developed.

5.4 Bushfire Threat

As mentioned in Section 5.2 Bushfire Risk, bushfire threat is best determined by undertaking a Bushfire Attack Level assessment. The maximum predicted radiant heat flux exposure for any dwelling in this development is less than 12.5kW/m2. In terms of bushfire history for this area, they are common in the City of Swan and there is a possibility of a bushfire impacting the site from the south and the attack mechanism being predominantly ember attack.

5.5 Summary of Bushfire Potential Issues

At the completion of the development, bushfire hazard will be concentrated south of Reid Highway. Low bushfire hazard surrounds the west, north and east perimeter of the site. Bushfire threat levels are highest for the sections of development adjacent to the southern perimeter of the site. This threat level is further enhanced by the predominant winds being south-westerly at the site on summer afternoons, however the worst bushfire weather conditions are the east winds followed by north and north west winds which should not threaten the development that all.

6. Fire Mitigation Strategies

This report adopts an acceptable solution and performance-based system of control for each bushfire hazard management issue. This approach is consistent with Appendix 2 of the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010). The management issues are:

- Location of the development;
- Vehicular Access;
- Water;
- Siting of the development; and
- Design of the development.

Acceptable solutions are proposed for four out of the five management issues and each illustrates a means of satisfactorily meeting the corresponding performance criteria. A performance-based approach is proposed for the remaining management issue.

6.1 Hazard Management

The management of hazard on the site including permanent hazard external to the site and temporary hazard within the site is comprehensively detailed in 6.2.4 Element: Siting of Development.

6.2 Bushfire Risk Management

As discussed in Section 5.2 Bushfire Risk, It is beyond the scope of this report is to detail a comprehensive bushfire risk assessment as per the Australian Risk Management Standard AS/NZS ISO 31000:2009.

Land use planning bushfire risk mitigation strategies are comprehensively detailed in this report by providing responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

6.2.1 Element: Location of the Development

Intent

To ensure that development/intensification of land use is located in areas where bush fire hazard does not present an unreasonable level of risk to life and property.

Acceptable Solution

Bushfire hazard levels are rated as predominantly low on the development site due to the existing land use and degraded nature of remnant vegetation. There are similarly low bushfire hazard ratings for land immediately to the west, north and east of the site due either to residential land developments or grazing pressure from livestock. Residual hazard will remain in open forest areas south of Reid highway external to the site.

The maximum Bushfire Attack Level (BAL) is predicted to be BAL-12.5 for all dwellings sited within 100 metres from Woodland or Open Forest.

Construction standards will be increased to align with the designated BAL rating to offset the requirement for a Hazard Separation Zone (HSZ). The site will be provided with an adequate water supply and has perimeter vehicular access to fight fires.

6.2.2 Element: Vehicular Access

Intent

To ensure vehicular access serving a subdivision development is safe if a bushfire occurs.

Background

Transcore has prepared a transport assessment for the site. The proposed road network integrates with the existing roads within and adjoining the site. Established homes on the land are reliant, for access, to the existing road network, which has been integrated into the proposed design.

The road hierarchy plan (Appendix G) highlights the series of local access streets that are proposed to extend throughout the site. Loop roads are common, providing two access routes and the interconnected roads create a permeable grid like pattern which attempts to minimise the impact on existing homes, but still achieves efficiency for vehicles, cyclists and pedestrians as well as the future lot yields of individual landowners.

The proposed road network also reflects the anticipated traffic volumes and integrates with the District Structure Plan and the public transport routes within and adjoining the site. The proposed road hierarchy on the site can be seen in Appendix G. This proposal complies with the performance criteria by applying the following acceptable solutions:

Acceptable Solution A2.1: Two Access Routes

The proposed road hierarchy plan (Appendix G) outlines an interconnected loop road system intersected by two major east-west roads and additional connections to the north onto Marshall Road and to the west onto Arthur Street.

Each development stage will have a minimum of two access roads into and out of the subdivision.

Acceptable Solution A2.2: Public Roads

St Leonards Boulevard and Victoria Road currently comply with the minimum public road standards. Arthur Street will be upgraded as part of the structure planning process with widening to occur reflecting the anticipated traffic volumes.

All new public roads within the site will comply with the minimum standards. The public road standards which will be achieved are:

- Minimum trafficable surface: 6 metres;
- Horizontal clearance: 6 metres;
- Vertical clearance: 4 metres;
- Maximum grades: 1 in 8;
- Maximum grades over <50 metres: 1 in 5;
- Maximum average grade: 1 in 7;
- Minimum weight capacity: 15 tonnes;
- Maximum crossfall: 1 in 33; and
- Minimum inner radius of curves: 12 metres.

Acceptable Solution A2.3: Cul-de-sacs and dead end roads

Two cul-de-sacs are outlined in the LSP design and temporary cul-de-sacs and dead end roads may be used during development stages. At all times cul-de-sacs and dead end roads are to achieve the following standards:

- Maximum length: 200 metres (if emergency access is provided between cul-de-sac heads maximum lengths can be increased to 600 metres provided more than 8 lots are serviced) ;
- Minimal trafficable surface: 6 metres;
- Horizontal clearance: 6 metres;
- Maximum grades: 1 in 8;
- Maximum grades over <50 metres: 1 in 5;
- Maximum average grade: 1 in 7;
- Minimum weight capacity: 15 tonnes;
- Maximum crossfall: 1 in 33;
- Minimum inner radius of curves: 12 metres; and
- As per turn around requirements (including 21 metre diameter head)

6.2.3 Element: Water

Intent

To ensure water is available to the development to enable life and property to be defended from bushfire.

Acceptable Solution: Reticulated Area

The development is located within an ESL (Emergency Services Levy) Category 1 area. This means it is located within the Perth Metropolitan Fire District and emergency response is provided by career Fire and Rescue Resources and the SES.

The area is provided with a reticulated water supply, together with fire hydrants that will meet the specifications of the Water Corporation Design Standard DS 63 and DFES. Residential dwellings (Class 1a) require fire hydrants to be sited within (or every) 200 metres in land zoned residential.

The process to determine hydrant coverage and compliance for the shopping centre precinct with Australian and DFES standards is outlined in DFES guideline No: GL-07 titled “Submission of documents to DFES for assessment” which can be downloaded at: http://www.dfes.wa.gov.au/regulationandcompliance/buildingplanassessment/Guidelines/GL-07-SubmissionOfDocumentsToDFESForAssessment.pdf.

A fire engineer will be engaged by the proponent for the shopping centre precinct to provide details to the City of Swan and DFES on how complete fire hydrant coverage will be achieved.

At subdivision approval stages, the developer is to provide detailed hydrant plans to the City of Swan and the DFES local fire station for monitoring. DFES local staff are to conduct an initial inspection of hydrants as well as routine inspections. The Water Corporation is responsible for all hydrant repairs.

Fire services require ready access to an adequate water supply during fire emergencies.

6.2.4 Element: Siting of the Development

Intent

To ensure the siting of the development minimises the level of bushfire impact.

Background

The site will be extensively cleared to accommodate the development. Four areas of Public Open Space (POS) will be accommodated within the site. All four POS areas will become parkland and reserves that are managed and maintained and will only pose a low risk to surrounding residential areas. One POS area will retain existing mature eucalypt trees. This is the 2.35 hectare POS site centrally located. The landscape plan indicates that this area will be designed as a local park for residents and will include walking paths, numerous areas of turf, picnic facilities and play equipment for informal recreation (Appendix H). When management of the POS areas is handed over by the developer to the City of Swan, formal advice will be provided with an agreed maintenance schedule outlining a range of maintenance issues including bushfire hazard considerations.

There are two important bushfire setback issues addressed by this plan. The first issue revolves around the entire site having an adequate perimeter Building Protection Zone to manage risk from long term residual hazard external to the site. The second strategy involves the management of risk at each stage of development. Each development stage is provided with acceptable setbacks from temporary hazards to reduce bushfire attack mechanisms impacting on the completed dwellings.

Vegetation that does not trigger a BAL assessment according to the Australian standard (AS3959-2009) includes one or a combination of the following:

- Vegetation of any type more than 100 metres from the site;
- Single areas of vegetation less than 1 hectare in area and not within 100 metres of other areas of vegetation being classified;
- Multiple areas of vegetation less than 1 hectare in area and not within 20 metres of the site or each other;
- Strips of vegetation less than 20 metres wide(measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 metres of the site or each other, or other areas of vegetation being classified;
- Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops, and
- Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parkland, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and wind breaks.

Acceptable Solution: Building Protection Zone (BPZ)

One of the most important fire protection measures influencing the safety of people and property is to create a BPZ around buildings. The BPZ is a low fuel area immediately surrounding a building. Non-flammable features such as irrigated landscapes, gardens, driveways, roads, and maintained grassland can form parts of a BPZ.

World first research into land management and house losses during the Black Saturday Victorian bushfires concluded that the action of private landholders who managed fuel loads close to their houses was the single most important factor in determining house survival when compared with other land management practices such as broad scale fuel reduction burning remote from residential areas (Gibbons et al. 2012).

Creating a perimeter BPZ will ensure vegetation and fuels within close-proximity to dwellings are managed to reduce predicted levels of radiant heat flux and improve the survival of buildings.

Creating a temporary BPZ during each stage of the development will ensure dwellings on the perimeter of each stage are not exposed to unnecessary risk from a temporary hazard.

The creation of the BPZ areas will ensure the predicted radiant heat flux exposure levels remains at or below BAL – 12.5 on all dwellings.

Managing vegetation in the BPZ has two main purposes - to reduce:

- Direct flame contact and radiant heat from igniting the building during the passage of a fire front; and
- Ember attack and provide a safer space for people to defend (if required) before, during and after a fire front passes.

The perimeter BPZ and the temporary staging BPZ must be established and maintained to the following standards:

- Perimeter BPZ Width: 20 metre minimum and within the lot boundary as identified in Appendices I and J;
- Temporary staging BPZ Width: 100 metres and within the overall perimeter of the development boundary as identified in Appendix K and implemented as each stage occurs;
- Fuel load: reduced to and maintained at 2 tonnes per hectare;
- All tree crowns (or clumps of crowns) are a minimum of 10 metres apart;
- All trees to have lower branches pruned to a height of 2 metres;
- All tall shrubs or trees are not to be located within 2 metres of a building (including windows);

- No tree crowns or foliage is to be within 2 metres of any building. This includes existing trees and shrubs and new plantings;
- All fences and sheds are constructed of non-combustible materials (i.e. Colorbond, brick or limestone);
- All shrubs to contain no dead material within the plant;
- No tall shrubs are to be in clumps within 3 metres of the building; and
- No trees are to contain dead material in the crown or on the bole.

The perimeter BPZ is only required for Stage 4 of the development. The BPZ in the south-east corner of the site is contained within the 70 metre gas pipe exclusion buffer which prohibits dwellings being constructed. The small southern boundary BPZ is designed to provide a sufficient setback from the small strip of open forest vegetation on the north side of Reid Highway. This strip of open forest vegetation necessitates a 20 metre minimum building protection zone. The strip of open forest vegetation is less than 0.25 hectares and averages less than 20 metres in width. For this reason it does not trigger the requirement for increased construction standards on all dwellings within 100 metres.

Each development stage will require a 100 metre cleared zone surrounding the perimeter and located within the lot boundary. This will be achieved by clearing vegetation in this zone as stages are developed (see example in Appendix K).

It is the responsibility of the developer to establish the temporary staging and perimeter BPZ including landscaping in the power line easement.

A Hazard Separation Zone (HSZ) is an additional fuel managed zone to create further separation between dwellings and bushfire hazard. It can extend out to 100 metres from buildings. In the LSP, a HSZ is not required on the perimeter of the site because low threat areas adjoin the site on three sides. A HSZ does not fit within the design of the proposed development on the southern boundary. The requirement for a HSZ in this area is offset by an increase in construction standards and compliance with AS3959-2009.

The following Bushfire Attack Level (BAL) assessment demonstrates that the proposed BPZ scenarios combined with increased dwelling construction standards will achieve acceptable levels of risk for the development.

By achieving this standard it will be possible to construct dwellings to an appropriate standard (i.e. BAL-29 or less) under the Australian Standard (AS 3959-2009: Construction of Buildings in Bushfire-Prone Areas).

Building Siting and Predicted Bushfire Attack Levels

The AS 3959-2009 standard comprises six categories of BAL, specifically BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ. These categories are based on heat flux exposure thresholds.

The method for determining the BAL involves a site assessment of vegetation and local topography. The assumed Fire Danger Index (FDI) for Western Australia is 80. The BAL identifies the appropriate construction standard that applies as a minimum standard in Construction of Buildings in Bushfire-Prone Areas (AS 3959-2009).

Methodology and Assumptions

The following indicative BAL assessment for two hypothetical dwellings (see Appendix K & Table 1) was determined using the methodology in Appendix A of AS 3959-2009. This methodology is also outlined in the Planning for Bush Fire Protection Guidelines. Indicative BAL assessments were established by inspecting the lot building envelope (Appendix I).

The strip of open forest vegetation in the Reid Highway is considered as “Low threat” when separated from dwellings by a 20 metre BPZ. The vegetation fits the following definition:

> *Strips of vegetation less than 20 metres in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 metres of the site or each other, or other areas of vegetation being classified” (Standards Australia 2009)*

The classified vegetation occurs south of Reid Highway and in the gas pipeline easement south of Victoria Road.

The criteria to determine the BAL is outlined as follows:

Designated FDI : 80
Flame Temperature: 1090
Slope : Downslope 2 degrees (See Table 1)
Vegetation Class : Woodland and Open Forest
Setback distances : 70m and 64m See Table 1

Indicative dwelling BAL assessment (Appendix J)	Setback Distance (m)	Classified Vegetation	Effective Slope (degrees)	BAL Rating
A	70m (due to 70m gas pipeline buffer)	Woodland	Downslope 2 degrees	BAL-12.5
B	64	Open Forest	Downslope 2 degrees	BAL-12.5

Table 1: Bushfire Attack Level (BAL) Assessment for indicative dwelling locations (See Appendix J for site details)

A dwelling sited 70 metres or greater from woodland vegetation with effective downslope of 2 degrees is rated as BAL- 12.5. The dwelling sited 64 metres from open forest vegetation with effective downslope on the southern side of Reid Highway is rated as BAL-12.5.

A Bushfire Attack Level of BAL-12.5 means the risk is considered to be low. It is expected that the construction elements will be exposed to a radiant heat flux not greater than 12.5kW/m^2. There is a risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to radiant heat (Standards Australia 2009). The recommended construction Sections are 3 and 5 in AS 3959-2009.

This indicative assessment demonstrates that all proposed dwellings will easily fall within the acceptable level of risk (i.e. BAL-29 and lower. All proposed new dwellings within 100 metres of identified classified vegetation require a BAL assessment at building licence application stage to confirm the BAL rating. It cannot be provided accurately at this stage because it is a site specific assessment and vegetation type and effective slope measurements from a dwelling are site specific variables.

6.2.5 Element: Design of the Development

Performance Criteria

The design of the development is appropriate to the level of bushfire hazard that applies to the site.

Acceptable Solution

All on-site development is to comply with the performance criteria or acceptable solutions 1 to 4 in the “Planning for Bushfire Protection” Guidelines. The buildings are to comply with AS 3959-2009: Construction of Buildings in Bushfire-Prone Areas if required. The City of Swan has the responsibility of ensuring dwellings meet this standard.

The predicted highest BAL level for the dwelling is BAL-12.5. All exposed dwellings (i.e. dwellings within 100 metres of classified vegetation) will have risk mitigated by compliance with the Australian Standard AS3959-2009.

6.3 Future Development

The development proposal is outlined in several sections within this report. Permanent 'classified vegetation' as defined in AS3 959 – 2009 is located south of Reid highway. This vegetation is an extreme bushfire hazard and as such should be designated as of bushfire prone area. The impact of a bushfire in this vegetation requires increased construction standards for dwellings within 100 m. A 100 m zone from the boundary of the vegetation south of Reid Highway should also be declared as 'bushfire prone' to ensure increased building construction standards are applied to residential dwellings to mitigate bushfire attack mechanisms. A small area of unmanaged grassland and woodland occur in the south east corner of the site and should also be declared bushfire prone.

The bushfire prone area map for this area as designated by the City of Swan should be updated to include the more accurate assessment undertaken for this report. The proposed Bushfire Prone Area map is outlined in Appendix L.

Residential development is limited to areas that are outside bushfire prone areas and areas within bushfire prone zones that have building construction standards increased to mitigate the risk. The highest predicted radiant heat flux level on any dwelling is 12kW/m2. The planning of the building protection zones, appropriate water supply and compliant access arrangements as detailed in later sections in this report will mitigate the risk to acceptable levels.

6.4 Access and Fire Breaks

As outlined in Element 6.2.2: Vehicular Access.

6.5 Public Education and Community Awareness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The 30 page booklet 'Prepare, Act, Survive' provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures include 'Fire Danger Ratings and what they mean for you' and 'Bushfire Warnings and what you should do'.

The City of Swan, their website and local bushfire brigades provide bushfire safety advice to resident have produced a bushfire information pamphlet that can be downloaded from their website at http://www.swan.wa.gov.au/Residents/Safety_and_Security/Fire_Safety_Information and local bushfire brigades provide bushfire safety advice to residents. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high risk areas.

6.6 Fire Safer Areas

There are no designated Community Fire Refuges in the City of Swan, However, at the time of an emergency, the relevant authorities can select an evacuation centre and DFES, the City and Police will provide this information to residents.

A predetermined centre cannot be nominated because there are no purpose built structures (such as bunkers) designed to withstand the impacts of a bushfire. This means the location of an evacuation centre is not determined until the position of the fire and the characteristics of a specific event are considered by authorities. There would be nothing more dangerous than sending residents to a centre which is in the direct path of a fire.

The safest place to be during a bushfire is away from it. Where to go is an important element when people are relocating during a time of emergency (NSW Rural Fire Service 2004). The preferred option for residents is to designate a destination that is not in a bushfire-prone area and will be safe to travel to before a bushfire attack.

Those who find themselves threatened by a bushfire need options (VBRC 2009). This may be because their plan to leave is no longer possible because they cannot reach a place away from the fire front, or their plan to defend their property fails. Residents may also be caught away from their home when a bushfire threatens.

The concept of a “Neighbourhood Safer Place” and Neighbourhood Safer Precincts” has arisen from recommendations by the Victorian Bushfire Royal Commission into the Black Saturday bushfires.

There are many areas within the City of Swan including landscaped open spaces and urban areas that are not bushfire-prone, but they have not been declared. Obviously a non-bushfire-prone area can provide a safe location for people during a bushfire, but there is no official criteria in Western Australia to determine these areas. As there is no specific criteria to guide this process, DFES’s general advice is for residents, when their household bushfire survival plans have failed, to go to a safer place such as a local open space or building where people may go to seek shelter from a bushfire (FESA 2010).

6.7 Assessment of Fire Management Strategies

Bushfire hazard that could threaten this development is not located on the site. It is not possible to impose fuel management strategies on the property South of Reid highway to reduced hazard and reduce the threat of bushfire attack mechanisms impacting on the southern portion of the site. The Reid Highway Road Reserve and the Gas Pipeline Easement provides a significant setback distance between external hazard and the development. This ensures the dominant bushfire attack mechanisms that will impact the site is ember attack.

It may not be possible to stop a fire in bushfire hazard outside of the site however increased construction standards on exposed dwellings will assist mitigating the risk. Fire response operations will utilise the reticulated water supply and the extensive road network to defend property and life and sites impacted by fire.

6.8 Implementing the Fire Management Plan

6.8.1 Developer’s Responsibilities

To maintain a reduced level of risk from bushfire, the developer’s responsibilities are to:

- Install the public roads and turn around areas to standards outlined in Element 6.2.2 Vehicular Access
- Lodge a Section 70A Notification on each Certificate of Title exposed to AS 3959 construction standards, proposed by this development. The notification shall alert

purchasers and successors in title, to these exposed lots, of the responsibilities of the Fire Management Plan and bushfire building construction requirements;

- Comply with the City of Swan Fire Control Notice as published, on all vacant land;
- Establish and maintain the temporary and perimeter Building Protection Zones to standards;
- Ensure 100 metres of vegetation is cleared from the perimeter of each construction stage within the overall development site to ensure temporary hazard does not threaten any subdivision stage;
- Install reticulated water supply and hydrants to Water Corporation, DFES and City of Swan standards;
- At subdivision approval stage, the developer is to provide detailed hydrant plans is to the City of Swan and DFES local fire station for monitoring.
- Before creating titles within areas identified as within 100 m of classified vegetation, assess subdivision stages for exposure to AS3959 bushfire construction requirements to identify which lots are exposed and which require BAL assessments at building licence application stage; and
- Supply a copy of this Fire Management Plan and The Homeowners Bush Fire Survival Manual, Prepare, Act, Survive (or similar suitable documentation) and the City of Swan's Fire Control Notice to each lot owner subject to AS 3959 construction standards.

6.8.2 Property Owners' / Occupiers Responsibilities

The owners/occupiers of the site, as created by this proposal, are to maintain a reduced level of risk from bushfire, and will be responsible for undertaking, complying and implementing measures to protect their own assets (and people under their care) from the threat and risk of bushfire. Site owners and occupiers' will be responsible for:

- Ensuring that all lots comply with City of Swan's Fire Control Notice;
- Maintain each property in good order to minimise bushfire fuels;
- Ensure that where hydrants are located, they are not obstructed and remain visible at all times;
- As part of the building license application, the property owner or the City of Swan shall have the proposed buildings re-assessed for Bushfire Attack Level (at the time of construction) with results to be submitted to the City of Swan;
- Ensuring construction of dwellings complies with AS 3959 if required; and

- If dwellings are subject to additional construction in the future such as renovations, AS3959 compliance is required.

6.8.3 City of Swan's Responsibilities

The responsibility for compliance with the law rests with individual property owners and occupiers and the following conditions are not intended to unnecessarily transfer some of the responsibilities to the City of Swan.

The City of Swan shall be responsible for:

- Providing fire prevention and preparedness advice to landowners upon request;
- Monitoring bush fuel loads in road reserve sites and liaising with relevant stakeholders to maintain fuel loads at safe levels;
- Maintaining public roads to appropriate standards and ensuring compliance with the City of Swan Fire Control Notice;
- Update City of Swan bushfire prone map as outlined in Appendix L;
- Review the Fire Management Plan as necessary;
- Ensuring dwellings are constructed to AS 3959 where applicable; and
- Endorsing a section 70A notification on the new Certificate of Title for all lots within 100m of "classified vegetation" affected by this Fire Management Plan that states "the Lots are subject to a Fire Management Plan"

6.8.4 Department of Fire and Emergency Services Responsibilities

- Conduct an initial inspection of hydrants and conduct routine inspections.

6.8.5 Water Corporation Responsibilities

Repair water hydrants as needed.

6.8.6 Conclusion

This Plan provides acceptable solutions and responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010). However, community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals.

The planning and building controls outlined in this Plan will reduce the risk of bushfire to people and property. It will not remove all risk, however the entire site will become low risk as it is developed into an urban area. External bushfire hazard only occurs to the south of the site. How people interpret the risk, prepare and maintain their properties and buildings and the decisions and actions they take (i.e. evacuate early or stay and defend or other) greatly influence their personal safety. Residents need to be self-reliant and not expect warnings or assistance from emergency services.

6.8.7 Compliance Checklist

Performance Criteria and Acceptable Solutions

Element	Question	Answer
1: Location	Does the proposal comply with the performance criteria by applying acceptable solution A1.1?	Yes
2: Vehicular access	Does the proposal comply with the performance criteria by applying acceptable solution A2.1?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.2?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.3?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.4?	Not Applicable

Element	Question	Answer
2: Vehicular access	Does the proposal comply with the performance criteria by applying acceptable solution A2.5?	Not Applicable
	Does the proposal comply with the performance criteria by applying acceptable solution A2.6?	Not Applicable
	Does the proposal comply with the performance criteria by applying acceptable solution A2.7?	Not Applicable
	Does the proposal comply with the performance criteria by applying acceptable solution A2.8?	Not Applicable
	Does the proposal comply with the performance criteria by applying acceptable solution A2.9?	Not Applicable
	Does the proposal comply with the performance criteria by applying acceptable solution A2.10?	Not Applicable
3: Water	Does the proposal comply with the performance criteria by applying acceptable solution A3.1?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A3.2?	Not Applicable.
	Does the proposal comply with the performance criteria by applying acceptable solution A3.3?	Not Applicable

Element	Question	Answer
4: Siting of the Development	Does the proposal comply with the performance criteria by applying acceptable solution A4.1?	Yes - Construction standards are increased to align with site bushfire attack level if required.
	Does the proposal comply with the performance criteria by applying acceptable solution A4.2?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	Yes – dwellings that require a 20 m minimum BPZ to separate from hazard is achieved.
	Does the proposal comply with the performance criteria by applying acceptable solution A4.4?	No - However the proposal does satisfactorily comply with performance criterion P4 because building construction standards are to be increased to comply with AS 3959-2009 to offset the reduced Hazard Separation Zone if required. Construction standards will achieve a maximum of BAL-12.5.
	Does the proposal comply with the performance criteria by applying acceptable solution A4.5?	Not Applicable - Shielding not applicable.

Element	Question	Answer
5: Design of the Development	Does the proposal comply with the performance criteria by applying acceptable solution A5.1?	No - However the proposal does comply with the performance criterion P5 because building construction standards will be increased to comply with AS 3959-2009 to offset the reduced HSZ. BAL-29 is not exceeded.
	Does the proposal comply with the performance criteria by applying acceptable solution A5.2?	Yes - The proposal complies as the development will meet the performance criteria because of compliance with AS 3959 and BAL-29 is not exceeded.

Applicant Declaration

I declare that the information provided is true and correct to the best of my knowledge

Rohan Carboon

23/5/13

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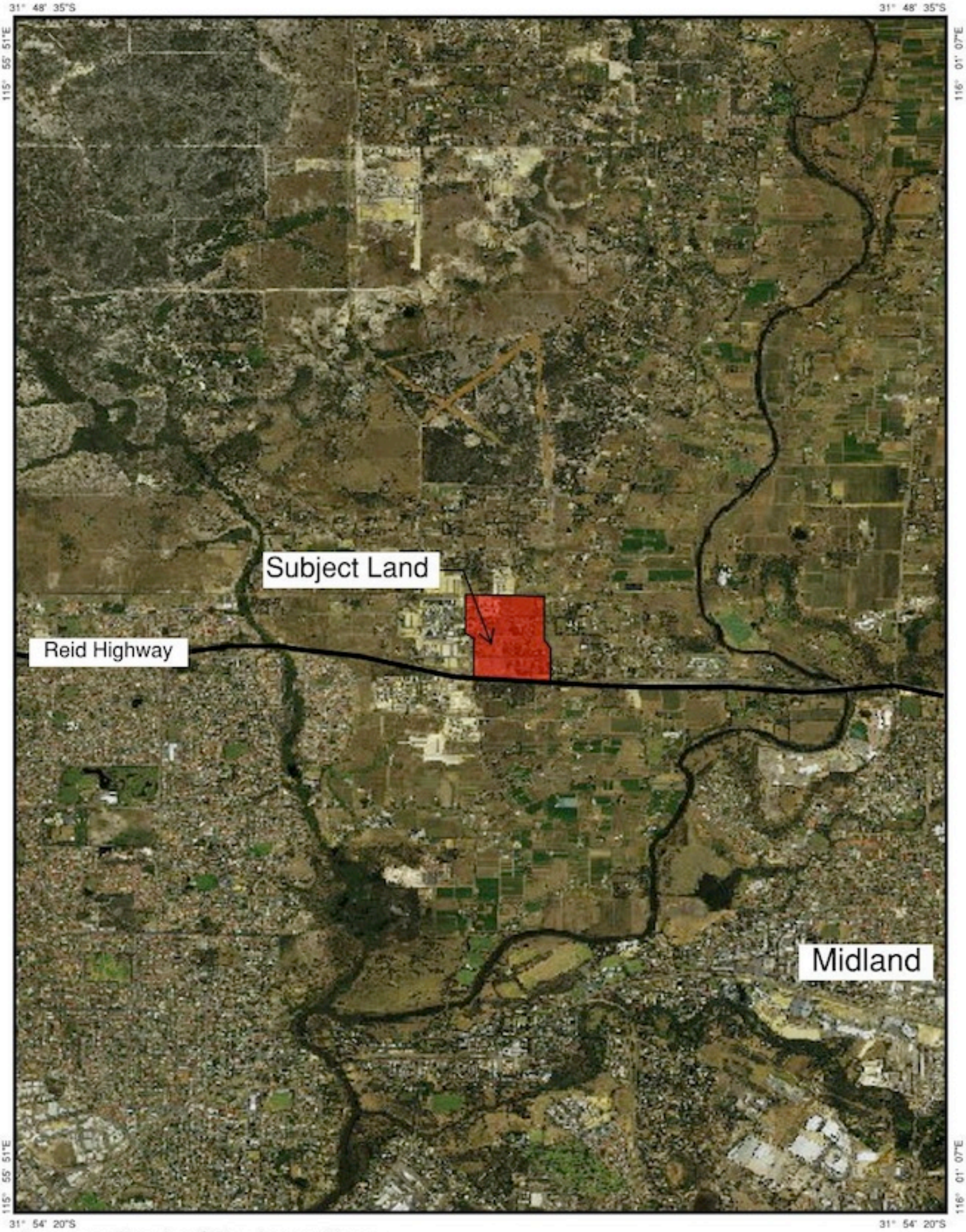


Appendix A: Site Location

LSP2A Dayton

City of Swan

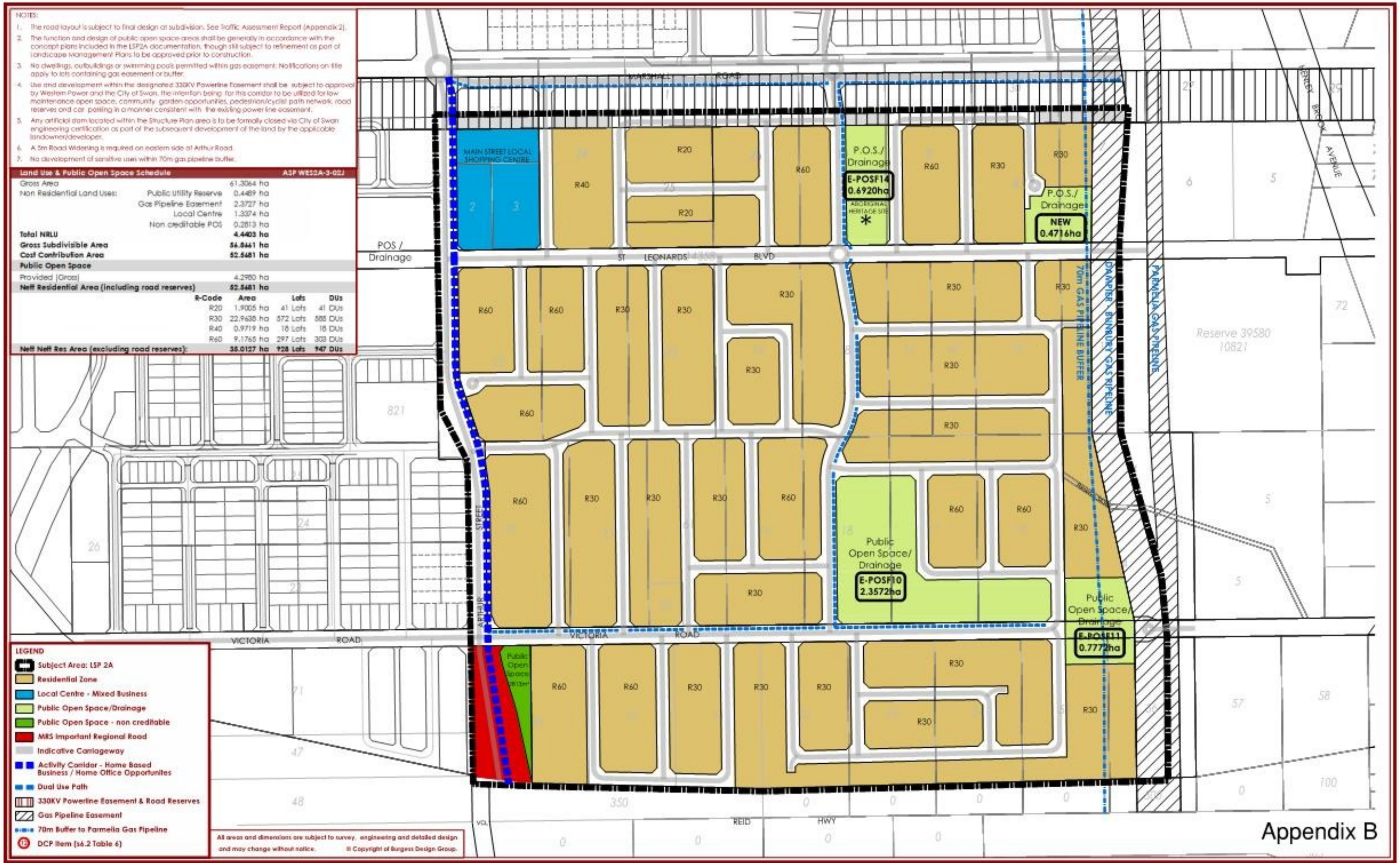
Bushfire Safety
CONSULTING

NOTES:

1. The road layout is subject to final design at subdivision. See Traffic Assessment Report (Appendix 2).
2. The function and design of public open space areas shall be generally in accordance with the concept plans included in the LSP2A documentation, though still subject to refinement as part of Landscape Management Plans to be approved prior to construction.
3. No dwellings, outbuildings or swimming pools permitted within gas easement. Notifications on title apply to lots containing gas easement or buffer.
4. Use and development within the designated 330KV Powerline Easement shall be subject to approval by Western Power and the City of Swan, the intention being for this corridor to be utilized for low maintenance open space, community garden opportunities, pedestrian/cyclist path network, road reserves and car parking in a manner consistent with the existing power line easement.
5. Any artificial dam located within the Structure Plan area is to be formally closed via City of Swan engineering certification as part of the subsequent development of the land by the applicable landowner/developer.
6. A 5m Road Widening is required on eastern side of Arthur Road.
7. No development of sensitive uses within 70m gas pipeline buffer.

Land Use & Public Open Space Schedule **ASP WES2A-3-02J**

Gross Area		61.3064 ha		
Non Residential Land Uses:	Public Utility Reserve	0.4489 ha		
	Gas Pipeline Easement	2.3727 ha		
	Local Centre	1.3374 ha		
	Non creditable POS	0.2813 ha		
Total NRLU		**4.4403 ha**		
Gross Subdivisible Area		**56.8661 ha**		
Cost Contribution Area		**52.5681 ha**		
Public Open Space				
Provided (Gross)		4.2980 ha		
Nett Residential Area (including road reserves)		**52.5681 ha**		
	R-Code	**Area**	**Lots**	**DUs**
	R20	1.9005 ha	41 Lots	41 DUs
	R30	22.9638 ha	572 Lots	585 DUs
	R40	0.9719 ha	18 Lots	18 DUs
	R60	9.1765 ha	297 Lots	303 DUs
Nett Nett Res Area (excluding road reserves):		**35.0127 ha**	**928 Lots**	**947 DUs**



Appendix B

LEGEND

- ■ Subject Area: LSP 2A
- 🟫 Residential Zone
- 🟦 Local Centre - Mixed Business
- 🟩 Public Open Space/Drainage
- 🟩 Public Open Space - non creditable
- 🟥 MRS Important Regional Road
- ▭ Indicative Carriageway
- ■ ■ Activity Corridor - Home Based Business / Home Office Opportunites
- ■ ■ Dual Use Path
- ▥ 330KV Powerline Easement & Road Reserves
- ▨ Gas Pipeline Easement
- ·-·- 70m Buffer to Parmelia Gas Pipeline
- ⑮ DCP Item (s6.2 Table 6)

All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

NORTH

SCALE 1:4,000 (A3)

LOCAL STRUCTURE PLAN 2A
LSP2A DAYTON
CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN
PO Box 374 Northbridge WA 6865
www.burgessdesigngroup.com.au
P (08) 9328 6411
F (08) 9328 6511

Plan No: ASP WES 2A 3-02J Client: St Leonards Estate Pty Ltd
Date: 13.02.13 Planner: KW

Appendix C

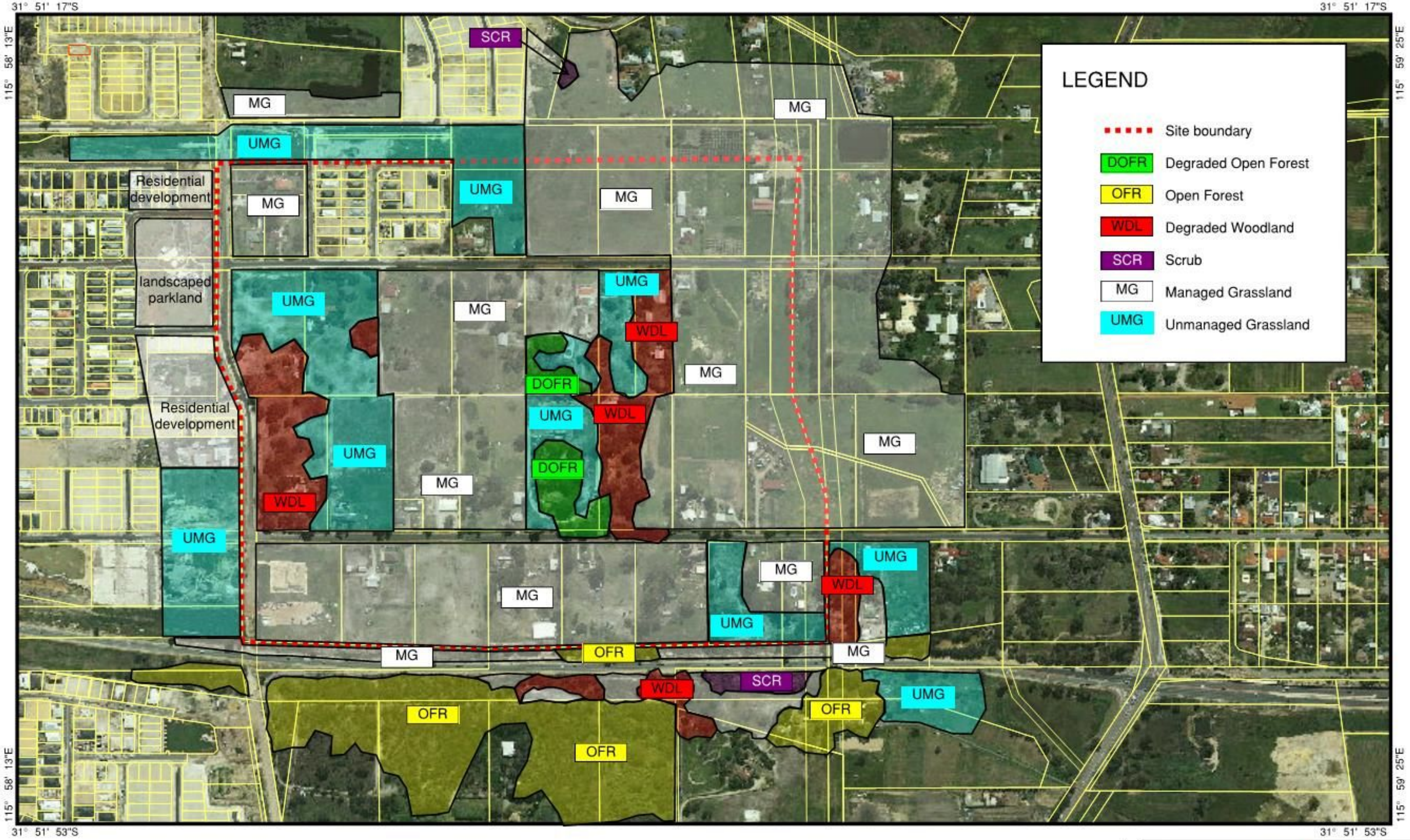
NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

INDICATIVE STAGING PLAN
LSP2A DAYTON
CITY OF SWAN

burgess design group
TOWN PLANNING + URBAN DESIGN
PO Box 374 Northbridge WA 6865
www.burgessdesigngroup.com.au
P (08) 9328 6411
F (08) 9328 6511

Plan No: ASP WES 2A 3-02L
Date: 27.02.13
Client: St Leonards Estate Pty Ltd
Planner: KW



Appendix D: Vegetation Type Map

LSP2A Dayton

City of Swan

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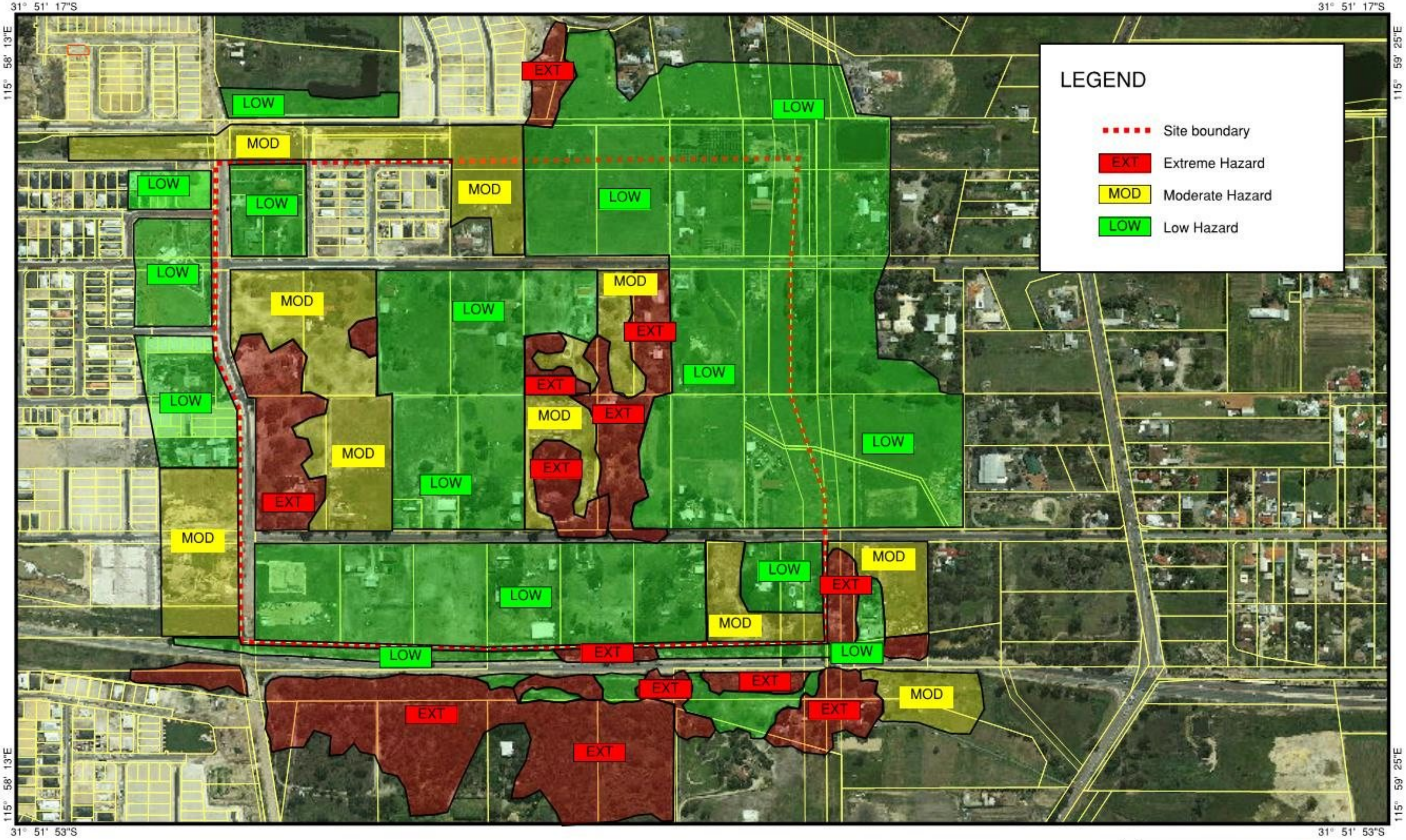

Appendix E: Bushfire Hazard Rating Map

LSP2A Dayton

City of Swan

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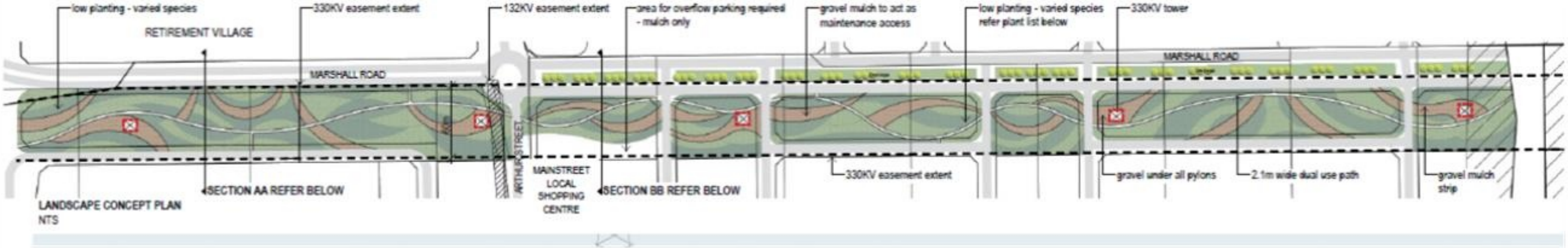
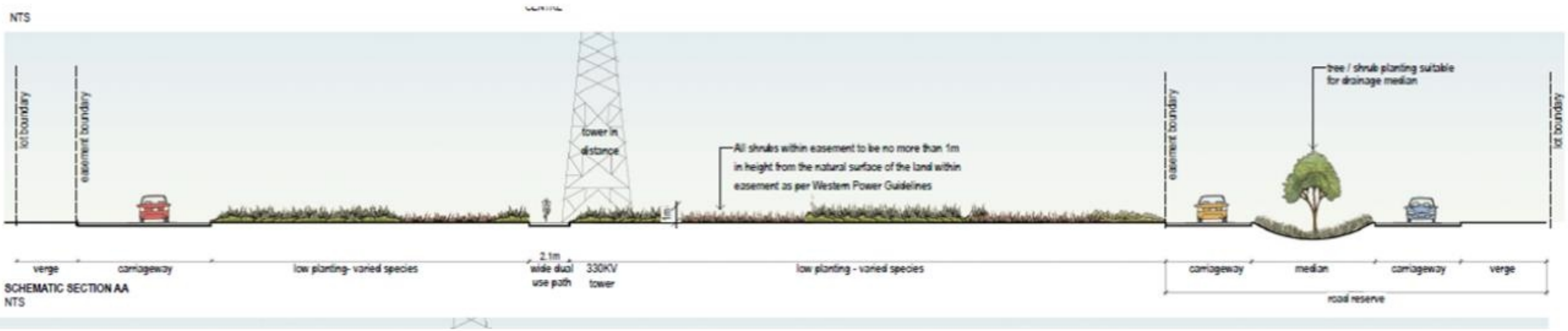


LANDSCAPE CONCEPT PLAN
NTS



SCHEMATIC SECTION AA
NTS

Appendix F: Marshall Road Easement Landscaping

LSP 2A Dayton
City of Swan

(Landscape plans by Emerge Associates)

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Appendix G

All areas and dimensions are subject to survey, engineering and detailed design and may change without notice.

LEGEND

🟦	Other Regional Road	🟥	Access Street B
🟪	District Distributor Integrator B	🟩	Access Street C
🟫	Neighbourhood Connector A	⬜	Access Street D
🟨	Neighbourhood Connector B		

NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

DRAFT

ROAD HIERARCHY
LSP2A DAYTON
CITY OF SWAN

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P (08) 9328 6411
F (08) 9328 6511

Plan No: ASP WES 2A 3-02K Client: St Leonards Estate Pty Ltd
Date: 15.02.13 Planner: KW

EPOS F10 – 23, 572 m^2

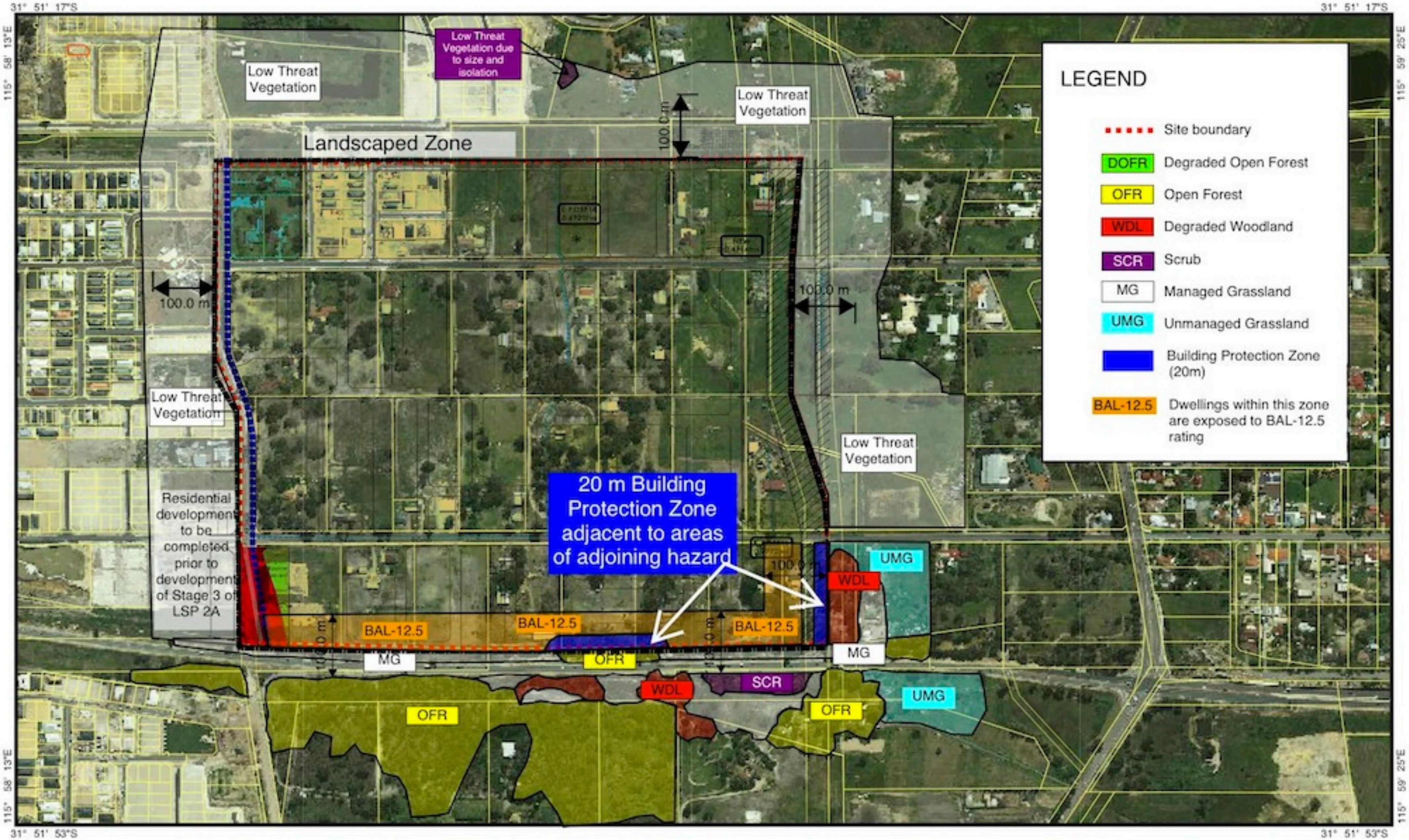
EPOS F10 provides a local park for residents within 200-400m walking distance, with numerous pockets of turf and nooks for play, gatherings and informal recreation. Picnic facilities, play equipment and a connected path network are proposed to accommodate for the recreational needs of the community. The shape of the open space allows for drainage to be integrated through a vegetated drainage basin, with waterwise planting and dry gardens to be planted so as to minimise irrigation requirements, whilst having sufficient separation to informal passive open spaces.

Appendix H: Landscape Plan for Centrally Located POS

LSP2A Dayton
City of Swan

(Landscape Plan by Emerge Associates)

Bushfire Safety CONSULTING

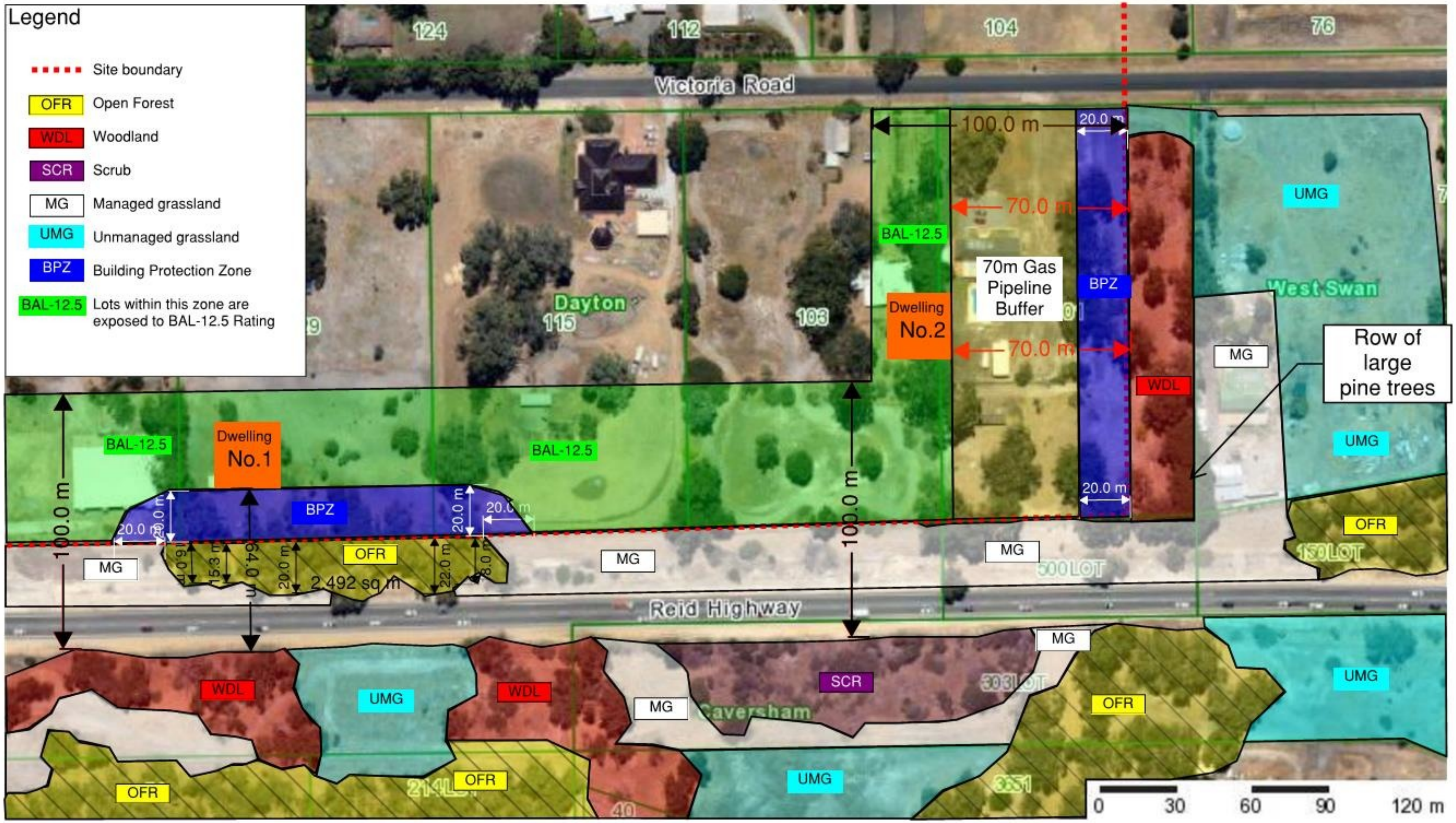


Appendix I : Perimeter Building Protection Zone

LSP2A Dayton

City of Swan

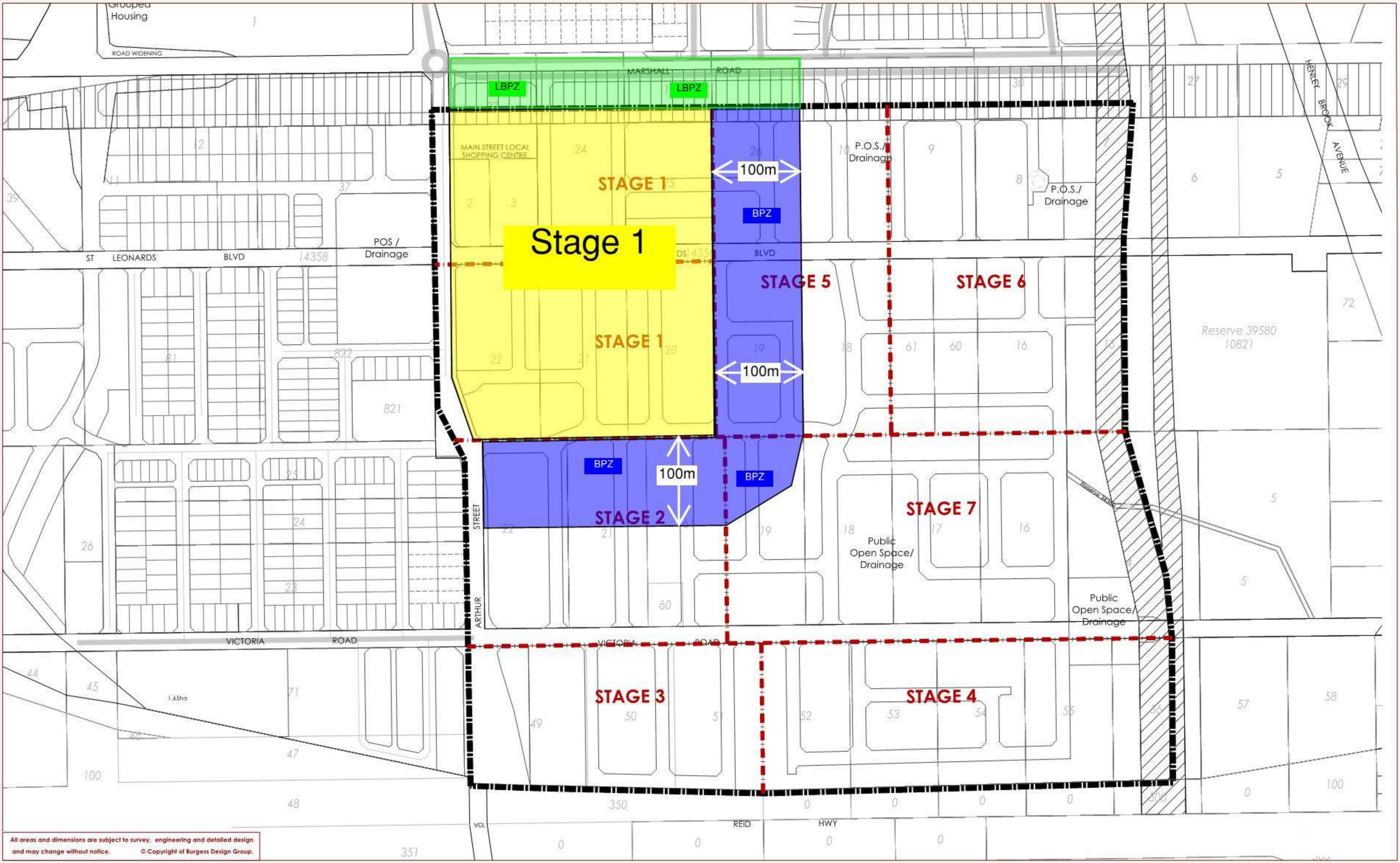
Bushfire Safety
CONSULTING



Appendix J: Perimeter vegetation, internal building protection zone and AS3959 implications

Dayton LSP 2A - South East Corner

Bushfire Safety Consulting



Appendix K: Temporary Building Protection Zone

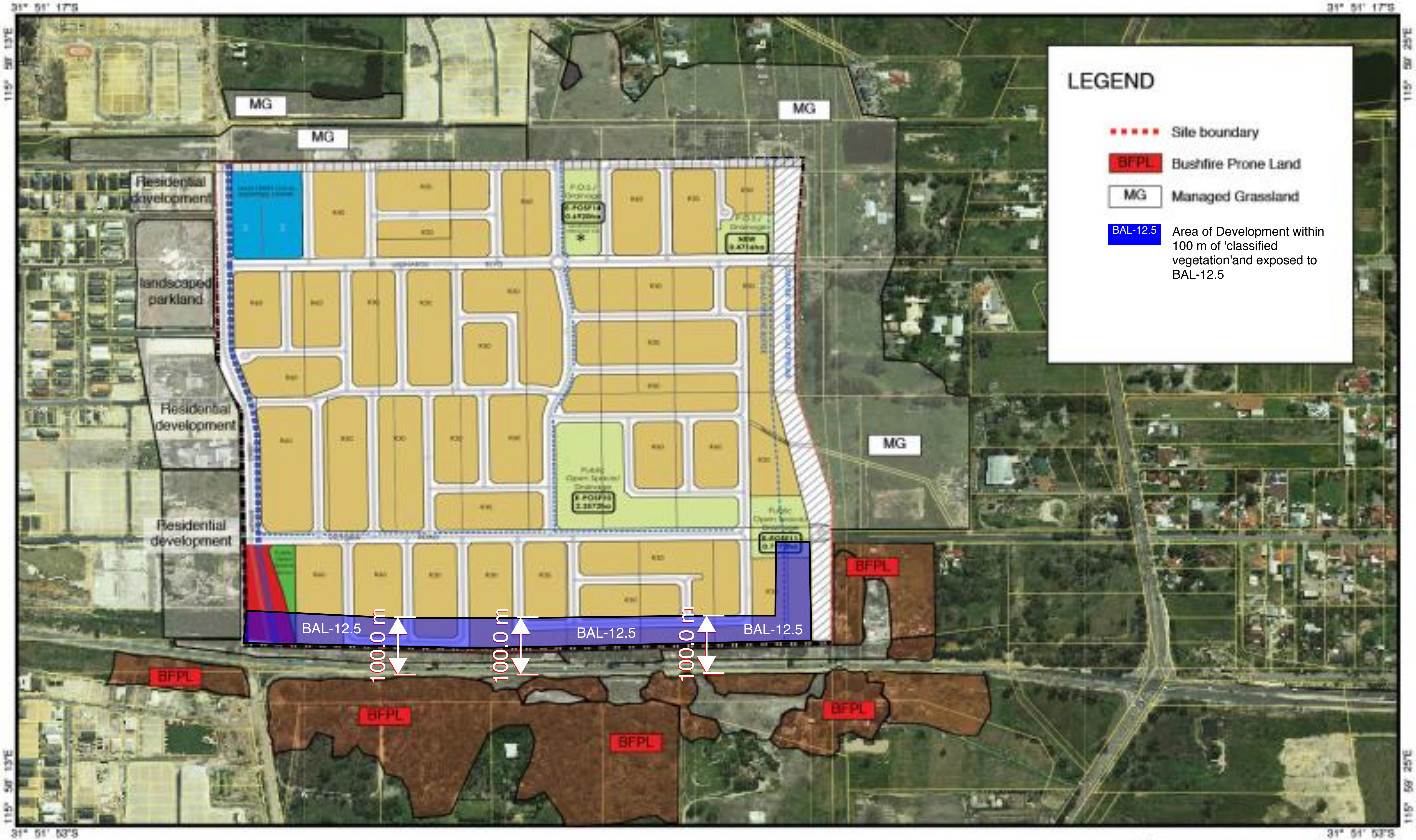
Legend

BPZ	Internal 100 m Building Protection Zone
LBPZ	Landscaped Building Protection Zone

NORTH

0 25 50 75 100m
SCALE 1:4,000 (A3)

LSP2A DAYTON
CITY OF SWAN



Appendix L: Post Development Bushfire Prone Areas

LSP2A Dayton

City of Swan

N

Bushfire Safety

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APPENDIX 8

LOCAL WATER MANAGEMENT STRATEGY

St Leonards Estate Pty Ltd

West Swan East
Local Water Management Strategy (LWMS)

2nd Revision

January 2014

JDA
Consultant Hydrologists

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J5132i	17/01/2014

	Name	Signature	Date
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Checked by	Scott Wills	SWills	17/1/2014
Approved by	Jim Davies	J.R. Davies	17/1/2014

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APPENDICES

1. INTRODUCTION

This document has been revised from, and supersedes, the previously approved LWMS (JDA, 2009), to address additional information obtained during the design process, which alters the broader water management strategy.

1.1 Background

This Local Water Management Strategy (LWMS) is provided in support of the District Structure Plan (DSP) prepared by Burgess Design Group for approximately 269 ha of land located immediately north-east of the Reid Highway and Lord St intersection at West Swan (Figure 1).

The LWMS is consistent with the North East Corridor Urban Water Management Strategy (GHD,2007), prepared on behalf of Department of Water (DoW) as the overarching regional drainage strategy for the area. It is also consistent with the requirements of the Swan Urban Growth Corridor Drainage and Water Management Plan (DWMP) (DoW, 2009) and provides an appropriate level of detail to support both the DSP and individual Local Structure Plans (LSP) for West Swan East.

A copy of an LWMS Checklist for Developers has been included as Appendix A to assist the City of Swan and DoW in review of this document.

1.2 Key Principles and Objectives

The LWMS uses the following documents to define its key principles and objectives:

- Drainage Management Strategy for North East Corridor (GB Hill & Partners, 1995)
- Statement of Planning Policy 2.9: Water Resources (WAPC, 2004);
- Decision Process for Stormwater Management in WA
  (Department of Environment and Swan River Trust, 2005)
- Stormwater Quantity Management Manual for WA (Department of Water, 2007)
- North East Corridor Urban Water Management Strategy (GHD, 2007).
- Better Urban Water Management (WAPC, 2008).
- Swan Urban Growth Corridor Drainage and Water Management Plan (DoW, 2009)

A summary of the key principles and objectives of the LWMS for the Study Area based on these documents is provided in Table 1 and summarised in Sections 1.2.1 to 1.2.5.

Table 1: Summary of LWMS Principles and Objectives

Key Guiding Principles
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development

Category	**DWMS Criteria**	**LWMS Objectives**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the Principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage.	• Post-development critical 1 yr ARI and 100 yr ARI peak flow shall be consistent with pre-development peak flow at the discharge point of each sub-catchment and discharge points of all subdivisions into waterways • All 1 yr 1 hr ARI event runoff be infiltrated at source where possible. • Waterway alignment or profile modification may be carried out if the pre-development hydraulic capacity has been maintained. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation.
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Managing and minimising changes in groundwater levels and groundwater quality following development. • Subsurface drainage (sub-soils) and drainage infrastructure set at or above the design water level (agreed CGL), although existing inverts below this level may remain. • Installed subsoil drainage outlets to be free draining. • Treatment provided for subsoil discharge.

Monitoring and Implementation	• Adopt an adaptive management approach.
	• Maintain drainage and treatment structures.
		DoW to develop site specific targets for the area. In the interim, targets achieved though:
		• Design based on methodology in Stormwater Management Manual of adopting a treatment train including:
		  • retention of 1yr 1hr ARI events,
		  • structural treatment measures (infiltration storages, plus bio-retention/ treatment structures sized to min 2% of connected impervious area)
		  • non-structural measures to reduce applied nutrient loads.
		• Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
		• Treatment provided for subsoil discharge.

Water Conservation	• Adopt drinking water consumption target. • Ensure that non-potable water supply systems deliver a net benefit to the community. • Ensure that non-potable water supply systems are designed as part of an integrated water supply	• Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • Consider alternative fit for purpose water sources where appropriate and cost-effective.

1.2.1 Drainage Management Strategy for North East Corridor (GB Hill, 1995)

The regional drainage strategy for the North-East Corridor was developed by GB Hill and Partners in 1995. The strategy outlined the development areas proposed within the corridor (including the Study Area) and developed an approach to manage groundwater and drainage constraints within the area to facilitate development.

The strategy (GB Hill, 1995) reviewed regional groundwater modelling and provided modelling of urban drainage scenarios, including estimating allowable post-development discharges from various catchments within the North East Corridor, and providing indicative storage volumes for stormwater detention at a regional scale.

With respect to water quality management, the strategy adopted an end of pipe approach through use of Water Pollution Control Ponds (WPCP), as the primary mechanism for nutrient removal. This approach has since been superseded, and DoW recommends the use of treatment train approaches to water quality management, which include the use of source controls to minimise nutrient input/application.

The (then) Water and Rivers Commission (now DoW) commissioned GHD in 2002, to undertake a review of this strategy. The final report of this process, the North East Corridor Urban Water Management Strategy (UWMS) was completed in 2006.

Details contained in the UWMS have been used to guide the development of principles and objectives for water management shown in Table 1.

Further discussion on assessment criteria for water quality management is contained in Section 4.6.

1.2.2 Planning Policy 2.9 and Liveable Neighbourhoods (WAPC, 2004)

The LWMS has been developed in accordance with regional and local principles and objectives of integrated urban water management (IUWM).

The Western Australian Planning Commission (2004) defines IUWM (also known as total water cycle management) as promoting '*management of 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*'.

IUWM should also promote water conservation measures, reuse and recycling of water and best practice in stormwater management (Western Australian Planning Commission, 2004).

These objectives are consistent with Liveable Neighbourhoods (Western Australian Planning Commission, 2007).

1.2.3 North East Corridor Urban Water Management Strategy (GHD, 2007)

This Strategy was developed to support the North East Corridor Structure Plan. The Strategy is based on a review of GB Hill & Partners (1995) and proposes new criteria and methods for managing the quantity and quality of surface runoff, for managing groundwater levels and quality, for protecting wetlands and waterways and for managing the potential risk from acid sulphate soils.

The updated Strategy endorses the Water Sensitive Urban Design principles adopted by the 1995 Strategy, but it recommends alternative approaches to the relatively costly water pollution control ponds previously proposed.

The new Strategy recommends that as District or Local Structure Plans are prepared for the North East Corridor, they are supported by District Drainage and Water Management Plans (DWMP's). The Strategy recognises that in some areas Local Structure Plans are prepared without the completion of a District Structure Plan. In this instance the Strategy recommends that the Department of Water, in consultation with the Department of Planning and Infrastructure and The City of Swan, prepare a DWMP for areas where development is anticipated without a District Structure Plan. It notes that the highest priority is the Henley Brook-West Swan-Caversham DWMP. The Strategy also notes that should local structure planning proceed before the completion of the necessary DWMP, the proponent should be required to prepare a Local Water Management Plan that addresses the issues that would otherwise have been included in the DWMP.

The latter is the approach which has been taken in this LWMS.

1.2.4 Stormwater Quality Management Manual for WA (DoW, 2007)

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

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

The (then) Department of Environment and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.

A copy of the Decision Process is contained as Appendix B with key elements summarised in Table 1.

1.2.5 Better Urban Water Management (WAPC, 2008)

This LWMS has been developed to be consistent with the framework and process detailed in the guideline document Better Urban Water Management (WAPC, 2008), with acknowledgement of the modified planning framework adopted for the Henley Brook/West Swan/Caversham Sub Regional Plan, as shown in Table 2.

A previously stated, the overarching regional strategy has been completed (GHD, 2007) and the DWMP completed in June 2009.

This LWMS has been prepared to an appropriate level of detail to support both the District Structure Plan and individual Local Structure Plans for West Swan East.

Urban Water Management Plans for each individual Local Structure Plan will be required to support subdivision applications in due course.

1.2.6 Swan Urban Growth Corridor Drainage and Water Management Plan (DoW, 2009).

Following from the UWMS, DoW released the Swan Urban Growth Corridor Drainage and Water Management Plan (DoW,2009). The report aims to cover all aspects of total water cycle management as a holistic approach to water management. The following aspects have been addressed:

- Protection of significant environmental assets within the Structure Plan area, including meeting their water requirements and managing potential impacts from development
- Water demands, supply options, opportunities for conservation and demand management measurements, and wastewater management
- Surface runoff, including both peak event (flood) management and the application of WSUD principles to frequent events
- Groundwater, including the impact of urbanisation, variation in climate, installation of drainage to reduce groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource
- Water quality management, which includes source control of pollution inputs by catchment management, acid sulphate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures
- Implementation strategy for the DWMP including monitoring and action plans.

The report also presents the proposed Arterial Drainage Scheme for the Caversham Swan urban growth corridor in accordance with the responsibilities for Drainage Planning assigned to DoW by the State Government.

This LWMS has been prepared consistent with this report.

Table 2: Integrated Planning and Urban Water Management Process for West Swan East

Planning Phase	Planning Document	Urban Water Management Document and Status
Regional	NE Corridor Structure Plan	North East Corridor Urban Water Management Strategy (GHD, 2006) **COMPLETE**
Sub Regional	Henley Brook West Swan Caversham Sub Regional Plan	Swan Urban Growth Corridor Drainage and Water Management Plan (DoW,2009) **COMPLETE**
District	West Swan East District Structure Plan	West Swan East Local Water Management Strategy **THIS DOCUMENT**
Local	Local Structure Plan	
Subdivision	Subdivision Application	Urban Water Management Plan (required for individual stages of development) **FUTURE PREPARATION**

2. PRE-DEVELOPMENT ENVIRONMENT

2.1 Location and Topography

West Swan East (herein referred to as the Study Area) comprises of a total of approximately 254 ha located approximately 15 km north east of Perth on the eastern portion of the Swan Coastal Plain. It is situated immediately south east of Whiteman Park with the Swan Valley to the east (Figure 1).

In its regional context, the Study Area is located within the catchment of the Swan River.

The topography of the site is shown in Figure 2 and can be classified into two distinct areas. The southern area is lower lying than the northern area and is typically undulating. The elevation in this southern area generally ranges between 14 to 18 mAHD with a very slight fall from east to west. The south west corner is the lowest lying of the study area at 14 mAHD.

The northern area contains two predominant mounds with elevation ranging between 17 to 23 mAHD at the western mound and 17 to 26 mAHD at the steeper eastern mound.

Topographic data is based on aerial survey completed by Fugro in August 2005 producing 0.2 m contours. The accuracy of this data is considered appropriate for decision making at the planning level of an LWMS.

2.2 Climate

The Study Area has a Mediterranean climate with warm dry summers and cool wet winters.

Annual rainfall recorded at the Bureau of Meteorology’s Midland station (009163, 1918 - 2011) is shown in Figure 3. The long term average annual rainfall for this site is 729 mm. The average annual rainfall has decreased significantly since 1975, with the average annual rainfall of 677 mm, reflecting a 10% reduction compared to the long term average.

The monthly rainfall distribution is also shown in Figure 3. This distribution has also altered since 1975, with a reduction of average monthly totals in the winter months, and an increase in monthly rainfall in the drier summer months from November to February.

The average annual pan evaporation for West Swan is approximately 2,080 mm (Luke et al., 1988).

2.3 Surface Geology

The Perth 1:50 000 Environmental Geology map (Gozzard, 1986) indicates that the study area is characterised by a variable thickness of Bassendean Sand overlying the Guildford Formation (Figure 2).

The Bassendean Sands consist of a white to pale grey sand, at surface, grading yellow with depth, fine to medium grained sand and are of aeolian origin. The underlying Guildford Formation is of alluvial origin and consist of white to brown, fine to coarse grained, clayey sands and sandy clays of low to high plasticity. A small pocket of peaty clay is located within the central lower lying area.

A preliminary geotechnical investigation was performed on 23 November 2005 by Coffey Geosciences (Coffey, 2005). A total of ten test pits were excavated by backhoe to depths between nominally 2.3 m and 2.5 m below existing natural surface.

The subsurface profile for the majority of the Study Area is generally as follows:

- Topsoil/Sand- fine to medium grained, pale grey to dark grey, with some grass roots and trace of organic matter, extending to 0.1 to 0.3 m below surface
- Sand- fine to medium grained, pale grey, brown/white , generally medium dense extending 1.6 to 2.3 m below surface
- Sand- fine to medium grained, yellow with iron stained or black/dark brown, weakly to moderately cemented (coffee rock) extending from 1.8 m to base of pit (2.3m).

The subsurface profile for the western edge of the Study Area is generally as follows:

- Topsoil/Sand or Clayey Sand- fine to medium grained, dark brown/dark grey with some roots and trace of organic matter, extending 0.2 m from surface
- Sand- fine to medium grained, yellow/pale grey, medium dense to dense, extending 0.2 to 0.9 m below surface
- Clayey Sand/Sandy Clay- fine to medium grained sand and medium plastic fines, brown/yellow/green, approximately 0.4 to 1.1 m from natural surface and 1.4 to 1.6 m thick
- Sand-fine to medium grained grey, medium dense to dense at 2.0 depth with thickness to the base of test.

The geotechnical report also specified that some uncontrolled fill would be encountered over some parts of the Study Area.

Further more detailed geotechnical investigations were undertaken in 2008 for the early stage areas of development (Douglas Partners, 2008a, 2008b). These investigations included conducting in-situ permeability testing using falling head and constant head methods at various locations across the site. Testing was typically conducted at depths 0.5 to 0.7 m below the existing natural surface. Permeability ranged widely from approximately 0.1m/day in areas of stiff sandy clay to 34 m/day in areas of medium grained sands. Areas of sand with some clay show a permeability of 9 m/day.

Site values are generally consistent with regional estimates by Davidson (1995) of hydraulic conductivity for fine to medium grained sands and clayey sands of 8 m/day and 1 m/day respectively.

2.4 Surface Water Hydrology

2.4.1 Existing Surface Drainage

The existing drains which traverse the Study Area are a combination of natural drainage lines and excavated drains, extended or deepened to enhance drainage from the area. A series of agricultural drains from private rural lots connect to four district drains as shown in Figure 8. There is no specified level of service for the district drains and the capacity of these drains varies.

There is no Water Corporation main drainage within the Study Area.

2.4.2 Previous Drainage Planning

As previously discussed in Section 1.2.2, a regional drainage strategy for the North-East Corridor was developed by GB Hill in 1995 for the (then) Water Authority of WA. A review of the document by GHD on behalf of DoW was completed in 2007 (GHD,2007).

Prior to GB Hill (1995), GHD–Dwyer undertook the Swan Valley Drainage Study for the Shire of Swan in 1982 to provide a master plan for stormwater drainage within the Swan Valley. This document is not referred to or referenced in GB Hill (1995), and is understood to have been superseded by details contained in GB Hill (1995).

The recently released DWMP (DoW, 2009) supersedes all these previous drainage planning documents.

2.4.3 Existing Floodplain Mapping

The (then) Water Authority of WA previously undertook a flood study for the Swan River between Middle Swan Rd and Walyunga National Park (WAWA, 1987). Flood mapping indicates a 100 year flood level of 7.72 mAHD in the Swan River adjacent to Victoria Rd and 7.77 mAHD adjacent to Coast Rd.

A flood study was also undertaken by WAWA in 1989 for Bennett Brook. The mapping indicates a 100 year flood level for Bennett Brook of 6.18 mAHD at Benara Road.

The minimum elevation of 14 mAHD within the Study Area is well above these 100 year flood levels.

2.4.4 Environmental Water Requirements

There are no current Environmental Water Requirements (EWR's) or Environmental Water Provisions (EWP's) established for the Swan River. The provisions of EWR's are discussed in River Plan, (SRT, 2005) but no resources are currently allocated to determining the required flow rates.

With respect to groundwater, the Study Area has no defined EWR's. It is however located south of the area covered by the East Gnangara Environmental Water Provisions Plan (WRC, 1997b) which recommends EWR's and EWP's for groundwater. WRC (1997b) presents criteria for wetland water levels, seepage flows and groundwater minimum levels aimed at protecting significant vegetation assemblages.

The nearest criteria bore for WRC (1997b) which has EWR and EWP levels is located 2km north west of the Study Area.

2.4.5 Surface Water Quality

Surface water quality sampling for the Study Area was commenced by JDA in July 2005 at 2 sites (Figure 4). Samples were analysed for physical parameters, nutrients and metals.

Surface water quality monitoring and data is contained in Appendix C and summarised in Table 3 with comparison to ANZECC (2000) and Swan River Trust (1999) guidelines values. It should be noted that while Swan River Trust (1999) and ANZECC (2000) guideline values are valuable as benchmark values, they are not based on surface water and groundwater quality specific to the Study Area and thus are intended for general comparison purposes only.

Summarising the monitoring results :

- pH in all samples were relatively neutral and generally within the ANZECC guideline value of 6.5– 8.
- Conductivity was greater than the upper ANZECC (2000) guideline value of 0.30 mS/cm on all occasions. The recorded conductivity ranged from 0.87 to 4.51 mS/cm.
- Median and mean Total Nitrogen concentrations were 4.7 mg/L and 4.3 mg/L respectively. These concentrations were lower than median and mean groundwater concentrations. These compare to Swan River Trust (1999) and ANZECC (2000) guideline values of 1 mg/L and 1.2 mg/L respectively.
- The median Total Phosphorus concentration of 0.63 mg/L, was considerably higher than the Swan River Trust (1999) and ANZECC (2000) guideline values of 0.1 mg/L and 0.06 mg/L respectively.

These results reflect the impact of the historical and existing land use of the Study Area, without implementation of any water sensitive urban design practices.

The Swan River Trust (1999) Swan-Canning Cleanup Program Action Plan also provides an assessment of Nitrogen and Phosphorus discharge rates for the Bennett Brook catchment for the period 1995 to 1997. The study classified the catchment as moderate discharge (median concentration 1 to 2 mg/L) for Total Nitrogen and low discharge for Total Phosphorus (median concentration less than 0.1 mg/L).

Table 3 also provides a comparison of monitoring data from the Study Area with Australian Runoff Quality (Institution of Engineers Australia, 2006) stormwater concentration estimates, and typical mean concentrations of urban runoff on the Swan Coastal Plain based on local data (Martens et al, 2004).

Further detailed description of pre-development surface water quality data is presented in the pre-development hydrological monitoring report (JDA, 2007).

Table 3: Pre-development Surface Water Quality Summary

Parameter and unit of measurement	ANZECC Guideline Value	SCCP Guideline Value	ARQ (IEAust 2006)	Martens et al (2004)	Surface Water Monitoring Summary				
					Samples	Min	Max	Median	Mean
Physical Properties									
pH	6.5-8.0	-	6.8	7.0	4	7.0	8.9	7.7	7.8
EC (ms/cm)	0.12-0.30	-	-	0.6	4	0.87	4.51	1.05	1.87
TDS (mg/L)		-	-	400	4	490	1300	730	812
Nutrients									
Total N (mg/L)	1.2	1.0	2.7	1.1	5	2.3	5.80	4.70	4.28
TKN (mg/L)	-	-	-	-	5	2.20	5.60	3.90	3.70
NOx-N (mg/L)	0.15	-	-	-	5	0.11	0.95	0.68	0.55
Ammonia_N (mg/L)	0.08	-	-	-	5	<0.2	<0.2	<0.2	<0.2
Total P (mg/L)	0.065	0.1	0.29	0.21	4	0.12	0.73	0.63	0.53
PO4-P (FRP) (mg/L)	0.040	-	-	-	5	0.11	0.43	0.18	0.21

1. Values adopted for Lowland River, South West Australia
2. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
3. SCCP Targets for TN and TP based on 20 year target values.

2.5 Groundwater Hydrology

The geological formations have been grouped into four distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined)
- Mirrabooka Aquifer (semi-confined)

- Leederville Aquifer (confined)
- Yarragadee Aquifer (confined)

The Yarragadee Aquifer is not considered in detail in the LWMS as private groundwater abstraction is not economically viable from this aquifer due to its depth below ground surface and water quality generally brackish to saline.

2.5.1 Superficial Aquifer

Groundwater in the Superficial Aquifer is contained within the Bassendean Sand and Guildford Clay strata of the Superficial Formations, with an average saturated thickness of about 40 m (WRC,1997a).

The Superficial Aquifer forms part of the Gnangara Mound groundwater flow system, a vast shallow groundwater resource to the north of Perth. At the Study Area groundwater flow is to the east and southeast, and salinity is generally less than 1000 mg/L.

Recharge to the Superficial Aquifer is directly from rainfall infiltration at a rate of between 10 to 30% of the mean annual rainfall. The greatest recharge occurs in areas of Bassendean Sand and the least in clayey areas (Davidson, 1995).

Leakage from the Superficial Aquifer provides recharge to the underlying Mirrabooka Aquifer, or Leederville Aquifer, in areas where there are downward potentiometric heads and where confining beds are absent. The Superficial Aquifer discharges locally into creeks and drains when the water table rises to the surface, generally in winter (Davidson, 1995).

2.5.2 Mirrabooka Aquifer

The Mirrabooka Aquifer is a locally important semi-confined aquifer. It is in general hydraulically connected with the overlying Superficial Aquifer and generally has a saturated thickness of 40 m, extending to a depth of –50 mAHD (Davidson, 1995).

The Mirrabooka Aquifer is recharged by leakage from the Superficial Aquifer, which is estimated to be 4% of rainfall. Groundwater flow in the Mirrabooka Aquifer is in a south-east direction, generally parallel to that of the Superficial Formation. The groundwater salinity is generally less than 500 mg/L (Davidson, 1995).

The Mirrabooka Aquifer is an important resource of fresh groundwater in areas where the groundwater of the Superficial Aquifer is brackish and abstraction from the underlying Leederville Aquifer is not permitted.

2.5.3 Leederville Aquifer

The Leederville Aquifer is a major confined aquifer that is present to the north and west of the Gnangara Mound and has an average thickness of about 300 m.

The Leederville Aquifer is reserved for public water supply and new allocations are generally not permitted.

2.5.4 Groundwater Levels

A spatial network of 15 bores (AS1 to AS15) was installed by JDA in July 2005 on behalf of St Leonards Estate Pty Ltd within the Study Area (Figure 4). A further 4 bores (AS16 to AS19) were installed in October 2006, to extend groundwater mapping coverage to the east.

Of the 19 bores, 12 were installed by hand auger (AS8 to AS19), and 7 (AS1 to AS7) installed by drill rig. Drilling was conducted using a hollow auger, constructed typically to 5.0 m below the water table and slotted for the lower 3.0 m.

Hand augered bores consisted of 50 mm PVC capped at both ends and screened for approximately the lower 1.0 m. Bore details and lithological logs are presented in Appendix D.

JDA (2005) detailed the calculation of an initial estimate of the average annual maximum groundwater level (AAMGL) for the Study Area, based on water levels recorded on 20 July 2005. These calculations have since been revised based on results of an 16 month water level monitoring program between July 2005 and December 2006. Estimated AAMGL's are shown in Figure 4, with calculations detailed in Appendix E. The AAMGL was found to vary from approximately 20.0 mAHD in the northwest of the Study Area to approximately 13.0 mAHD in the south western corner. The AAMGL is used in this report as a benchmark for the establishment of a Controlled Groundwater Level (CGL) as described in Section 4.5.

The direction of groundwater flow is typically to the south or south east for the northern region of the site, with the influence of drains prevalent in the southern region. Groundwater flow direction varies from south west to north east locally in this area.

Figure 4 shows the estimated depth to AAMGL from natural surface. The majority of the northern region of the site has in excess of 1.0 m clearance. The central and southern regions typically have depth to AAMGL of less than 1.0 m.

2.5.5 Seasonal and Inter-Annual Water Table Variation

Pre-development monthly water level monitoring data from July 2005 to December 2006 is included as Appendix F, including time series graphs of data as Figures F1 to F3.

The seasonal water table varies between 1.1 to 1.6m across the Study Area. This variation is consistent with long term DoW bores MM47, MM48 and M80c located near the Study Area (Appendix F, Figure F3). The area of highest water table variation was found to be located in the southern region of the site.

Differences in the seasonal water table variations with the Study Area are likely to be due to local differences in soil types, impacts of nearby drains and the impact of existing groundwater abstractions.

In addition to the seasonal variation, DoW bore MM48 indicates maximum and minimum groundwater levels may also vary by up to 1.5 m inter-annually.

2.5.6 Water Quality

Pre-development groundwater quality sampling of the Superficial Aquifer was completed by JDA from July 2005 to December 2006 (18 months, 2 winters) at quarterly frequency for 7 spatially distributed monitoring bores (AS1 to AS7). Samples were analysed for physical parameters, nutrients and metals.

The groundwater quality monitoring data is contained in Appendix G, and results summarised in relation to ANZECC (2000) and Swan River Trust (1999) guidelines values in Table 4.

Summarising the monitoring results:

- The majority of groundwater samples were relatively neutral with a pH between 6 and 7. Groundwater in bores AS1, AS2 and AS3 were slightly acidic with all but one sample having a pH value between 5 and 6. The mean and median pH levels across all monitoring locations were 6.1 and 6.2 respectively. This compares to an ANZECC (2000) guideline value of 6.5 to 8.0.
- Conductivity was generally below 2 mS/cm except in AS1 and AS4 which had levels generally greater than 2.5 mS/cm. The mean and median conductivity was 1.65 mS/cm and 1.18 mS/cm respectively. This compares to an ANZECC (2000) guideline value of 0.12 to 0.30 mS/cm.
- Total Dissolved Solid (TDS) concentrations were highest in bores AS1 and AS4, ranging to 3400 mg/L. The mean and median TDS were 1030 and 770 mg/L respectively.
- Total Nitrogen levels were highly variable across the Study Area and within each bore over the sampling period. Significant variation in Nitrogen is likely due to different land use, soils and local hydrological regimes. Mean and median Total Nitrogen levels are 9.6 mg/L and 5.1 mg/L respectively. This compares to Swan River Trust (1999) and ANZECC (2000) guideline values of 1 mg/L and 1.2 mg/L respectively.
- Total Phosphorus levels were generally below 1 mg/L, except in bores AS2 and AS3. The highest recorded Total Phosphorus level was 8.9 mg/L in AS5. The mean and median Total Phosphorus level of 0.91 mg/L and 0.19 mg/L were greater than the SCCP and ANZECC guideline value of 0.1 mg/L and 0.065 mg/L respectively.
- Mean and median Filterable Reactive Phosphorus (FRP) concentrations of 0.44 mg/L and 0.07 mg/L compare to the ANZECC (2000) guideline value of 0.04 mg/L.

Table 4 also provides a comparison of monitoring data from the Study Area with Australian Runoff Quality (ARQ, Institution of Engineers Australia, 2006) mean stormwater concentration estimates for Australia, and typical mean concentrations of urban runoff on the Swan Coastal Plain based on local data (Martens *et al.*, 2004). Post-development stormwater quality for the Study Area is considered likely to be similar to Martens *et al.* (2004).

Martens *et al.* (2004) found vertical leaching of fertiliser to the groundwater table at the domestic scale rather than local authority drainage stormwater system to be the major pathway for nutrients to groundwater on the Swan Coastal Plain. Based on pre-development monitoring data, this is considered likely to also be the case for the Study Area. Analysis of the likely impact of land use change on groundwater quality is assessed in Section 4.6.1 on the basis of comparing nutrient inputs for existing and proposed development.

It should also be noted that the ANZECC (2000) and Swan River Trust (1999) guideline values relate to surface flow rather than groundwater. Comparisons to the guideline values for groundwater are presented in this report, as implementation of a controlled groundwater level may result in the periodic export of groundwater as surface flow.

Table 4: Pre-development Groundwater Quality Summary

Parameter and unit of measurement	ANZECC Guideline Value	SCCP Guideline Value	ARQ (IEAust 2006)	Martens et al (2004)	Groundwater Monitoring Summary				
					Samples	Min	Max	Median	Mean
Physical Properties									
pH	6.5-8.0	-	6.8	7.0	41	5.10	7.80	6.1	6.1
EC (ms/cm)	0.12-0.30	-	-	0.6	41	0.21	5.82	1.18	1.65
TDS (mg/L)		-	-	400	41	110	3400	770	1030
Nutrients									
Total N (mg/L)	1.2	1.0	2.7	1.1	42	0.30	140	5.1	9.6
TKN (mg/L)	-	-	-	-	42	0.20	140	2.7	6.5
NOx-N (mg/L)	0.15	-	-	-	42	0.02	34.02	0.53	3.10
Ammonia_N (mg/L)	0.08	-	-	-	41	<0.2	2.10	<0.2	0.54
Total P (mg/L)	0.065	0.1	0.29	0.21	42	0.04	8.90	0.19	0.91
PO4-P (FRP) (mg/L)	0.040	-	-	-	42	<0.01	2.40	0.07	0.44

1. Values adopted for Lowland River, South West Australia
2. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
3. SCCP Targets for TN and TP based on 20 year target values

2.6 Wetlands

The location and boundaries of the DEC Geomorphic Swan Coastal Plain Wetlands dataset are shown in Figure 5. The majority of the southern region of the Study Area has been mapped as Palusplain of the Multiple Use management category (RPS BBG, 2005).

A sumpland is defined as a seasonally inundated basin. However, JDA's depth to AAMGL mapping (Figure 4) indicates the majority of this area as having an AAMGL level below natural surface. Some areas classified as sumpland in DEC mapping have a groundwater depth to AAMGL in excess of 3 m.

The Multiple Use category indicates that the wetland has few important ecological attributes and function remaining. The land can be developed but the development must be sympathetic to the wetland status of the land and be based on water sensitive urban design principles.

There are no Environmental Protection Policy (EPP) wetlands (Environmental Protection Policy Swan Coastal Plain Lakes, 1992) in the Study Area. The nearest Conservation Category Wetland is located approximately 400 m west of the north-western corner of the Study Area.

Two wetlands (Sumplands) classified as Resource Enhancement wetlands are located in the central and northern regions of the Study Area. Generic 50 m buffers around each of these wetlands are shown in Figure 5, subject to environmental review outcomes based on ecological survey and assessment.

2.7 Acid Sulphate Soils

Acid Sulphate Soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulphides. These naturally occurring iron sulphides are generally found in a layer of waterlogged soil or sediment and are benign. When disturbed and exposed to air they oxidise and produce sulphuric acid, iron precipitates, and concentrations of dissolved heavy metals such as aluminium, iron and arsenic. Release of acid and metals as a result of the disturbance of acid sulphate soils can cause significant harm to the environment and infrastructure.

The presence of ASS has been a recognised issue of concern in Western Australia since 2003. The DEC and the Western Australian Planning Commission (WAPC) have released guidance notes on ASS, covering the requirement for assessing sites and the management of sites where ASS are identified. ASS investigations are commonly required as part of the conditions of subdivision or as a requirement for a dewatering license application.

The WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping for the Study Area is shown in Figure 2. This mapping closely correlates with Surface Geology mapping also shown in Figure 2. In summary:

- The northern region and south eastern corner of the Study Area is predominately classified as having a moderate to low risk of actual acid sulphate soil (AASS) or potential acid sulphate soil (PASS) occurring >3 m from surface, and no risk of occurrence <3 m from soil surface.
- A small portion of the Study Area considered moderate to high risk of ASS or PASS occurring <3 m from soil surface. This is located in the eastern central region of the site corresponding to a region mapped as peaty clay soils.

RPS is undertaking an ASS assessment of West Swan East as a separate process to the LWMS.

2.8 Existing Land Use

An aerial photograph showing existing land use within the Study Area is shown in Figure 5.

Existing land use within the Study Area is generally broad acre grazing, with an existing Montessori School located on Harrow St near the northern boundary of the Study Area. An existing high voltage distribution power line running east-west along Marshall Rd will restrict development in its vicinity and along its length. The Dampier-Bunbury Gas Pipeline and the Parmelia Gas Pipeline run along the outside of the Eastern boundary of the development influencing development in its vicinity.

RPS (2005) reported no historical land uses that suggest significant contamination issues within the Study Area.

2.9 Water Resources

The Study Area is located within the South Swan sub area of the Swan Groundwater Area.

Table 5 summarises the current quotas, allocation and unallocated water for the both the Superficial and Mirrabooka Aquifers advised by DoW in July 2013

Table 5 shows that the South Swan sub-area is currently fully allocated for both the Superficial and Mirrabooka Aquifers.

St Leonards Estate Pty Ltd has to date secured licenced allocation totalling 167,000 kL/yr in this area.

Based on the current POS estimate of 40 ha for the DSP area, total irrigation demand will be in the order of 225,000 kL/yr compared to the 383,000 kL/yr currently licensed. Change of land use (and land ownership) within the Study Area to urban residential will see the majority of these existing licences transferred or relicensed with land ownership as development proceeds.

Table 5: **Groundwater Resources and Current Licenced Allocations**

Groundwater Area	Sub-area	Superficial Aquifer (ML/yr)			Mirrabooka Aquifer (ML/yr)		
		Current Quota	Current Allocation	**Unallocated**	Current Quota	Current Allocation	**Unallocated**
As at July 2013							
Swan	South Swan	3,400,785	3,737,231	**-**	1,600,000	1,645,657	**-**

2.10 Hydrological Opportunities and Constraints

The above described characteristics of the pre-development environment in the Study Area provide a number of key constraints and opportunities for the application of innovative approaches in water management with land use change:

- Ongoing groundwater monitoring and mapping by JDA within the Study Area has allowed for a local assessment of groundwater levels in relation to existing natural surface level. The shallow groundwater over the majority of the Study Area provides an opportunity for the implementation of a controlled groundwater level (CGL) to reduce development costs and minimise large-scale trucking of fill, consistent with sustainability principles.

- There are no EPP or Conservation Category wetlands within the Study Area which would be adversely affected by implementation of a CGL within the Study Area.

- Clayey soils are likely to limit infiltration opportunities in some regions of the Study Area, and may impact the ability to meet DoW's preference to infiltrate frequently occurring storm events (typically less than 1 year ARI). This is most likely to be the case in the central region of the Study Area.

- Historical rural land use within the Study Area has to varying degrees affected groundwater quality within the Study Area. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, and establishment of water quality targets, monitoring and compliance reporting.

- There are two degraded wetlands in the Study Area classified as Resource Enhancement, providing an opportunity for rehabilitation with land use change.

- In terms of meeting irrigation demand, St Leonards Estate Pty Ltd has to date secured licencing of 167,000 kL/yr in this area. Future POS irrigation demands for the remainder of the Study Area will be satisfied by 383,000 kL/yr in licences which currently exist across the Study Area.

These constraints and opportunities inform the local water management strategy presented in Chapter 4.

3. PROPOSED DEVELOPMENT

The Regional Structure Plan is shown in Figure 6, with a more detailed breakdown of proposed land use shown in Figure 7.

Proposed land use is predominately residential (R20-R30) with some pockets of higher density R40 adjacent to POS areas. A Mixed Use and Retail area is proposed in the south western corner of the site, with some group housing at R60.

The existing resource enhancement sumpland located centrally is proposed to be retained and enhanced. A corridor adjacent Marshall Rd is to be maintained to accommodate high voltage power lines.

Key elements of the Structure Plan related to urban water management include:

- Protection and rehabilitation of the existing waterway discharging to Bennett Brook under Reid Highway within a landscaped POS corridor to preserve Aboriginal Heritage values.
- Use of linear POS for detention, retention, conveyance, and treatment of stormwater.
- Use of locally distributed POS areas for stormwater retention and detention.
- Maintenance of key discharge points from the Study Area to the receiving environment.

4. LOCAL WATER MANAGEMENT STRATEGY

4.1 Water Supply and Wastewater

Public Open Spaces

Considering a fit for purpose strategy, the water supply for the public open spaces is proposed to be from local groundwater resources (Superficial and Mirrabooka Aquifers) through the transfer of existing licences to land developers during the land development process.

Water Servicing

JDA has been advised by St Leonards Estate Pty Ltd that water supply to households is to be scheme water via extension of the existing system, and that this is supported by Water Corporation.

Wastewater Servicing

JDA has been advised by St Leonards Estate Pty Ltd that Water Corporation has developed conceptual planning for the eventual sewer network for the West Swan East Study Area which will be implemented to service the West Swan East Study Area.

4.2 Water Use Sustainability Initiatives

4.2.1 Water Conservation

Development of the Study Area will lead to an increased demand for water for new residents as well as irrigation of public open spaces.

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

- Use of higher density residential zoning and smaller lots to reduce garden (ex house) use of water.
- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping)
- All houses to be built to 5 star building standards
- Use of native plants in POS areas
- Use of groundwater bores for irrigation of POS and common areas
- Maximising on site retention of stormwater

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

4.2.2 Non Potable Water Supply & Water Balance

A water balance at the LWMS stage is generally requested to support the identification of excess water generated by the development for potential use as a non-potable water supply scheme. No water balance was provided at the district or regional scale in the DWMP (DoW,2009).

The use of local groundwater or alternative non potable water supply schemes for households is not currently considered viable for the Study Area. The local groundwater area is currently fully allocated and alternative non potable supply options such as stormwater or wastewater reuse are unlikely to be viable within the current development timeframe.

Given the full allocation of existing groundwater resources (both Superficial and Mirrabooka Aquifers) within the South Swan groundwater allocation sub area, the water source planning strategy for the Study Area is for use of scheme water for domestic use (both in and ex house) supplemented to some extent by rainwater tanks and use of groundwater bores for irrigation of POS areas.

Sizing of rainwater tanks and further details of POS supplies will be provided at UWMP stage, commensurate with requirements of building design and DoW (2007).

Given the extended timeframe for development of the Study Area, reconsideration of the availability and feasibility of non-potable supply options should be undertaken during the development of individual UWMP’s to assess any future opportunity for implementation of non-potable supplies.

4.3 District Drainage

4.3.1 Existing Drains

The DWMP drainage strategy identifies three outlet points for the West Swan East cell:

- The north-east corner
- East along Marshall Rd, connecting to West Swan Road then heading south, and
- South west corner discharging to Bennett Brook.

On-site investigations and discussions with the City of Swan have found that the alignment of local drains differs from those shown in the DWMP. The discrepancies can be seen in Figure 8 and include:

- Marshall Rd drain continues east under West Swan Road discharging to the Swan River.
- The north east corner drains south via the Malvern Street drain, connecting to Marshall Road drain.
- There is an additional drain east along Victoria St, which flows south under Reid Highway discharging to a drain along West Swan Road.

As part of the review of the downstream drains completed for this LWMS, the capacity of the drains to convey the pre-development flow rates, as indicated in the DWMP, was also considered. Modelling indicates that the Bennett Brook connection, Victoria St drain and Malvern St drain have sufficient capacity to convey the pre-development flows. Marshall Road drain was found to be under capacity and unable to convey the pre-development 100 yr ARI flow of 1.50 m^3/s as shown in the DWMP.

The Marshall Rd drain is made up of alternating sections of open drain and pipes. The pipe sections range in size from 450 mm to 600 mm diameter (Figure 9). Modelling by JDA indicates that the existing drain has capacity for a 10 yr ARI storm. Rainfall events in excess of this cause the drain to overflow, which is unlikely to present an issue for the current rural land uses. Under existing land use in severe storms the land adjacent to the drain would be inundated.

The Marshall Rd drain system also currently includes a compensation basin within Lot 27, which is owned by the City. JDA understands that the Lot 27 basin was constructed by the City to reduce the overflow from the drain in major rainfall events.

4.3.2 Future Upgrade of Marshall Rd Drain

As development in the area progresses to urban, the overflow may no longer be acceptable. In storms more severe than the 10 yr ARI, inflow to the drain is limited by the capacity of the pipe section downstream of the West Swan East cell. The tailwater level for the West Swan East discharge point limits the outflow to 0.22 m^3/s (Figure 10), compared to the pre-development flow of 1.50 m^3/s as indicated in the DWMP (Figure 10).

The alignment for the future Marshall Rd, connecting to Henley Brook Drive (to be constructed), will result is at least half of the Lot 27 compensation basin being lost (Figure 9). Removing this compensation basin volume will further exacerbate overflow from the drain volume in major storm events.

For development of the West Swan East cell, the under capacity of the drain is limiting outflow from the site.

The Marshall Rd drain catchment includes inflow from the Malvern St drain to the north, which captures flow from a catchment between approximately Cranleigh St and Harrow St (Wandoo Creek and Cranleigh St Catchments).

The results of an indicative upgrade of the drain by JDA are shown in Figure 11. To convey a flow of 1.50 m^3/s the pipe sections of the drain need to be upgraded, by replacing with larger pipes.

This increased capacity will allow the full flow to enter the drain at the West Swan East outlet point and reduce the drain HGL. It should be noted that pipe sizes indicated on Figure 11 are indicative only and a further detailed assessment is necessary. Further assessment should also consider alternative layouts or arrangements that may offer a better solution than the indicative information provided in Figure 11.

Preliminary discussions with Department of Water and Swan River Trust occurred in May 2012 to consider the drain upgrade. This LWMS follows on from these discussions to provide sufficient information to allow in-principle support for the upgrade of Marshall Street drain. The Minutes of the May 2012 meeting are provided in Appendix H.

There are two rural dams adjacent to the drain on the eastern side of West Swan Road. Figure 9 shows the location of the dams ‘offline’ from the drain. It is possible that some drain flow enters these dams, and the upgrade should take this into account. Timing of construction of design and of drain upgrade is within the City’s control.

4.3.3 Gas Pipeline Crossings

As part of drainage planning, the current crossings of the Dampier-Bunbury Gas Pipline (DBGP) and the Parmelia Gas Pipeline will be utilised.

Three crossings currently exist as follows;

- Victoria Street- Roadside drain. Approximately 1.0 m deep with a base of 1.0 m and side slopes of 1:2 (v:h), crossing the DBGP at approximately 16.5 mAHD.

- Cranleigh Street connecting to Malvern St drain. Approximately 0.5 m deep with a base of 1.0 m side slopes of 1:4 (v:h), crossing the DBGP at approximately 14.90 mAHD

- Marshall Road drain. A siphon arrangement with a 525 mm (I.L. 11.25 mAHD) pipe running beneath a brick spillway (I.L.13.65 mAHD).

This LWMS does not propose any changes to the above crossings. If any modifications are required as a result of more detailed analysis completed at the UWMP stage, the changes will need to be negotiated with the DBGP and Parmelia pipeline operators.

4.3.4 DWMP Catchments

The DWMP identifies West Swan East (WSE) catchment with four sub-catchments (Figure 8), namely WSEa to WES d.

The WSE sub-catchments shown in the DWMP are aligned with the DSP area, with no flows entering the West Swan East cell from external areas.

Peak outflow rates for each of the sub-catchments as presented in the DWMP are summarised in Table 6.

Table 6: Allowable Peak Outflow

DWMP Sub-catchment Planning Criteria					
		Peak Discharge Flow (m^3/s)		Detention Volume (m^3)	
Catchment	Area (ha)	5-year	100-year	5-year	100-year
WSEa	77.0	0.1	0.7	3700	7700
WSEb	108.9	0.1	0.8	10100	16300
WSEc	39.3	0.1	0.4	4300	9000
WSEd	43.8	0.2	0.7	8200	10700
Total	**269**	**0.5**	**2.6**	**26300**	**43700**

4.4 Local Stormwater Management

4.4.1 Catchment Mapping

Based on site investigations, desktop studies and meetings with the City the catchments presented in the DWMP have been refined as shown in Figure 12 and presented in Table 7. The West Swan East Cell is now divided into 5 catchments compared to 4 shown in the DWMP, with outflow rates consistent with the DWMP guidance presented in Table 6.

Table 7: LWMS Catchments Discharge Rates

LWMS Pro-rata Flow Rates			
		Peak Discharge Flow (m^3)	
Catchment	**Area (ha)**	**5-year**	**100-year**
Malvern Street	39.7	0.05	0.27
Cranleigh Street	56.0	0.07	0.43
Marshall Road	82.4	0.07	0.80
Victoria Street	47.1	0.10	0.40
Bennett Brook	43.8	0.20	0.70
Total	**269.0**	**0.49**	**2.60**

4.4.2 Catchment Runoff Parameters

To ensure post-development outflow rates are consistent with the pre-development rates, storages are required to detain stormwater flows during rainfall events. The detention storages have been modelled using the XP-Storm model. Detention storage locations were determined based on existing topographic contours, survey levels, depth to groundwater mapping and district structure plan constraints (Figure 12). Storage invert levels have been assumed to be at least 0.3m above the groundwater design level, with storage outlets set at the storage invert levels.

The design storms modelled in XP-Storm were calculated according to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2006). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours.

The runoff coefficients applied for the various land uses in the Study Area is presented in Table 8.

Table 8: Land Use Runoff Parameters for XP-Storm Model

Land Use	Runoff coefficient	Initial loss (mm)
Commercial /Retail	60%	0
POS	10%	0
Power easement	10%	16
R20	40%	10
R30	40%	10
R40	70%	0
R5	10%	16
road	80%	0
school	50%	0
Power substation	60%	0

4.4.3 Major Drainage System

The stormwater drainage system will be designed using a major/minor approach adhering to district flow design criteria. The major drainage system is defined as the arrangement of roads, drainage reserves, detention basins and open space planned to provide safe passage of stormwater runoff from extreme events which exceed the capacity of the minor system, typically greater than 5 yr ARI. The major drainage system is described in section 4.2.2.1 with the major features of the drainage system shown in Figure 12.

The design strategy is consistent with the objectives provided in the district DWMP. Key points of the major drainage system strategy are as follows:

- Maintaining the water alignment of current natural channels on site.
- Discharge rates from detention basins controlled to retain existing outflow discharge rates outlined in the DWMP.
- Roads graded to direct flow to the lowest point in the catchment. Swales and spillways utilised in key locations to convey flow from detention basins to connect drains and channels of the site.
- Restoration of the existing channels to open swales to convey flows. Works may include re-grading the drain to prevent water pooling.
- At least a 0.5m clearance above the estimated 100 yr ARI flood level of the detention storages for all building finished levels.

4.4.4 Minor Drainage System

The minor drainage system is defined as the series of pipes, kerbs and gutters etc designed to carry runoff generated by low frequency ARI storms, typically less than 5 yr ARI. The minor drainage incorporates a treatment train of best management practice (BMP) water quality structural controls such as vegetated swale and storage systems that provide water quality treatment from the proposed development.

To meet the design criteria for the minor drainage system, the following strategies are proposed;

- Soakwells with a minimum capacity of 10mm rainfall for residential lots where separation to water table of 1.5m is achieved or where site geotechnical classification permits.
- The roadside pipe network will be sized to convey the 5yr ARI flow.
- Drainage treatment train systems will have capacity to treat the 3 month ARI event.

Stormwater Detention Areas

To integrate the detention storages into the available POS areas the 5 catchments have been divided into sub-catchments as summarised in Table 9.

Table 9: LWMS Sub-Catchments Allowable Discharge Rates

LWMS Pro-Rata Flow Rates			
		Peak Discharge Flow (m^3/s)	
Catchment	**Area (ha)**	**5-year**	**100-year**
Malvern Street Catchment			
MS1	20.1	0.03	0.15
MS2	16.6	0.024	0.12
Cranleigh Street Catchment			
CR1	7.6	0.01	0.06
CR2	27.1	0.04	0.21
CR3	7.3	0.01	0.05
CR4	13.8	0.02	0.11
CR5	0.23	0.0003	0.002
Marshall Road Catchment			
WS1	7.9	0.01	0.08
WS2	9.4	0.01	0.10
WS3	17.9	0.02	0.20
WS4A	11.9	0.01	0.13
WS4B	6.8	0.01	0.07
WS4C	5.7	0.01	0.06
WS4D	10.2	0.01	0.11
WS4E	4.9	0.01	0.05
Victoria Street Catchment			
VS1	47.1	0.10	0.40
Bennett Brook Catchment			
Linear POS	3.7	0.11	0.07
Lot 8001	19.1	0.10	0.34
Lot 8002	8.3	0.04	0.14
Lot8003	8.4	0.04	0.15

The detention storage and peak outflow rates for each catchment are presented in Tables 10 to 14. Modelling of the basins has assumed a maximum of 1.0 m depth with side slopes of 1:6.

Note that storage details shown are indicative only and are provided for comparison to the POS areas allocated in the structure plan. The final configuration (side slopes etc) and exact location of the storage areas will be dependent on final earthworks, drainage and road design levels for the development. The details will be refined at the sub-division stage and reported in the relevant Urban Water Management Plan (UWMP) along with details of water quality treatment structures.

There is insufficient information provided in the DWMP to reconcile the peak outflows and sub-catchment detention storages for the 5 yr ARI. As such the revised sub-catchments detention storage volumes for the 5 yr ARI were calculated based on achieving similar detention volumes to those provided in the DWMP using the DWMP runoff parameters. In most cases this results in higher peak outflow in the 5 yr ARI than shown in the DWMP.

Table 10: XP-STORM Model Results for 5 yr & 100 yr ARI Detention Storages Bennett Brook

Post-Development Storage : **(see Figure 13)**	Lot 8001	Lot 8002	Lot 8003	Linear POS
Storage Data				
Storage Invert (mAHD)	13.5	15.3	14.8	13.8
Side Slopes (v:h)	1:6	1:6	1:6	1:6
Outlet Invert (mAHD)	13.5	15.3	14.8	13.8
5 Year ARI				
Critical Duration (hrs)	6	6	6	6
Storm Rainfall (mm)	47.4	47.4	47.4	47.4
Runoff Volume (m^3)	9050	3935	3980	1755
Storage (m^3)	3080	1010	440	345
Water level rise (m)	0.76	0.20	0.26	0.38
Top Water Level (mAHD)	14.26	15.50	15.06	14.18
Top Water Level Area (ha)	0.67	0.55	0.24	0.13
Peak Outflow (m^3/s)	0.10	0.04	0.08[1]	0.10[2]
Stored Volume/Runoff Volume (%)	34	26	11	20
100 Year ARI				
Critical Duration (hrs)	6	6	6	6
Storm Rainfall (mm)	94.2	94.2	94.2	94.2
Runoff Volume (m^3)	18000	7820	7910	3480
Storage (m^3)	5020	1770	970	670
Water level rise (m)	0.83	0.35	0.53	0.65
Top Water Level (mAHD)	14.33	15.65	15.33	14.45
Top Water Level Area (ha)	0.69	0.63	0.31	0.15
Peak Outflow (m^3/s)	0.31	0.14	0.30[1]	0.36[2]
Stored Volume/Runoff Volume (%)	28	23	12	19

Note: 1- Outflow includes discharge from Lot 8002

2- Outflow includes discharge from Lot 8003

Table 11: XP-STORM Model Results for 5 yr & 100 yr ARI Detention Storages Cranleigh Street

Post-Development Storage : **(see Figure 14)**	CR1	CR2	CR3	CR4	CR5[1]
Storage Data					
Storage Invert (mAHD)	20.40	19.50	18.32	17.00	18.00
Side Slopes (v:h)	1:6	1:6	1:6	1:6	1:4
Outlet Invert (mAHD)	20.70	19.80	18.32	17.30	18.00
5 Year ARI					
Critical Duration (hrs)	36	36	24	36	36
Storm Rainfall (mm)	89.6	89.6	77.5	89.6	89.6
Runoff Volume (m^3)	6810	24280	5660	12360	205
Storage (m^3)	1500	4470	1180	1700	640
Water level rise (m)	0.54	0.65	0.42	0.59	0.44
Top Water Level (mAHD)	20.94	20.16	18.74	17.56	18.44
Top Water Level Area (ha)	0.46	0.99	0.31	0.47	0.19
Peak Outflow (m^3/s)	0.04	0.20	0.03	0.10	0.28
Stored Volume/Runoff Volume (%)	22	18	21	14	-
100 Year ARI					
Critical Duration (hrs)	24	24	24	6	48
Storm Rainfall (mm)	155.7	155.7	155.7	94.2	204.0
Runoff Volume (m^3)	11830	42190	11365	13000	470
Storage (m^3)	3300	9465	2730	3310	825
Water level rise (m)	1.00	1.00	0.89	0.99	0.50
Top Water Level (mAHD)	21.40	20.50	19.21	17.96	18.50
Top Water Level Area (ha)	0.52	1.20	0.38	0.54	0.22
Peak Outflow (m^3/s)	0.05	0.21	0.04	0.12	0.38
Stored Volume/Runoff Volume (%)	28	22	24	25	-

Note: 1- Includes outflow discharge from CR1 & CR2

Table 12: XP-STORM Model Results for 5 yr & 100 yr ARI Detention Storages Malvern Street

Post-Development Storage : **(see Figure 15)**	MS2
Storage Data	
Storage Invert (mAHD)	19.50
Side Slopes (v:h)	1:6
Outlet Invert (mAHD)	19.80
5 Year ARI	
Critical Duration (hrs)	36
Storm Rainfall (mm)	89.6
Runoff Volume (m^3)	14870
Storage (m^3)	1945
Water level rise (m)	0.57
Top Water Level (mAHD)	20.07
Top Water Level Area (ha)	0.54
Peak Outflow (m^3/s)	0.09
Stored Volume/Runoff Volume (%)	13
100 Year ARI	
Critical Duration (hrs)	36
Storm Rainfall (mm)	183.2
Runoff Volume (m^3)	30410
Storage (m^3)	4210
Water level rise (m)	1.00
Top Water Level (mAHD)	20.50
Top Water Level Area (ha)	0.61
Peak Outflow (m^3/s)	0.12
Stored Volume/Runoff Volume (%)	14

Table 13: XP-STORM Model Results for 5 yr & 100 yr ARI Detention Storages Marshall Road

Post-Development Storage : **(see Figure 17)**	WS1	WS2	WS3	WS4A[1]	WS4B[2]	WS4C[3]	WS4D	WS4E
Storage Data								
Storage Invert (mAHD)	16.30	16.00	15.10	13.46	14.80	13.20	14.80	14.16
Side Slopes (v:h)	1:6	1:6	1:6	1:2	1:4	1:2	1:6	1:6
Outlet Invert (mAHD)	16.30	16.00	15.25	13.46	14.80	13.20	14.80	14.46
5 Year ARI								
Critical Duration (hrs)	36	48	48	36	36	36	36	48
Storm Rainfall (mm)	89.6	98.4	98.4	89.6	89.6	89.6	89.6	98.4
Runoff Volume (m^3)	7080	9250	17610	10660	6090	5110	9140	4820
Storage (m^3)	1400	1190	1250	860[4]	210	810[4]	940	290
Water level rise (m)	0.58	0.39	0.38	0.64	0.5	0.70	0.50	0.42
Top Water Level (mAHD)	16.78	16.39	15.48	14.10	15.30	13.90	15.30	14.58
Top Water Level Area (ha)	0.32	0.33	0.38	0.20	0.19	0.15	0.28	0.10
Peak Outflow (m^3/s)	0.05	0.08	0.19	0.48	0.14	0.53	0.07	0.03
Stored Volume/Runoff Volume (%)	20	13	7	8	3	16	10	6
100 Year ARI								
Critical Duration (hrs)	24	24	6	6	24	24	24	6
Storm Rainfall (mm)	155.7	155.7	94.2	94.2	155.7	155.7	155.7	94.2
Runoff Volume (m^3)	12300	14630	16860	11210	10590	8870	15880	4620
Storage (m^3)	2810	3070	4290	1670[4]	570	1610[4]	2020	785
Water level rise (m)	0.87	0.93	0.90	1.19	0.6	1.15	0.85	0.89
Top Water Level (mAHD)	17.17	16.93	16.00	14.65	15.40	14.35	15.65	15.05
Top Water Level Area (ha)	0.36	0.41	0.46	0.24	0.19	0.19	0.33	0.13
Peak Outflow (m^3/s)	0.08	0.10	0.20	0.58	0.20	0.68	0.11	0.05
Stored Volume/Runoff Volume (%)	23	21	25	15	5	18	13	17

Note: 1- Outflow includes discharge from WS1, WS2, WS3, WS4D

2- Outflow includes discharge from Marshall Rd, Cranleigh St and Malvern Street Catchments

3- Outflow includes discharge from WS4A and WS4E

4- Storage located within Marshall Rd median swale

Table 14: XP-STORM Model Results for 5yr & 100yr ARI Detention Storages Victoria Street

Post-Development Storage : **(see Figure 16)**	VS1
Storage Data	
Storage Invert (mAHD)	15.50
Side Slopes (v:h)	1:6
Outlet Invert (mAHD)	15.80
5 Year ARI	
Critical Duration (hrs)	36
Storm Rainfall (mm)	89.6
Runoff Volume (m^3)	42200
Storage (m^3)	8920
Water level rise (m)	0.68
Top Water Level (mAHD)	16.18
Top Water Level Area (ha)	1.68
Peak Outflow (m^3/s)	0.26
Stored Volume/Runoff Volume (%)	21
100 Year ARI	
Critical Duration (hrs)	6
Storm Rainfall (mm)	94.2
Runoff Volume (m^3)	45780
Storage (m^3)	14370
Water level rise (m)	1.00
Top Water Level (mAHD)	16.50
Top Water Level Area (ha)	1.78
Detained Peak Outflow (m^3/s)	0.40
Stored Volume/Runoff Volume (%)	31

Wetland Buffer Storages

There is no proposed drainage to the northern wetland or its associated buffers. The wetland near Marshall Rd however will include drainage in its buffer, consistent with the Wetland Management Plan for LSP2B (ENV, 2012). The total drainage storage is shown in Figure 17 for the entire catchment, with a more refined design showing the wetland drainage concept presented in Figure 18.

4.4.5 Public Utility Easement

This LWMS assumes no drainage into the public utility easement. Currently as shown in the structure plan, drainage for LSP2A along the northern boundary is shown in the POS. However, drainage overflow to the public utility easement may be possible to reduce drainage requirement in the POS. Further planning is required at the UWMP stage.

4.4.6 Marshall Rd Central Median Swale

Marshall Rd drainage is contained within a central median swale which extends from Arthur St east to the Dayton DSP boundary. The swale provides storage for two sub-catchments (WS4A and WS4C) within the Marshall Rd catchment. This storage is achieved by two pipe culvert sections which limit flow through the swale. The concept for Marshall Rd central median swale is shown in Figure 22.

4.5 Groundwater Management

The shallow AAMGL over the majority of the Study Area provides an opportunity for the implementation of a controlled groundwater level (CGL) to reduce development costs and minimise large-scale trucking of fill consistent with sustainability principles.

The implementation of a controlled groundwater level (CGL) within a development area is dependent on a range of local site conditions including the soil type and its relationship to groundwater levels (regional and/or perched), the presence of ASS, the existence of pollutants or nutrients within groundwater, and the need to protect wetlands and receiving environments.

This LWMS proposes establishing a CGL at the AAMGL level established in Section 2.5.4.

While the LWMS does not specifically identify areas for CGL, the following information is provided to assist identification of CGL areas and fill requirements at later planning stages.

A study was undertaken to identify where the AAMGL is located above the clay layer (ie water table within sand) as an estimate of areas where a CGL below the AAMGL could be implemented. Data for determination of the depth of the clay layer has been based on lithological logs from 18 groundwater monitoring bores installed in the Study Area (JDA, 2005a), and checked against geotechnical investigation test pits detailed in Coffey (2005).

Figures 19 to 20 detail the results of the depth to clay layer investigation:

- Figure 19 shows contour mapping of the clay layer in mAHD over the Study Area. Only bores which intersected the clay layer (defined as the level for commencement of clayey sand or sandy clay in soil profile) are shown on Figure 18. The clay layer elevation ranged from a minimum of approximately 12 mAHD on the southern boundary of the Study Area to a maximum of 18 mAHD in the north western corner.
- Figure 19 also presents this information as a depth to clay layer below natural surface based on available topographic data. This figure provides an indication of the thickness of the sand surface layer above the clay.
- Based on this information and the depth to AAMGL/CGL indicative areas of fill and lot infiltration are shown in Figure 20. Approximately 60% of the site is considered possible for lot scale soakwell use and infiltration.
- Figure 20 details indicative areas of subsoil drainage based on areas where the AAMGL/CGL is less than 1.8 m below the existing natural surface. The majority of the site is likely to require subsoil drainage at the AAMGL/CGL.

Mapping presented in Figures 19 and 20 should be considered indicative only for assisting in LWMS strategy evaluation purposes and subject to further investigation (including geotechnical assessment) during detailed design.

4.5.1 Manage groundwater levels to protect infrastructure and assets

Minimum separation between building floor levels for development and groundwater will be achieved by filling of house pads and/or installation of subsoil drainage to limit groundwater to the CGL consistent with DWMP (DoW,2009) requirements and City of Swan considerations. The agreed approach will be documented in the UWMP.

With respect to the use of soakwells, fill importation, lot connections, and subsoil drainage, the following criteria apply:

- Soakwells to be used in areas with 2.0 m of sand (as classified by geotechnical engineer), which includes a combination of imported sand fill and in-situ sand. Sandy clay and clayey sand are deemed to be unsuitable for infiltration drainage techniques.

- If less than 2.0 m of sand, the lot will have an overflow direct connection to the stormwater drainage system.

- If the AAMGL/CGL is 1.8 m below the finished surface or greater, no subsoil drainage is required and infiltration drainage is considered acceptable.

- If the AAMGL/CGL is between 1.2 m and 1.8 m below the finished surface, subsoil drainage will be provided either at 1.2 m (where soakwells infiltration possible within lots), or immediately above the clay layer (with direct connection to the stormwater drainage system), whichever is the higher of the two.

- If the AAMGL/CGL is less than 1.2 m beneath the finished surface place subsoil drainage at the AAMGL/CGL (with direct connection to the stormwater drainage system).

Finished lot levels and fill requirements are a detailed design issue and will be addressed during preparation of UWMP's and submitted for council approval.

Design groundwater levels will continue to be updated and refined where necessary during the UWMP process.

4.5.2 Maintain groundwater regimes for the protection of wetlands

A wetland management plan for the Study Area has been prepared (RPS, 2007a).

There are no CCW's or EPP lakes located within the Study Area, with the nearest CCW located approximately 400 m west of the north western corner of the Study Area. The existing Resource Enhancement wetland adjacent to Harrow St on the northern boundary of the Study Area is to be retained in POS and rehabilitated.

It is understood that wetland buffers may be used for public open space subject to agreement of the City of Swan, WAPC, and DEC.

4.6 Water Quality Management

Water quality management criteria for this LWMS have been adopted from the Storm Water Management Manual for Western Australia (2007). A treatment train approach using a variety of structural and non-structural controls will be adopted by this LWMS to meet district water quality design criteria.

Non Structural Controls

Non-structural source controls to reduce nutrient export from the site focus on reducing nutrient inputs into the urban landscape. The following strategies are proposed;

- POS design; Local native plants to make up a minimum 50% of the landscape and streetscape treatments.
- Maintenance practices; Street sweeping co-ordinated with the City of Swan
- Educational and participatory practices; Promotion of local native plants and drought tolerant gardens to lot purchases via a landscape package.

Structural Controls

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the development. The following structural controls are considered appropriate for the development area;

- The use of bottomless manholes to infiltrate the road runoff where soil permeability and depth to groundwater permit. The use of vegetated swales preferentially over pipe systems where design constraints permit.
- The use of vegetated swales and vegetated ephemeral storages to treat road runoff in minor events. As per the design criteria, the vegetated swale and detention storages should provide treatment surface area of approximately 2% of connected impervious area, which is approximately a 3 month ARI.

  The minimum specifications for vegetated detention systems will be as follows;

Item	Specification
Plant selection	Tolerant of periodic inundation and extended dry periods. Spreading root system. Preferential selection of endemic and local native species. Planting to provide 70-80% coverage at plant maturity.
Planting density and distribution	Planting density appropriate for species selection. Even spatial distribution of plant species.
Amended soil media	Minimum 500 mm thick PRI > 2 Hydraulic Conductivity (sat) > 3 m/day pH 5.5-7.5 Total clay fraction < 8% in total (w/w) Organic matter content <5% (w/w) Phosphorus content <100 mg/kg Light compaction only to achieve specified Hydraulic Conductivity.

4.6.1 Post-development Nutrient Input

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in landuse management planning, and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient input for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on:

- estimates of total phosphorus (TP) and total nitrogen (TN) application to an area;
- estimates of reductions due to source control measures (education, street sweeping);
- estimates of reductions due to in-transit controls (Gross Pollutant Traps, WPCP's); and
- estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Study Area to model existing land use and the proposed Structure Plan land use. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work of Gerritse *et al.* (1991,1992) at CSIRO on rural residential lots.

Results of NiDSS modelling are presented in Appendix J. Summarising modelling results :

- Pre-development (existing) rural land use is estimated to have nutrient input loadings of greater than 19 kg/ha/yr for TP and 59 kg/ha/yr of TN. These estimates are based on assuming typical rural land use nutrient application rates for pasture, and do not reflect higher application rates for more nutrient intensive land use practices which may occur locally within the Study Area.

- With the proposed urban land use and assuming no WSUD, the Study Area is estimated to have nutrient input loadings of 26 kg/ha/yr for TP and 115 kg/ha/yr of TN. With implementation of a typical WSUD program including :

  1. Gross Pollutant Traps,
  2. Street Sweeping,
  3. Education Campaigns (targetting fertiliser application rates),
  4. Focus on Native Plantings for Residential and POS Areas (and use of P free fertilisers),

  it is estimated nutrient input loadings can be lowered to below current application levels under existing land use. An example program is shown in Appendix J.

These results together with the results of pre-development water quality monitoring indicate both stormwater runoff quality and groundwater quality from the proposed urban development may be better than existing surface water and groundwater quality under current land use in the Study Area.

4.7 Water Management Strategy Summary

Table 15 provides an overall summary of key elements of the proposed water management strategy for the Study Area, with an assessment of the strategy in relation to DoW (2007) principle objectives for stormwater management in Western Australia (Section 1.2.4).

Table 15: Summary of Proposed Local Water Management Strategy

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	• Maintain flow paths for existing catchments • Maintain 1 in 1 year ARI event post-development discharge peak flow rates relative to pre-development conditions • Maintain 5 and 100 year ARI peak flows from the Study Area to at pre-development rates. • Stormwater detention area outlets set at defined CGL. • Maximise infiltration opportunities.
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	• Maintain 1 in 1 year ARI event post-development peak flow rates relative to pre-development conditions • Where possible infiltrate frequently occurring events using soakwells, open based manholes, and swales. • Bioretention areas set at 2% of the equivalent impervious area of development consistent with draft DWMP requirements • Regeneration of trapezoidal drains to living streams • Use of treatment train approach to stormwater management • Application of source controls – street sweeping, education to reduce nutrient application, native plantings, swales, passive POS areas, lot soakwells. • Application of structural controls – retention/detention areas, gross pollutant trapping devices, swales, living streams. • Ongoing pre-development and post-development monitoring programs and performance review process
Water Conservation To maximise the reuse of stormwater	• Implement water efficiency and demand management measures in and ex-house. • Maximise stormwater infiltration opportunities, and infiltrate 1 in 1 year event where possible. • Use of native plantings in POS areas and passive POS areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	• Existing resource enhancement wetlands to be rehabilitated, revegetated, and retained. • Creation of vegetation and habitat linkage via multiple use corridors • Existing drains located below the water table to remain to maintain the existing hydrological regime of wetlands. • Gross pollutant trapping devices to be installed on outlets to significant receiving water bodies
Economic Viability To implement stormwater systems that are economically viable in the long term	• Use of proven structural WSUD technology • Use of source control techniques to minimise cost of nutrient management (Appendix J)
Public Health To minimise the public risk, including risk of injury or loss of life to the community	• Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	• Provision of 100 year ARI flood protection for Study Area • Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI. • Subsoil drainage to be implemented to control seasonal groundwater rise to the defined CGL.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	• Existing degraded resource enhancement wetlands to be rehabilitated and retained • Retention of some trapezoidal drains with conversion to living streams • Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	• Development of the LWMS in accordance with government agency guidelines and best management practice recommendations. • Use of CGL to minimise large scale trucking of fill consistent with sustainability principles. • Use outcomes of continuing pre-development and post-development monitoring programs to help guide future water management.

5. IMPLEMENTATION

5.1 Roles and Responsibilities

Table 16 details the roles and responsibilities for implementation of the strategy.

Table 16: Implementation Responsibilities

IMPLEMENTATION		RESPONSIBILITY	
LWMS Section	**Action**	**Land Developer**	**City of Swan**
5.3	Preparation of an Urban Water Management Plan for individual development stages	✓	
5.4	Construction of stormwater system and 12 months maintenance post construction (defects period)	✓	
5.4	Long term stormwater system operation and maintenance		✓
5.5	Monitoring program – 5 years post-development	✓	

5.2 Local Structure Plan Process

As detailed in Section 1.2.4 and Table 2, this LWMS has been prepared to an appropriate level of detail to support both District Structure Plans and individual Local Structure Plans for West Swan East. No additional urban water management planning document is required to support individual Local Structure Plans for various stages of development.

5.3 Subdivision Application Process

Consistent with processes defined in WAPC (2007), Urban Water Management Plans (UWMP's) will be developed and submitted to support subdivision applications for various stages of development. UWMP's will address:

- Compliance with LWMS criteria and objectives to the satisfaction of CoS and DoW.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels (including proposed fill levels and subsoil drainage inverts).
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works (including development of a strategy for sediment control during construction).

- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken for each UWMP area consistent with the monitoring program defined in the LWMS (Section 5.5).
- Contingency plans (where necessary).

5.4 Stormwater System Operation & Maintenance

Operation and maintenance of the drainage system will initially be the responsibility of the developer, ultimately reverting to the local government. The surface drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- Removal of debris to prevent blockages;
- Street sweeping to reduce particulate build up on road surfaces and gutters;
- Cleaning of sediment build up and litter layer on the bottom of basins;
- Mowing of grassed open channel sections monthly and grass clippings removed;
- Application of slow release/zero phosphorus fertilisers for maintenance of POS areas and any swales;
- Undertake education campaigns regarding source control practices to minimise pollutant runoff into stormwater drainage system; and
- Checks on subsoil drainage function.

5.5 Monitoring

The following monitoring program has been designed consistent with Joint Australian/ New Zealand Standards (1998a,b,c) to allow quantitative assessment of hydrological impacts of proposed development within the Study Area.

In particular the program addresses the monitoring of surface water discharges and groundwater quality within the development area. The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area. Any modification to the program would require the agreement of all parties (DoW, CoS, and developer). The program is designed to operate over a five year post-development period including construction to allow for time lag for full impacts of development on the receiving environment to occur.

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

The timing of commencement of the monitoring program for each individual subdivision area should be negotiated at UWMP stage with DoW and the City of Swan, with consideration to the City's Environmental Planning Policy POL-C-104.

Surface and groundwater monitoring are described below and summarised in Table 17. On-going tracking of environmental performance will be undertaken as monitoring data becomes available through a series of consolidated data spreadsheets.

5.5.1 Surface Water

Surface water monitoring includes both quality and quantity parameters at key discharge points from the Study Area in order that both post-development average nutrient concentrations and loads can be established.

Discharge at the three key outlet points of the Study Area to the downstream receiving drains will be monitored over the first five years post-development including construction. Timing for the commencement of monitoring will be agreed with DoW. Where possible outflow monitoring stations will be established and loggers installed to provide a continuous flow record at each discharge point from the Study Area.

Water quality sampling will be undertaken approximately monthly from June to October. Monitoring of the following parameters is proposed consistent with requirements of the DWMP (DoW,2009):

- In situ - pH, EC and Temperature
- TP, TN (with components including FRP, TKN, Nitrate/Nitrite), TSS
- Heavy Metals

In addition it is also proposed to establish a continuous water level recorder at POS flood storage areas to assess the frequency and duration of inundation for comparison of performance against design.

The frequency of surface flow water quality monitoring will be reviewed annually.

5.5.2 Groundwater

Monthly monitoring of water levels is proposed, with quarterly monitoring of groundwater quality. Monitoring at seven existing bores (AS1 to AS7) is proposed (Figure 5).

Any bores disturbed during development will be replaced as near as possible to existing bore sites, and surveyed to Australian Height Datum (AHD).

Depth to water table will be measured by electrical depth probe or an alternative suitable device. Water samples will be taken after purging the bores to ensure a fresh sample is obtained.

Water quality parameters to be measured initially are as described above for surface water monitoring.

Table 17: Monitoring Schedule and Reporting

Monitoring Type	Parameter	Location	Method	Frequency and Timing	Reporting
Groundwater Level	Water Level (m AHD)	7 monitoring bores providing spatial coverage	Electrical depth probe or similar	Monthly for 5 years	Annual assessment reports to be submitted to DoW & CoS for a 5 year period. Suitability of existing monitoring and reporting frequencies to be assessed annually with any modifications requiring agreement by all parties (DoW,CoS, & Developer) .
Groundwater Quality	pH, EC Nitrogen Phosphorus Metals	7 monitoring bores providing spatial coverage	Pumped bore samples	Quarterly for 5 years (typically Jan, Apr, Jul & Oct)	
Surface Water Flow	Discharge Flow Rate	3 outflow locations from the development area to receiving environment	Continuous flow measurement via water level recorder and data logger	Continuous for 5 years	
Surface Water Quality	pH, EC, TSS Nitrogen Phosphorus Metals	3 outflow locations from the development area to receiving environment	Collected grab samples	Monthly sampling when flowing, typically June to October for 5 years. Frequency to be reviewed following initial 12 month sampling period.	
POS Usability	Water Level (m AHD)	Water level recorder at POS flood storage area	Continuous water level measurement via water level recorder and data logger.	Continuous for 2 years	

5.5.3 Annual Reporting

The annual reports will be prepared for individual UWMP areas as development proceeds co-ordinated by the developer and submitted to CoS and DoW for review. The reports will compare the monitoring results with target design criteria and performance objectives and determine if further actions may be necessary, and provide on-going assessment of the suitability of existing monitoring and reporting frequencies.

The proposed process for contingency action in the assessment of performance compliance is

- Assess if an isolated, development area or regional occurrence.
- Determine if due to the development or other external factors.
- Perform appropriate contingency action as required, which may include:
  a) Identify and remove any point sources.
  b) Reinforce Community Education/Awareness program.
  c) Review constructional, operational and maintenance (eg fertilising) practices.
  d) Consider alterations to POS areas including landscape regimes and soil amendment.
  e) Consider modifications to the stormwater system.
  f) Consider initiation of community based projects.
- Record in the annual report any action taken, and communicate findings with Department of Water Swan River Trust and City of Swan.

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

5.6 Construction Management

5.6.1 Dewatering

Dewatering of the Superficial Aquifer will be required for some elements of development construction. Prior to the commencement of any dewatering, construction contractors will be required to apply for and obtain from DoW a ‘Licence to Take Water’. All dewatering will be carried out in accordance with the conditions of the licence, which may include preparation of a Dewatering Management Plan.

Currently exemptions to dewatering licences are available when dewatering is for a period of less than 30 days, at a pumping rate not exceeding 10 L/s and the total abstraction does not exceed 25,000 kL total.

Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirements.

5.6.2 Acid Sulphate Soils

All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series Identification and Investigation of Acid Sulphate Soils (DoE, 2004a), including a Preliminary Site Assessment (PSA) involving a targeted soil and groundwater sampling and analysis program, .detailed site assessment (if required), and ultimately and an ASS Management Plan if ASS is to be impacted.

During construction, appropriate handling methods will need to be employed by the construction contractor to manage any potential acid sulphate soils. Handling should be in accordance with the Acid Sulphate Soils Guidelines Series Treatment and Management of Disturbed Acid Sulphate Soils (DoE, 2003). These guidelines specify holding times and specific methods for treatment of such soils.

To confirm the status of soils, the site engineer or scientist will regularly inspect the excavations and spoil, and ensure such soils where encountered are appropriately tested and managed before reuse or disposal off-site.

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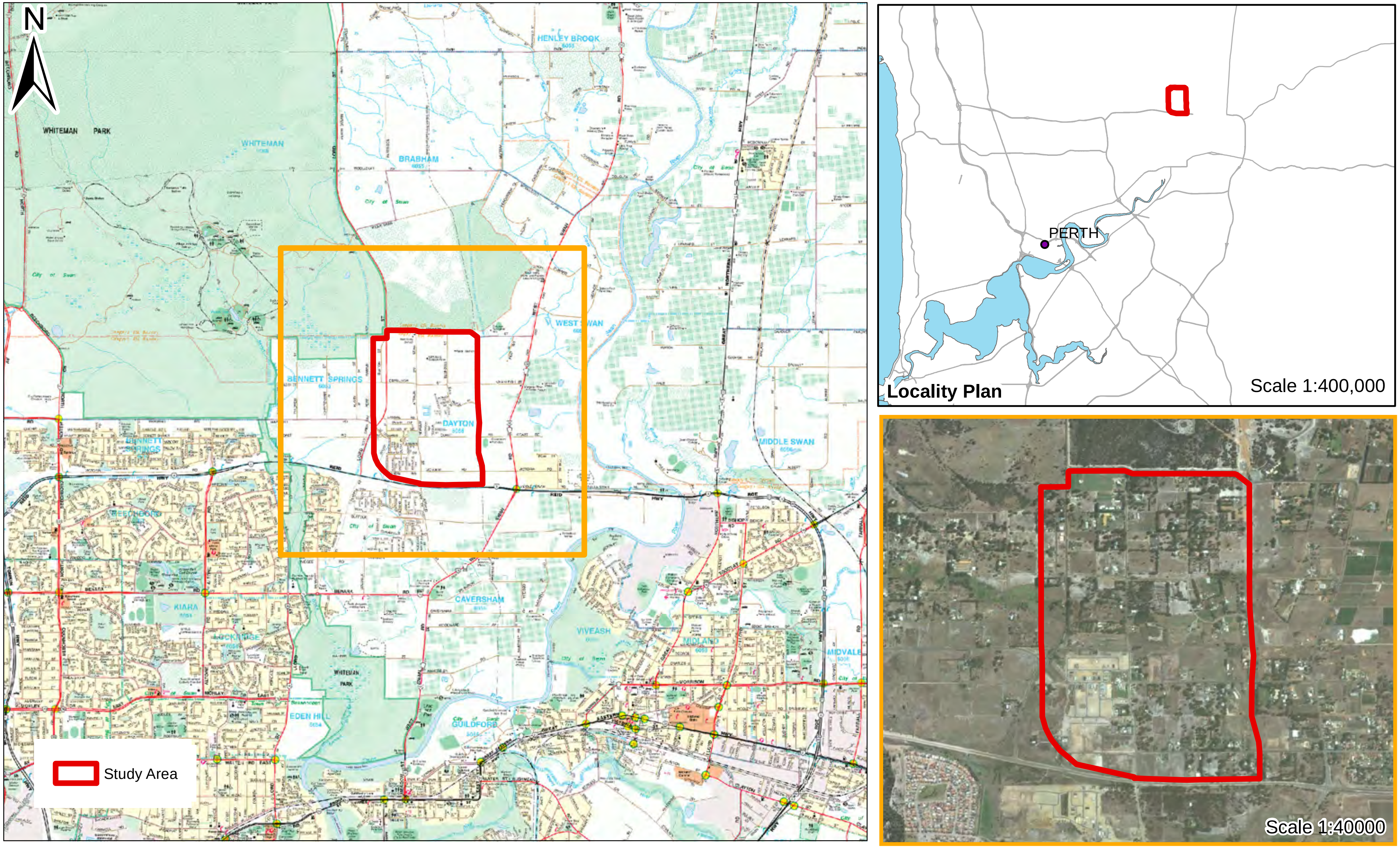
FIGURES



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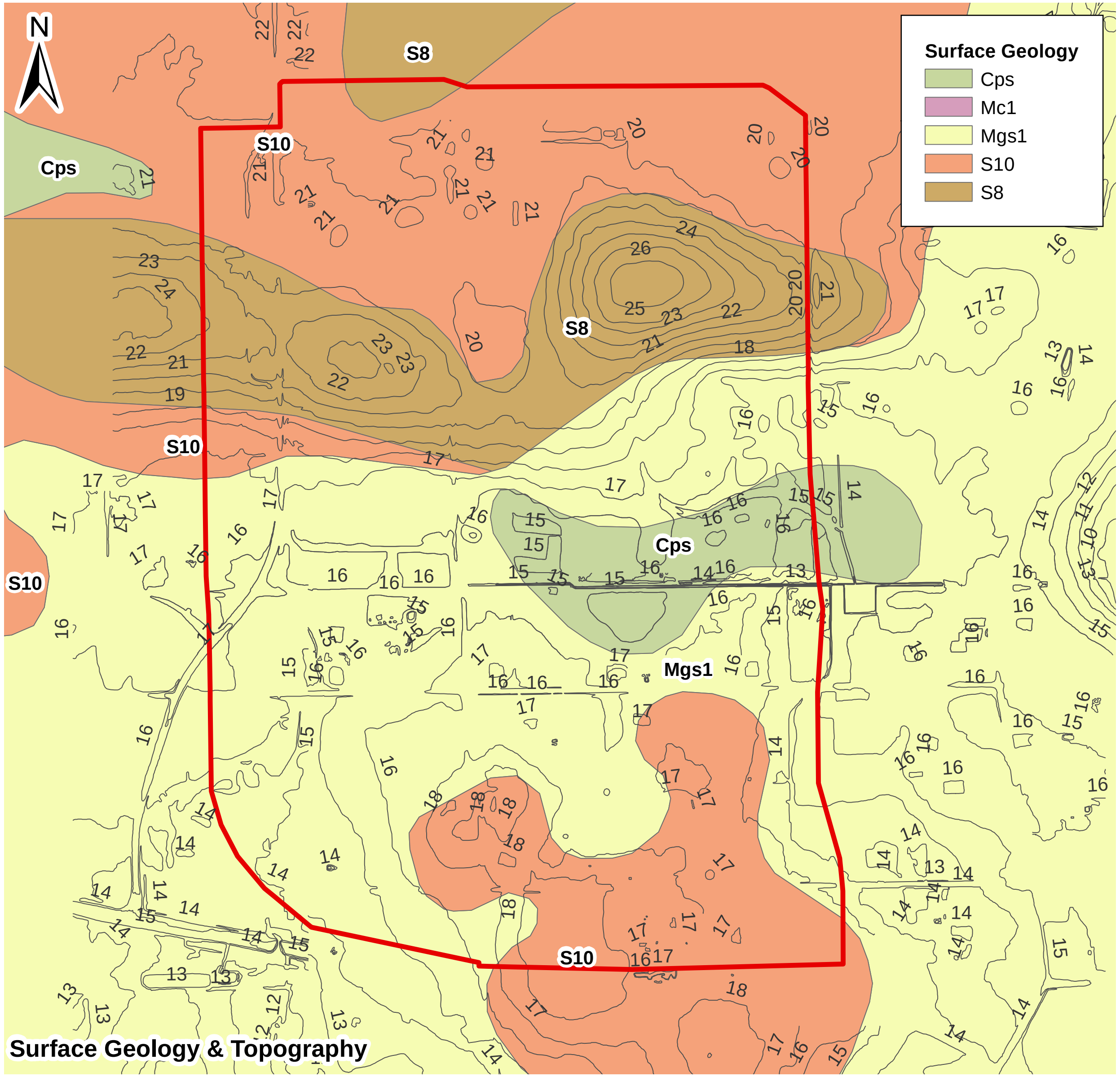
St Leonards Estate Pty Ltd
West Swan East: LWMS

Figure 1: Location Plan



Surface Geology

Cps: PEATY CLAY. dark grey and black with variable sand content of lacustrine origin.

Mc1: CLAYEY SILT. yellow brown to strong brown, blocky, mottled, soft, with variable clay content, dispersive in part, of alluvial origin.

Mgs1:PEBBLY SILT. strong brown silt with common laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin.

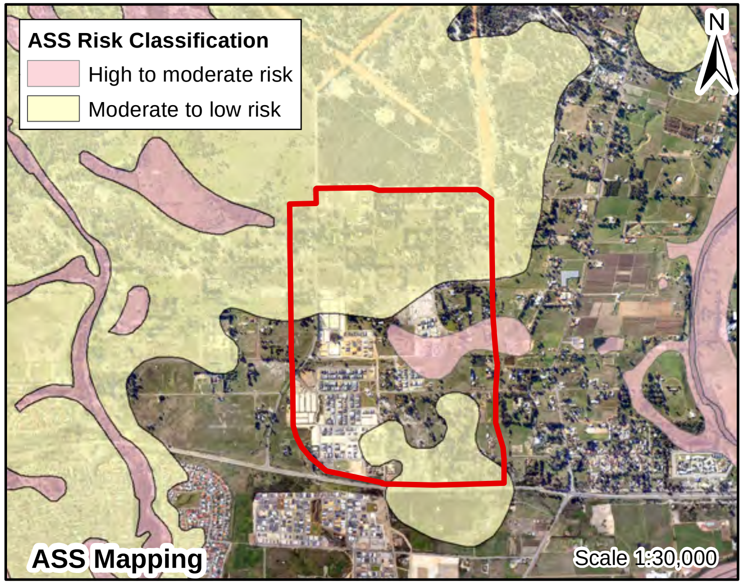
S10: SAND. very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin.

S8: SAND. as S10

ASS Risk Classification

High Risk - Moderate to high risk of ASS or PASS occurring less than 3m from soil surface

Moderate Risk - Moderate to high risk of ASS or PASS occurring more than 3m from soil surface; no risk of occurrence less than 3m from soil surface



Data Source: DOW (2013), Armadale Sheet of Perth Metropolitan Region Environmental Geology Series, GSWA.

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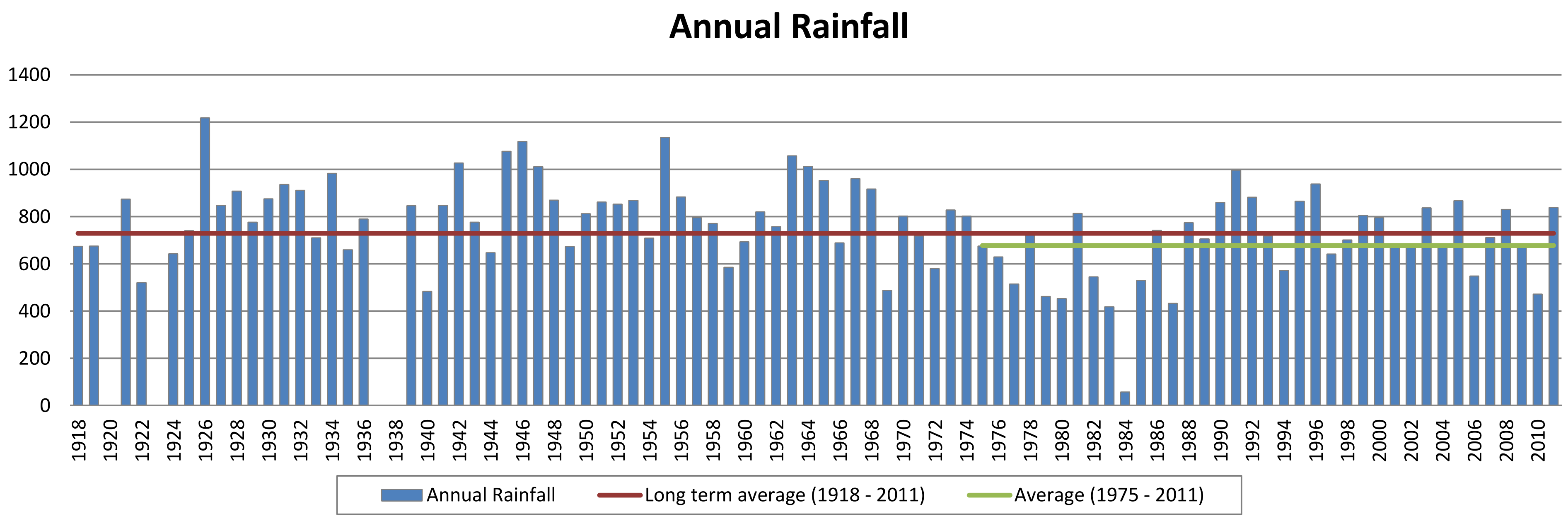
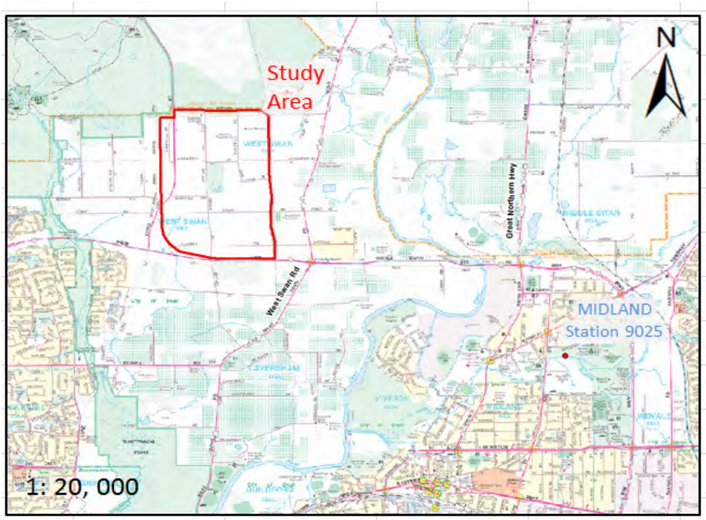
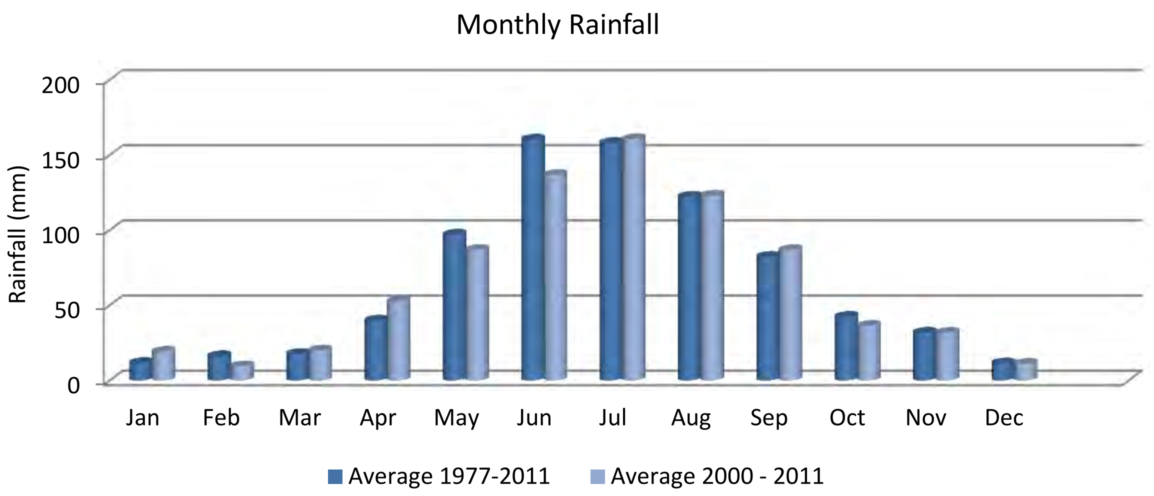
St Leonards Estate Pty Ltd
West Swan East: LWMS
Figure 2: Surface Geology and ASS







Data Source: BoM (2012)

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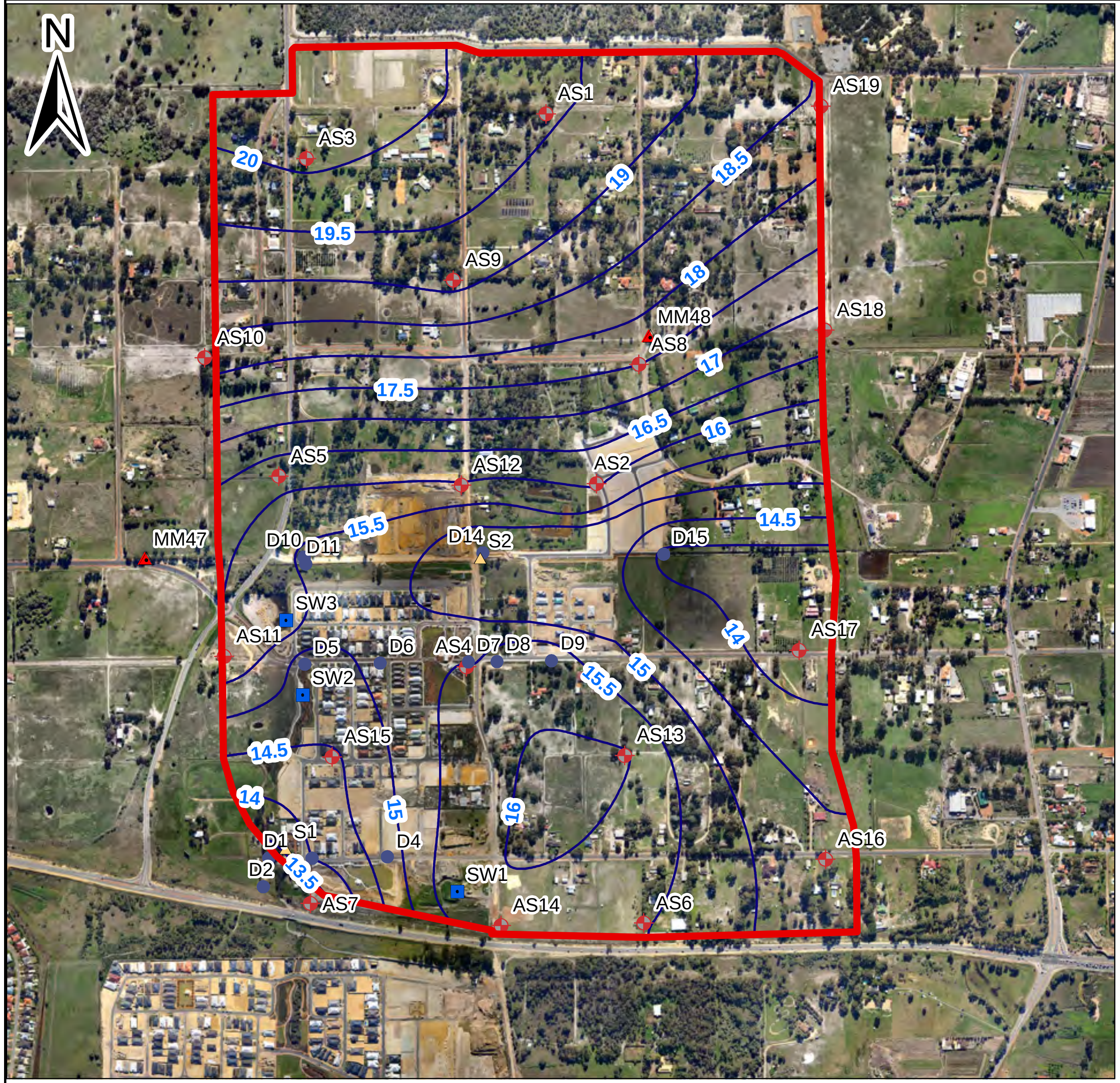
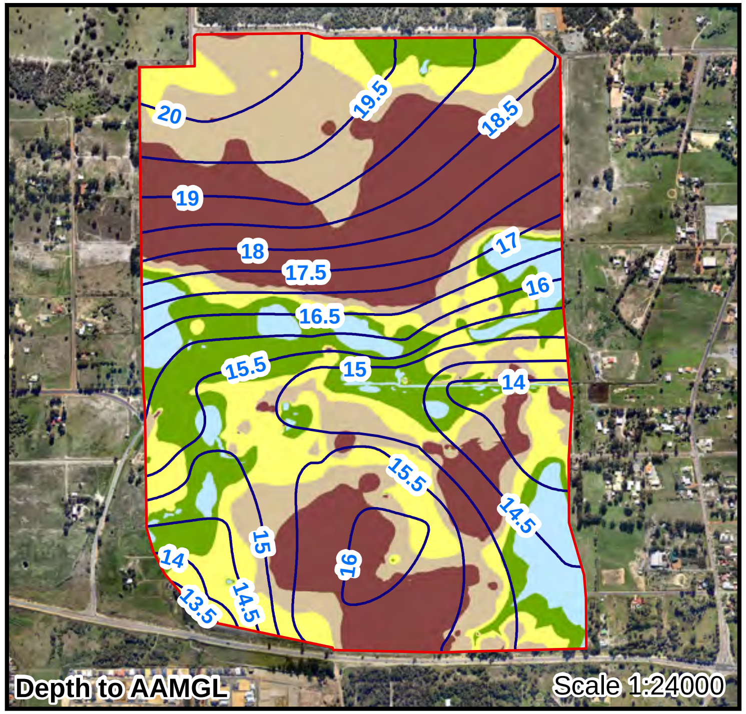
West Swan East: LWMS
Figure 3: Rainfall





— AAMGL (mAHD)

🟥 Study Area

Monitoring Locations

▲ DOW Groundwater Monitoring Bore

● Drain Invert

⊕ JDA Groundwater Monitoring Bore

△ JDA Surface Water Quality

■ JDA Surface Water Level

— AAMGL (mAHD)

Depth to Estimated AAMGL (m)

▢	Ponding at surface
🟩	0 - 0.5
🟨	0.5 - 1
🟫	1.0-1.5
🟥	>1.5

Data Source: DoW (2010) WIN data set, MAPS (2011) Site Survey

JDA

Job No. J5132
Scale: 1:15,000

0 200 400 600 800 Metres

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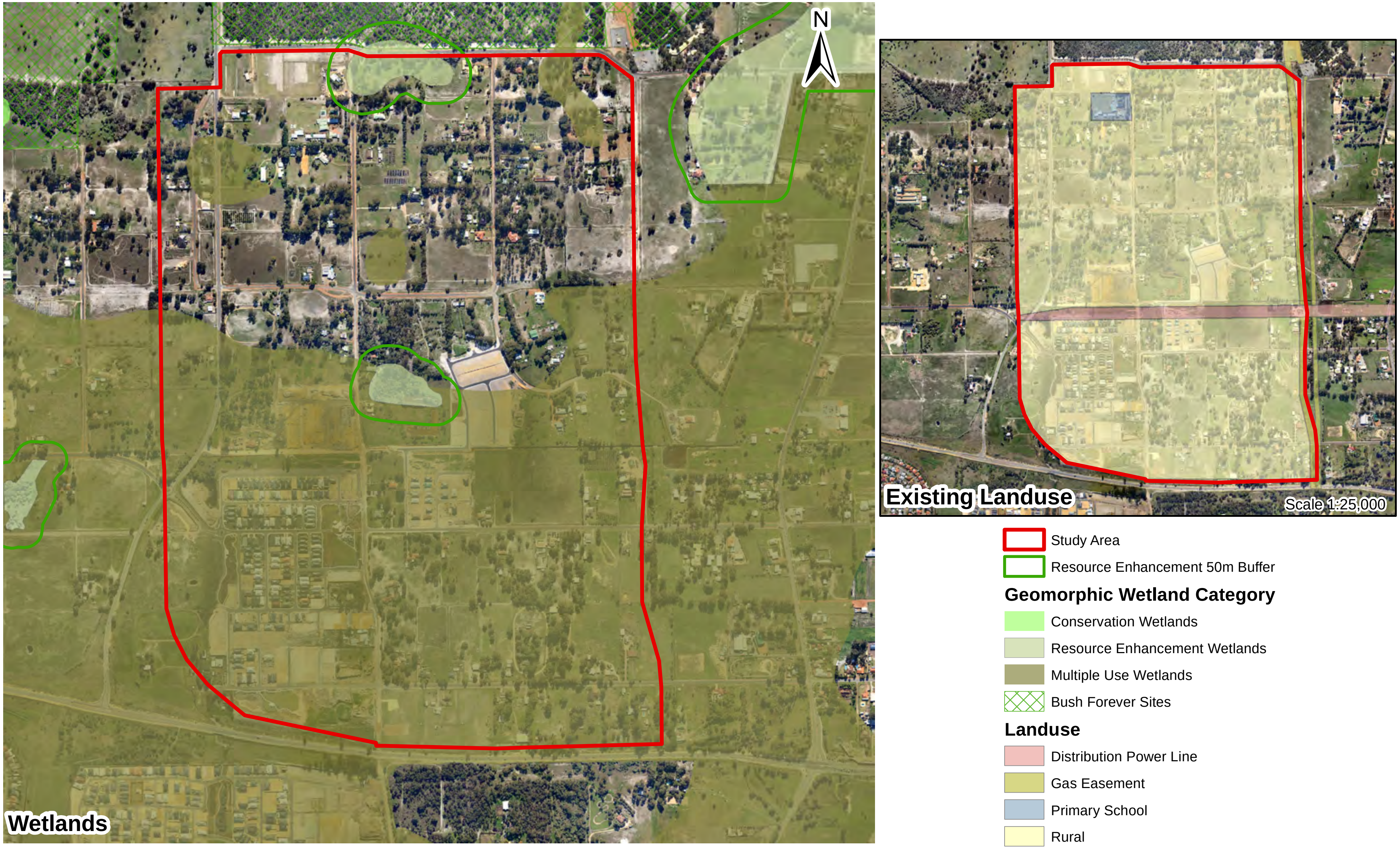
West Swan East: LWMS

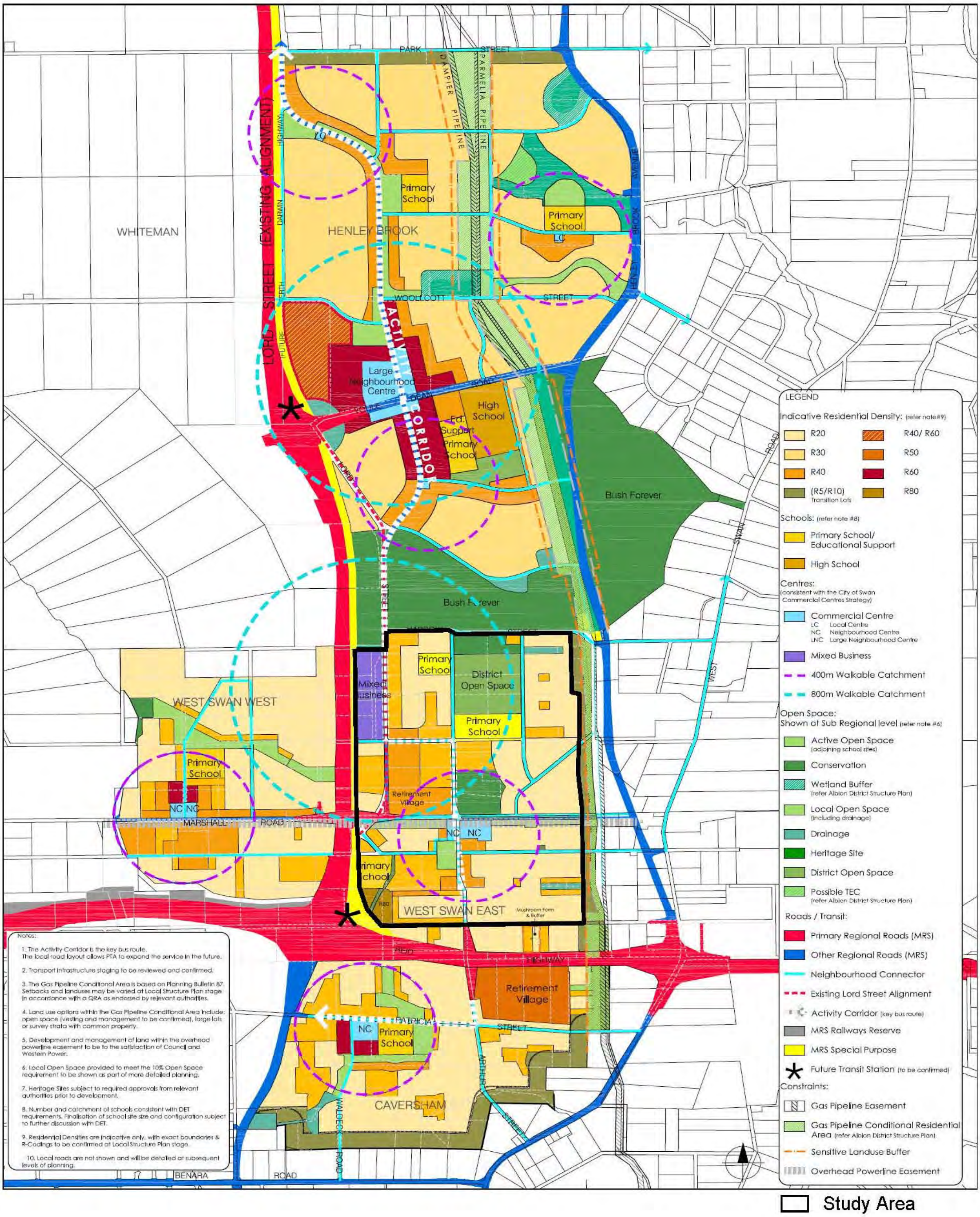
Figure 4: Depth to groundwater and Monitoring Locations



Data Source: DoW (2013) Geomorphic Wetland Dataset

Job No. J5132
Scale: 1:15,000
0 200 400 600 800 Metres

St Leonards Estate Pty Ltd
West Swan East: LWMS
Figure 5: Existing Landuse and Wetlands



Notes:

1. The Activity Corridor is the key bus route. The local road layout allows PTA to expand the service in the future.

2. Transport Infrastructure staging to be reviewed and confirmed.

3. The Gas Pipeline Conditional Area is based on Planning Bulletin 87. Setbacks and landuses may be varied at Local Structure Plan stage in accordance with a QRA as endorsed by relevant authorities.

4. Land use options within the Gas Pipeline Conditional Area include: open space (vesting and management to be confirmed), large lots or survey strata with common property.

5. Development and management of land within the overhead powerline easement to be to the satisfaction of Council and Western Power.

6. Local Open Space provided to meet the 10% Open Space requirement to be shown as part of more detailed planning.

7. Heritage Sites subject to required approvals from relevant authorities prior to development.

8. Number and catchment of schools consistent with DET requirements. Finalisation of school site size and configuration subject to further discussion with DET.

9. Residential Densities are indicative only, with exact boundaries & R-Codings to be confirmed at Local Structure Plan stage.

10. Local roads are not shown and will be detailed at subsequent levels of planning.

Data Source: Burgess Design Group (2009)

Job No. J5132

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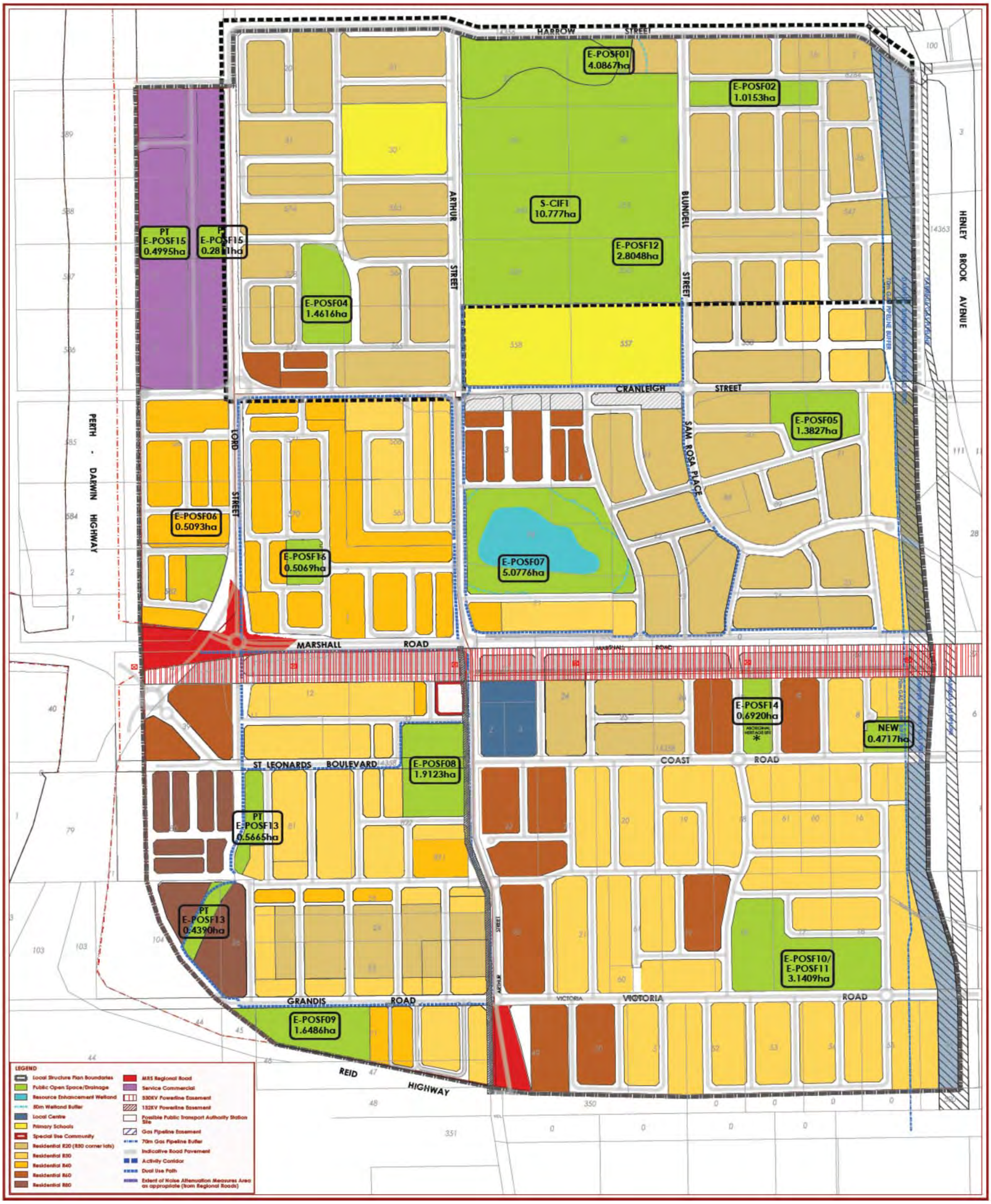
West Swan East LWMS

Figure 6: Regional Structure Plan



Data Source: Burgess Design (2013)

Job No. J5132

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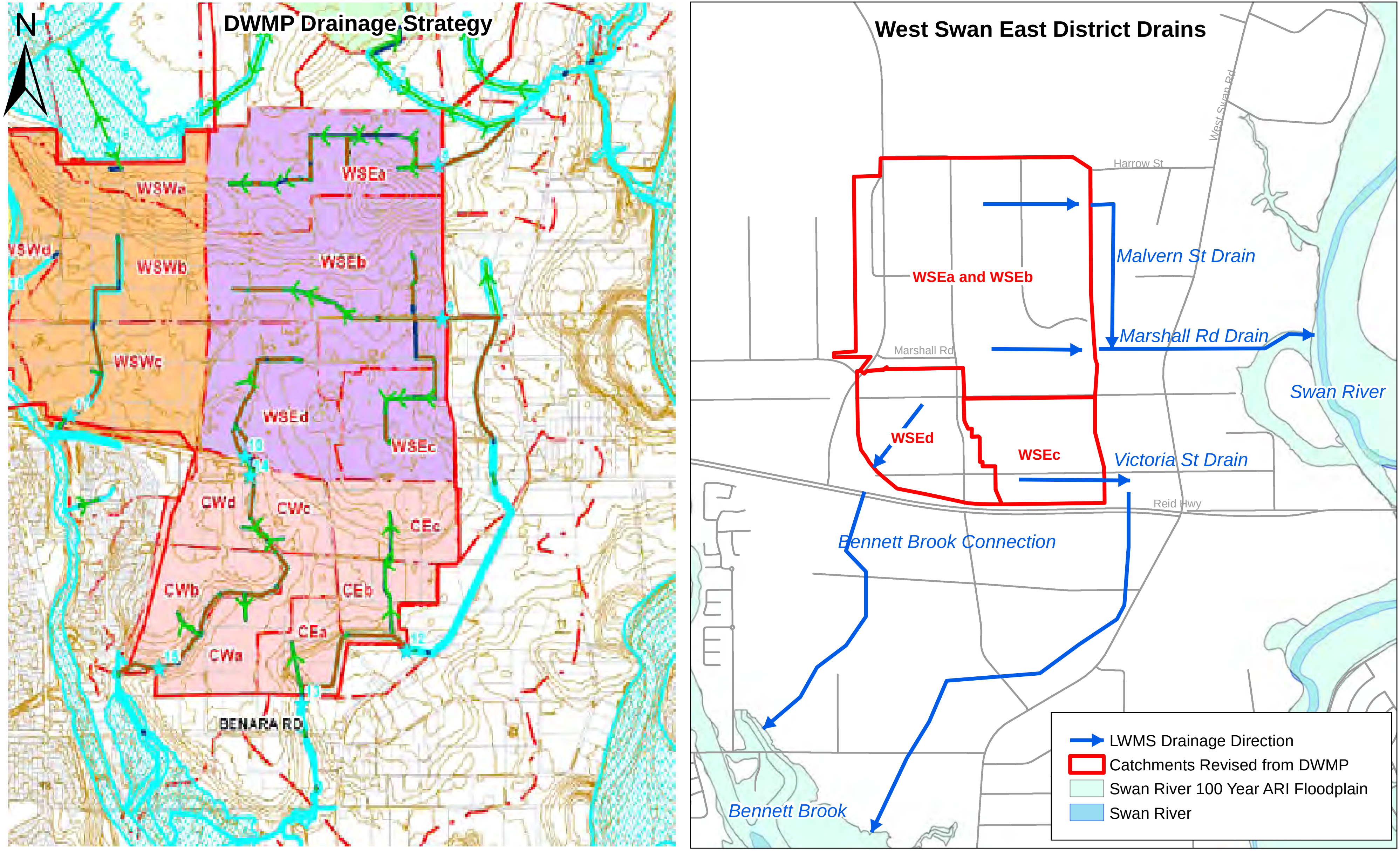
West Swan East LWMS

Figure 7: Proposed Land Use Plan



Data Source: DoW (2009)

Job No. J5132

Scale: 1:30,000

0 500 1,000 1,500 2,000 Metres

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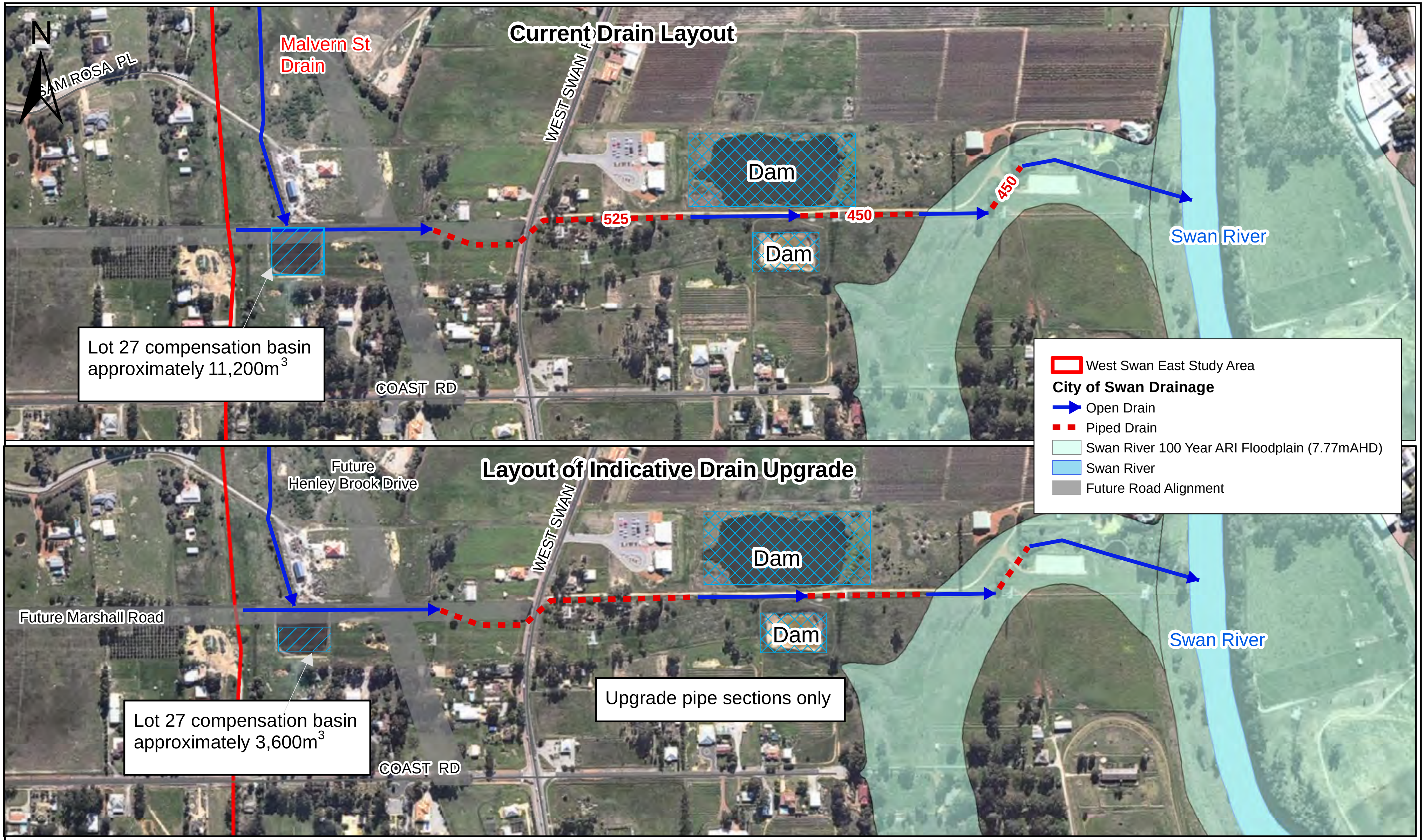
West Swan East LWMS

Figure 8: District Surface Drainage


Current Drain Layout

Layout of Indicative Drain Upgrade

Lot 27 compensation basin approximately 11,200m^3

Lot 27 compensation basin approximately 3,600m^3

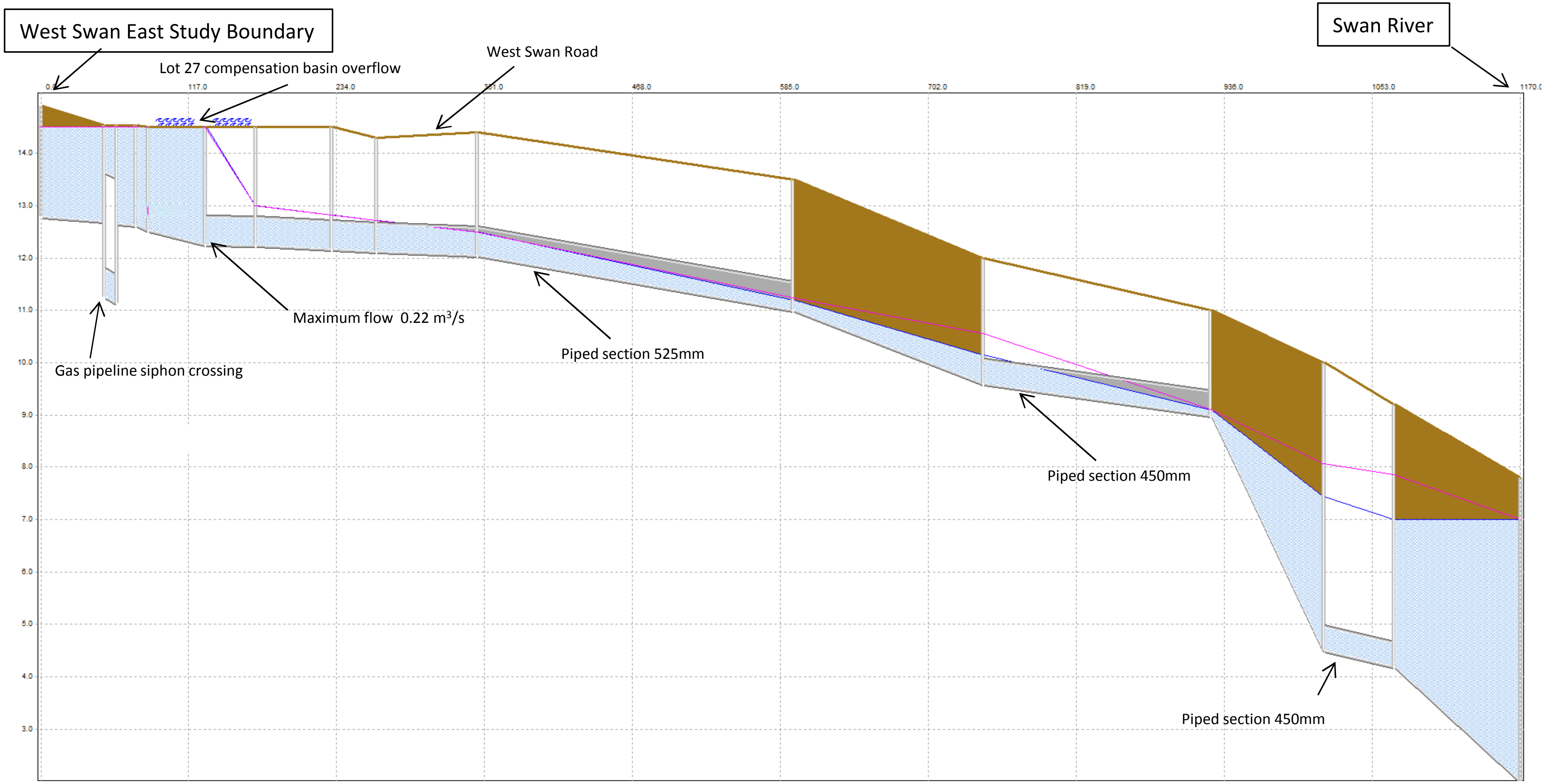
Upgrade pipe sections only

Data Source: DWMP, DoW (2009)

Job No. J5132
Scale: 1:7,000
0 100 200 300 400 Metres

St Leonards Estate Pty Ltd
West Swan East: LWMS
Figure 9: Marshall Rd Drain D/S of Study Area

100yr ARI



Job No: J5132

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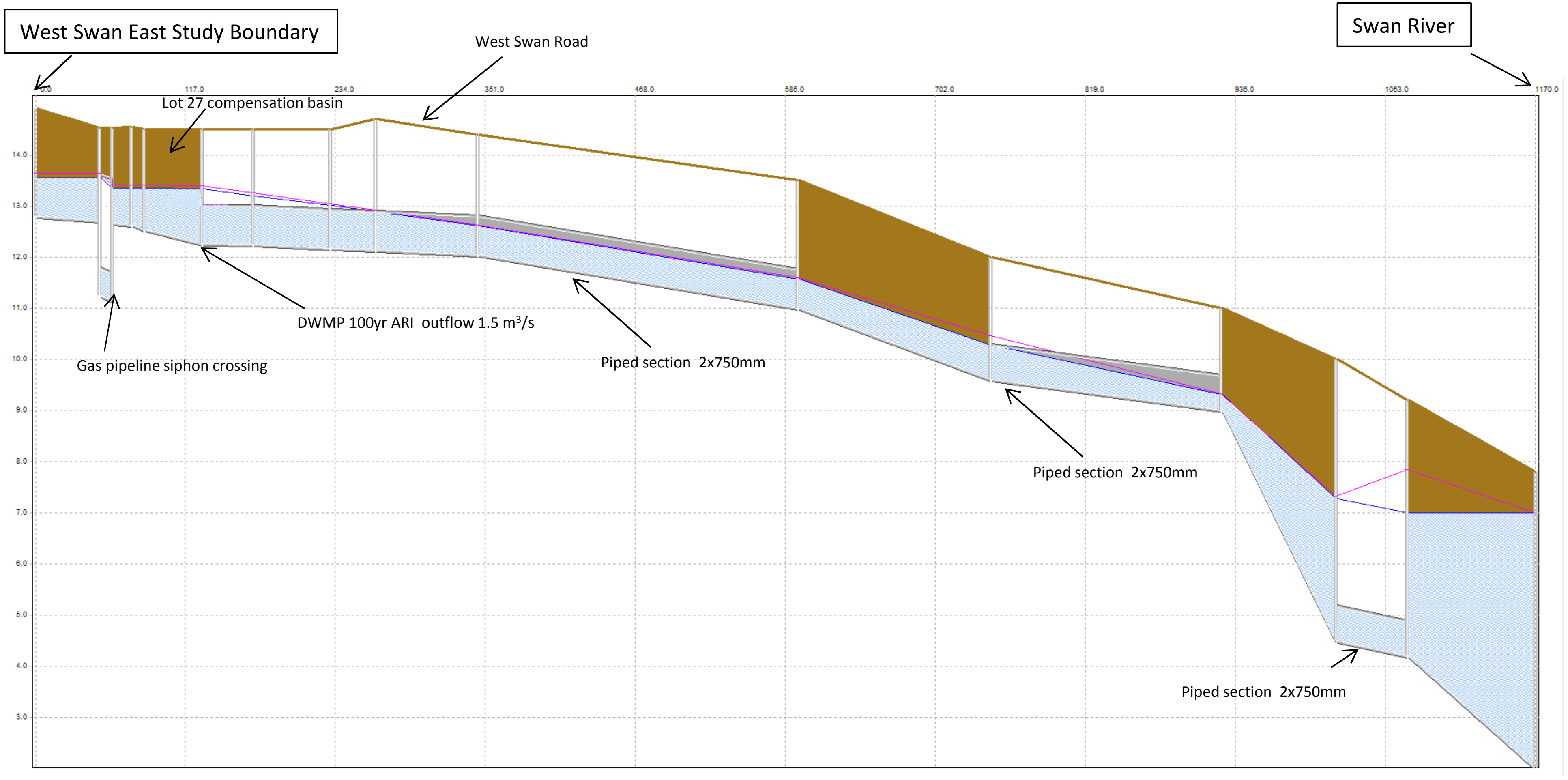
West Swan East LWMS

Figure 10: Pre-Development Drain Cross Section

100yr ARI



Note: Pipe sizes are indicative only and are subject to further detailed assessment

Job No: 5132

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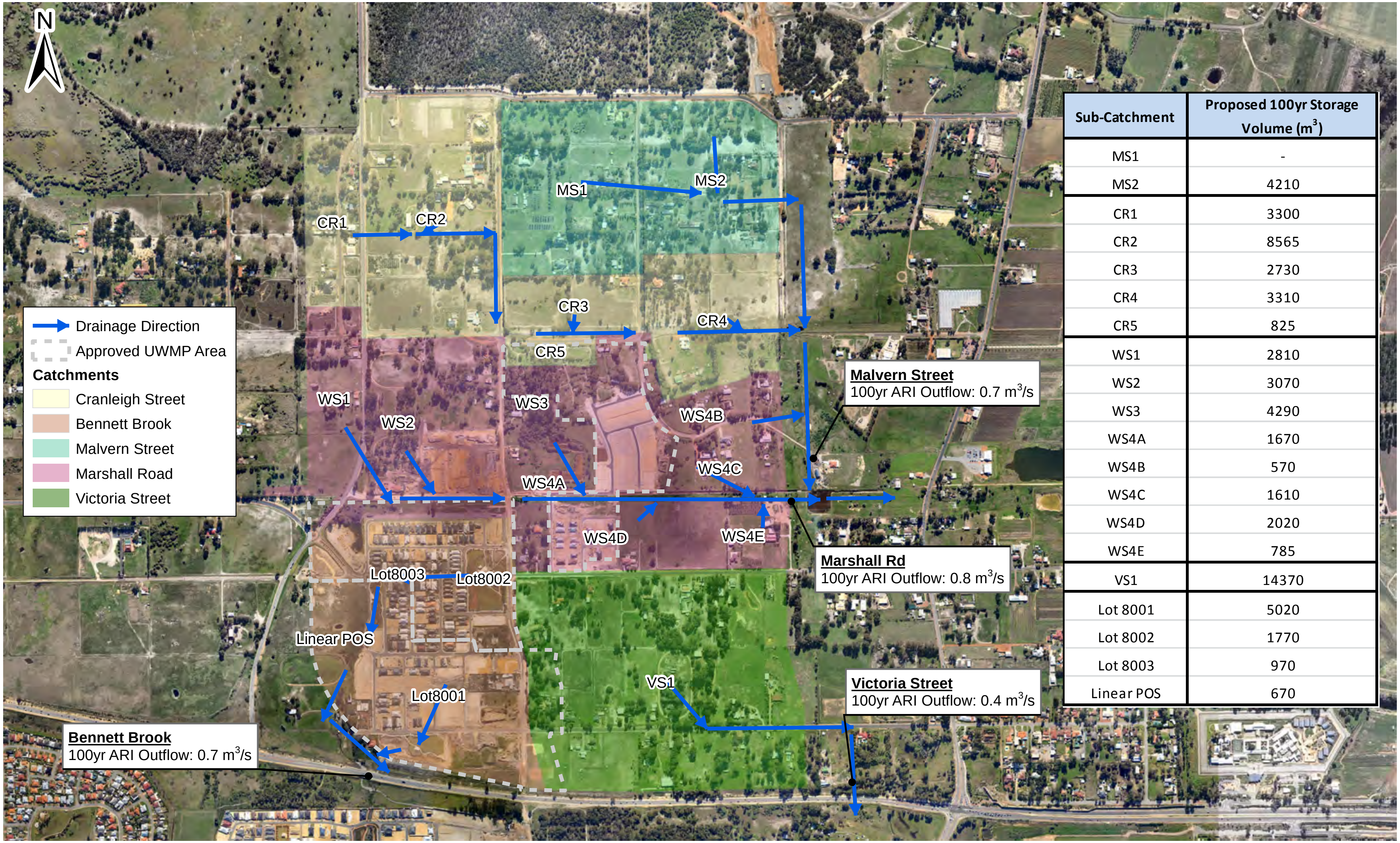
West Swan East LWMS

Figure 11: Cross Section of Indicative Drain Upgrade



Malvern Street
100yr ARI Outflow: 0.7 m^3/s

Marshall Rd
100yr ARI Outflow: 0.8 m^3/s

Victoria Street
100yr ARI Outflow: 0.4 m^3/s

Bennett Brook
100yr ARI Outflow: 0.7 m^3/s

Sub-Catchment	Proposed 100yr Storage Volume (m^3)
MS1	-
MS2	4210
CR1	3300
CR2	8565
CR3	2730
CR4	3310
CR5	825
WS1	2810
WS2	3070
WS3	4290
WS4A	1670
WS4B	570
WS4C	1610
WS4D	2020
WS4E	785
VS1	14370
Lot 8001	5020
Lot 8002	1770
Lot 8003	970
Linear POS	670

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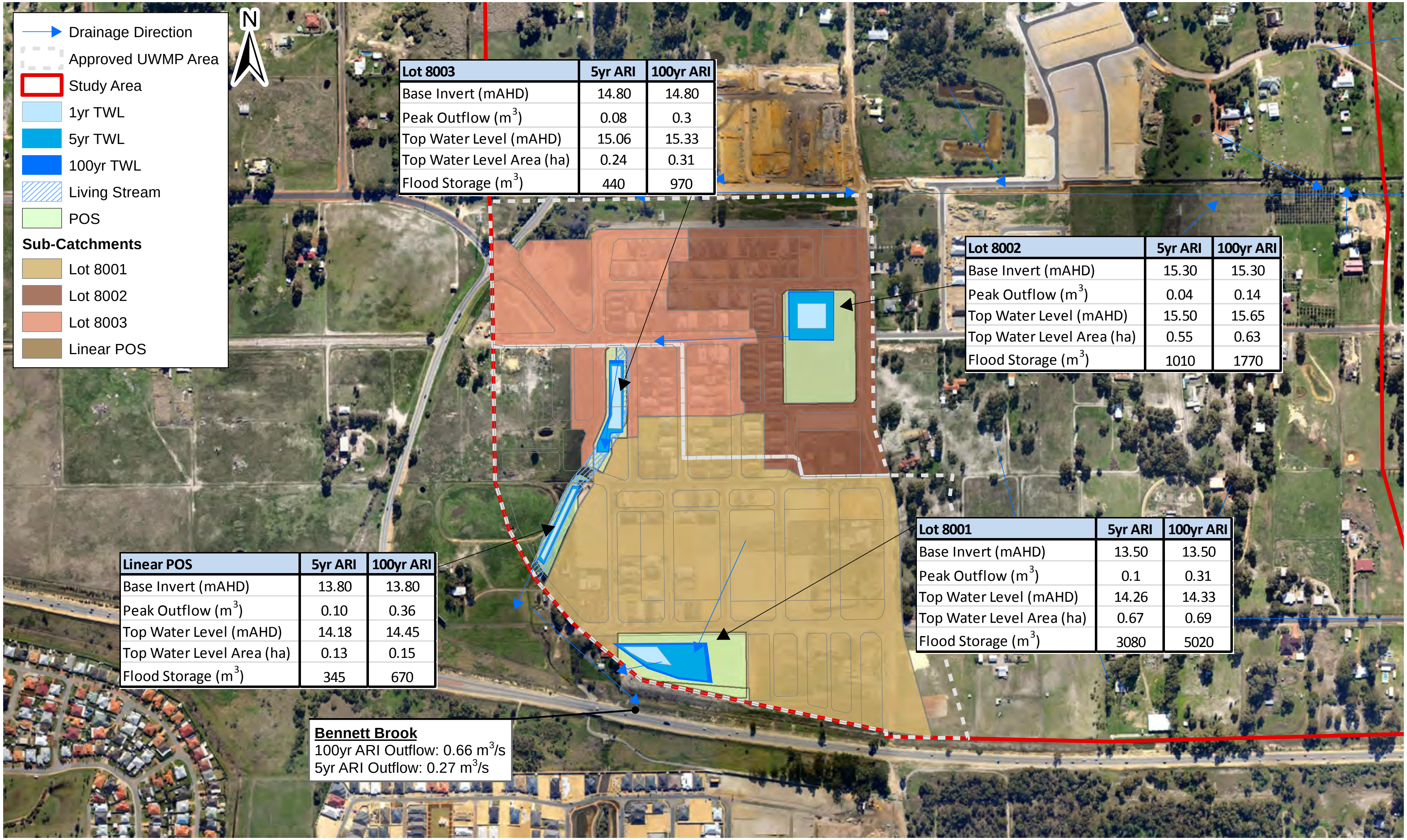
Scale:1:15,000

St Leonards Estate Pty Ltd
West Swan East: LWMS

Figure 12: Proposed Stormwater Management System



Lot 8003	5yr ARI	100yr ARI
Base Invert (mAHD)	14.80	14.80
Peak Outflow (m^3)	0.08	0.3
Top Water Level (mAHD)	15.06	15.33
Top Water Level Area (ha)	0.24	0.31
Flood Storage (m^3)	440	970

Lot 8002	5yr ARI	100yr ARI
Base Invert (mAHD)	15.30	15.30
Peak Outflow (m^3)	0.04	0.14
Top Water Level (mAHD)	15.50	15.65
Top Water Level Area (ha)	0.55	0.63
Flood Storage (m^3)	1010	1770

Linear POS	5yr ARI	100yr ARI
Base Invert (mAHD)	13.80	13.80
Peak Outflow (m^3)	0.10	0.36
Top Water Level (mAHD)	14.18	14.45
Top Water Level Area (ha)	0.13	0.15
Flood Storage (m^3)	345	670

Lot 8001	5yr ARI	100yr ARI
Base Invert (mAHD)	13.50	13.50
Peak Outflow (m^3)	0.1	0.31
Top Water Level (mAHD)	14.26	14.33
Top Water Level Area (ha)	0.67	0.69
Flood Storage (m^3)	3080	5020

Bennett Brook
100yr ARI Outflow: 0.66 m^3/s
5yr ARI Outflow: 0.27 m^3/s

Note: POS and drainage locations are indicative only and subject to approval of the Local Structure plan, subdivision design and UWMP

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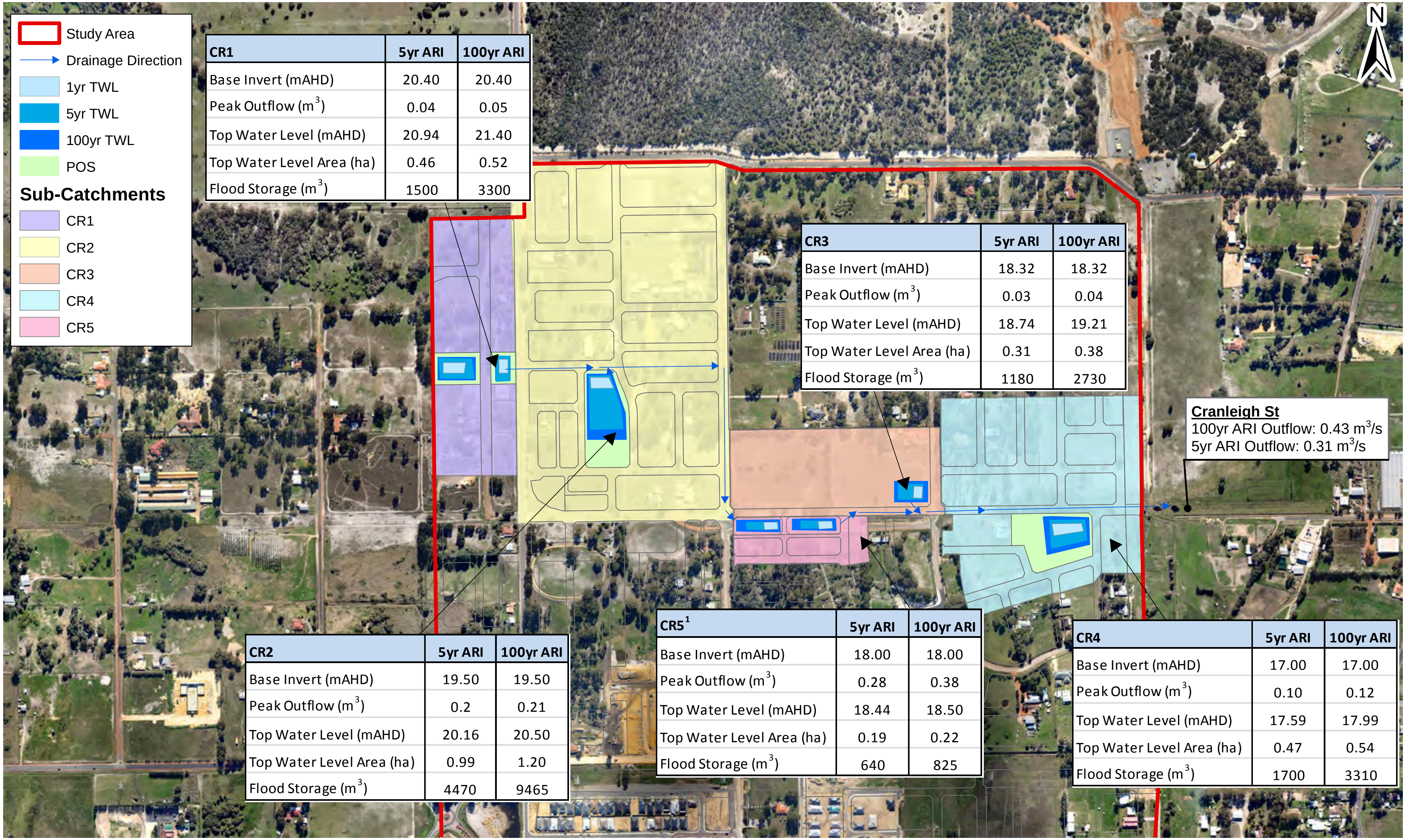
Job No. J5132
Scale: 1:8,000

0 200 400 600 800 Metres

St Leonards Estate Pty Ltd
West Swan East: LWMS

Figure 13: Proposed Stormwater Management: Bennett Brook Catchment



CR1	5yr ARI	100yr ARI
Base Invert (mAHD)	20.40	20.40
Peak Outflow (m^3)	0.04	0.05
Top Water Level (mAHD)	20.94	21.40
Top Water Level Area (ha)	0.46	0.52
Flood Storage (m^3)	1500	3300

CR3	5yr ARI	100yr ARI
Base Invert (mAHD)	18.32	18.32
Peak Outflow (m^3)	0.03	0.04
Top Water Level (mAHD)	18.74	19.21
Top Water Level Area (ha)	0.31	0.38
Flood Storage (m^3)	1180	2730

Cranleigh St
100yr ARI Outflow: 0.43 m^3/s
5yr ARI Outflow: 0.31 m^3/s

CR2	5yr ARI	100yr ARI
Base Invert (mAHD)	19.50	19.50
Peak Outflow (m^3)	0.2	0.21
Top Water Level (mAHD)	20.16	20.50
Top Water Level Area (ha)	0.99	1.20
Flood Storage (m^3)	4470	9465

CR5[1]	5yr ARI	100yr ARI
Base Invert (mAHD)	18.00	18.00
Peak Outflow (m^3)	0.28	0.38
Top Water Level (mAHD)	18.44	18.50
Top Water Level Area (ha)	0.19	0.22
Flood Storage (m^3)	640	825

CR4	5yr ARI	100yr ARI
Base Invert (mAHD)	17.00	17.00
Peak Outflow (m^3)	0.10	0.12
Top Water Level (mAHD)	17.59	17.99
Top Water Level Area (ha)	0.47	0.54
Flood Storage (m^3)	1700	3310

Note: 1- CR5 shows combined stroage. POS and drainage locations are indicative only and subject to approval of the Local Structure plan, subdivision design and UWMP

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Job No. J5132
Scale:1:10,000
0 200 400 600 800 Metres

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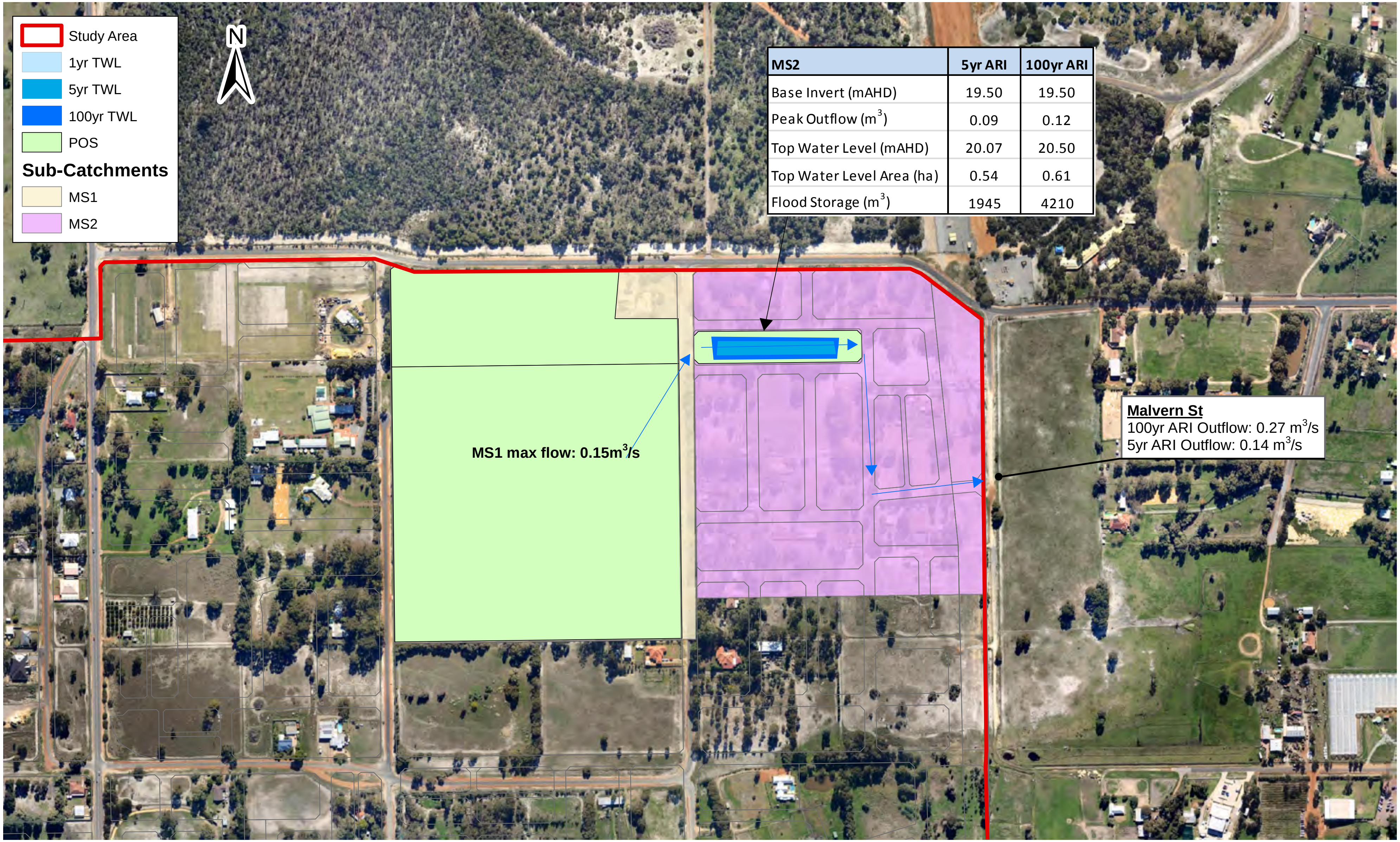
West Swan East: LWMS

Figure 14: Proposed Stormwater Management: Cranleigh St Catchment



MS2	5yr ARI	100yr ARI
Base Invert (mAHD)	19.50	19.50
Peak Outflow (m^3)	0.09	0.12
Top Water Level (mAHD)	20.07	20.50
Top Water Level Area (ha)	0.54	0.61
Flood Storage (m^3)	1945	4210

Malvern St
100yr ARI Outflow: 0.27 m^3/s
5yr ARI Outflow: 0.14 m^3/s

Note: POS and drainage locations are indicative only and subject to approval of the Local Structure plan, subdivision design and UWMP

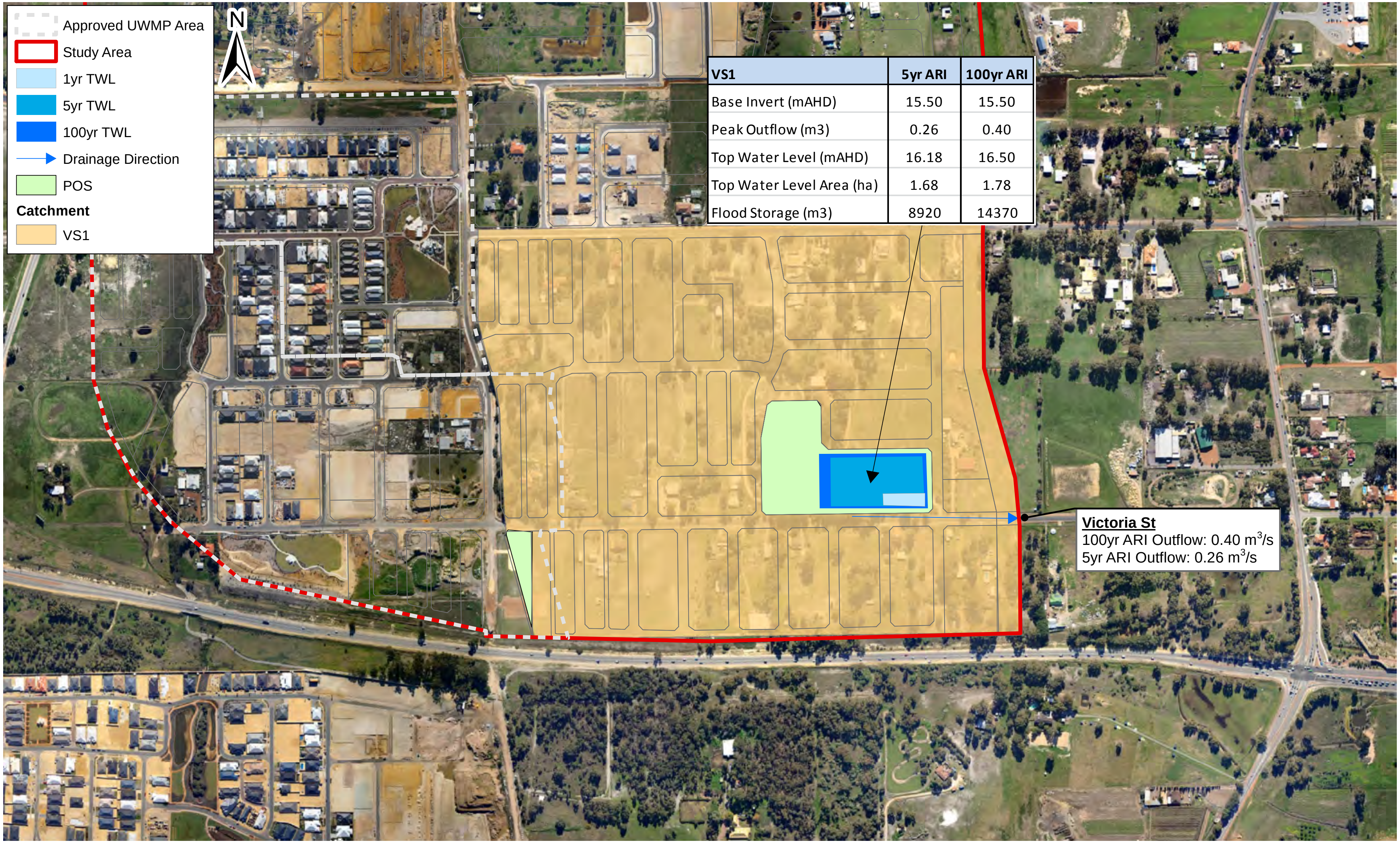
JDA

Job No. J5132
Scale:1:7,000

0 200 400 600 Metres

St Leonards Estate Pty Ltd
West Swan East: LWMS

Figure 15: Proposed Stormwater Management System: Malvern Street



VS1	5yr ARI	100yr ARI
Base Invert (mAHD)	15.50	15.50
Peak Outflow (m3)	0.26	0.40
Top Water Level (mAHD)	16.18	16.50
Top Water Level Area (ha)	1.68	1.78
Flood Storage (m3)	8920	14370

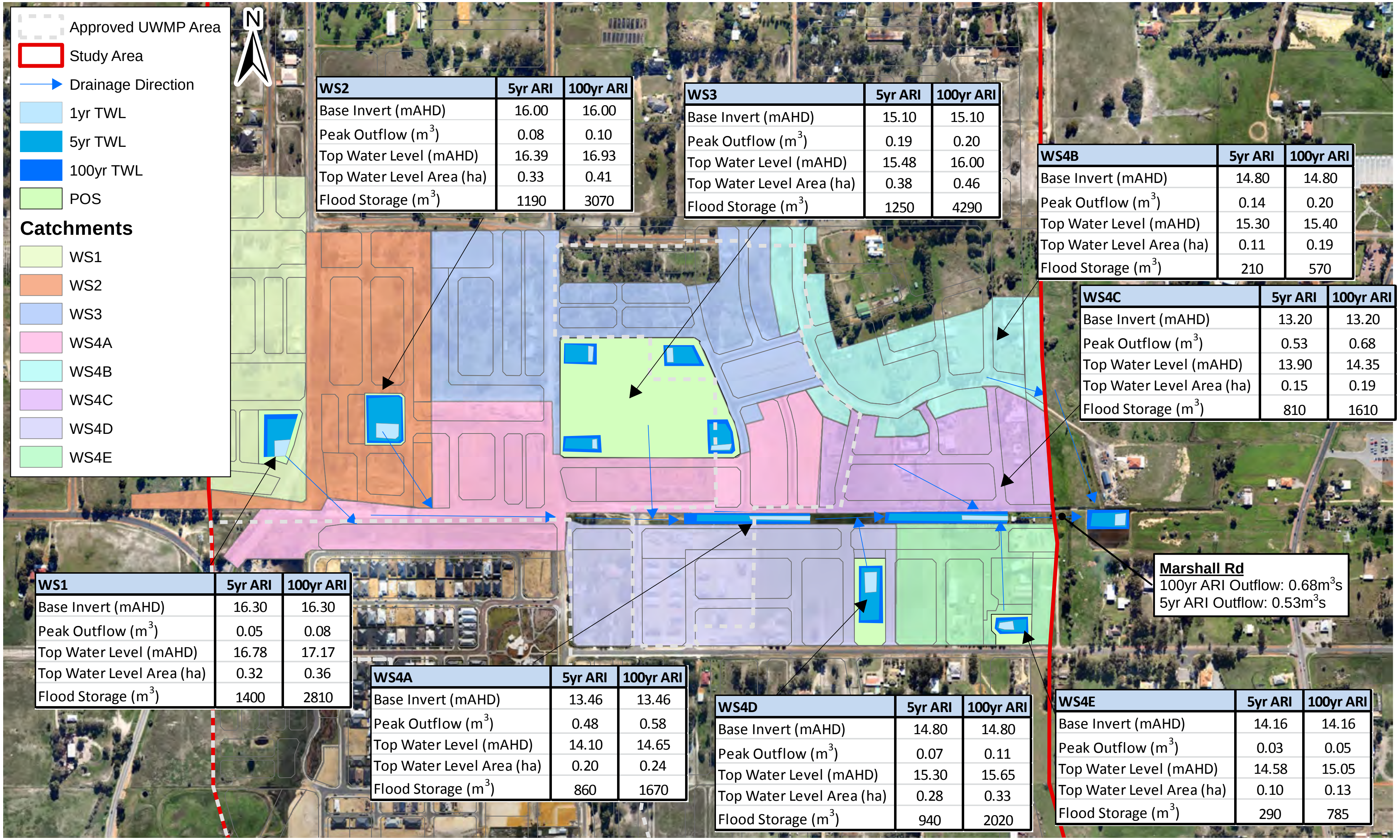
Victoria St
100yr ARI Outflow: 0.40 m^3/s
5yr ARI Outflow: 0.26 m^3/s

Note: POS and drainage locations are indicative only and subject to approval of the Local Structure plan, subdivision design and UWMP

Job No. J5132
Scale:1:8,000

St Leonards Estate Pty Ltd
West Swan East: LWMS

Figure 16: Proposed Stormwater Management: Victoria St Catchment



WS1	5yr ARI	100yr ARI
Base Invert (mAHD)	16.30	16.30
Peak Outflow (m^3)	0.05	0.08
Top Water Level (mAHD)	16.78	17.17
Top Water Level Area (ha)	0.32	0.36
Flood Storage (m^3)	1400	2810

WS2	5yr ARI	100yr ARI
Base Invert (mAHD)	16.00	16.00
Peak Outflow (m^3)	0.08	0.10
Top Water Level (mAHD)	16.39	16.93
Top Water Level Area (ha)	0.33	0.41
Flood Storage (m^3)	1190	3070

WS3	5yr ARI	100yr ARI
Base Invert (mAHD)	15.10	15.10
Peak Outflow (m^3)	0.19	0.20
Top Water Level (mAHD)	15.48	16.00
Top Water Level Area (ha)	0.38	0.46
Flood Storage (m^3)	1250	4290

WS4A	5yr ARI	100yr ARI
Base Invert (mAHD)	13.46	13.46
Peak Outflow (m^3)	0.48	0.58
Top Water Level (mAHD)	14.10	14.65
Top Water Level Area (ha)	0.20	0.24
Flood Storage (m^3)	860	1670

WS4B	5yr ARI	100yr ARI
Base Invert (mAHD)	14.80	14.80
Peak Outflow (m^3)	0.14	0.20
Top Water Level (mAHD)	15.30	15.40
Top Water Level Area (ha)	0.11	0.19
Flood Storage (m^3)	210	570

WS4C	5yr ARI	100yr ARI
Base Invert (mAHD)	13.20	13.20
Peak Outflow (m^3)	0.53	0.68
Top Water Level (mAHD)	13.90	14.35
Top Water Level Area (ha)	0.15	0.19
Flood Storage (m^3)	810	1610

WS4D	5yr ARI	100yr ARI
Base Invert (mAHD)	14.80	14.80
Peak Outflow (m^3)	0.07	0.11
Top Water Level (mAHD)	15.30	15.65
Top Water Level Area (ha)	0.28	0.33
Flood Storage (m^3)	940	2020

WS4E	5yr ARI	100yr ARI
Base Invert (mAHD)	14.16	14.16
Peak Outflow (m^3)	0.03	0.05
Top Water Level (mAHD)	14.58	15.05
Top Water Level Area (ha)	0.10	0.13
Flood Storage (m^3)	290	785

Notes: WS3 combined storage values shown. POS and drainage locations are indicative only and subject to approval of the Local Structure plan, subdivision design and UWMP

Job No. J5132
Scale:1:10,000
0 200 400 600 800 Metres

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West Swan East: LWMS

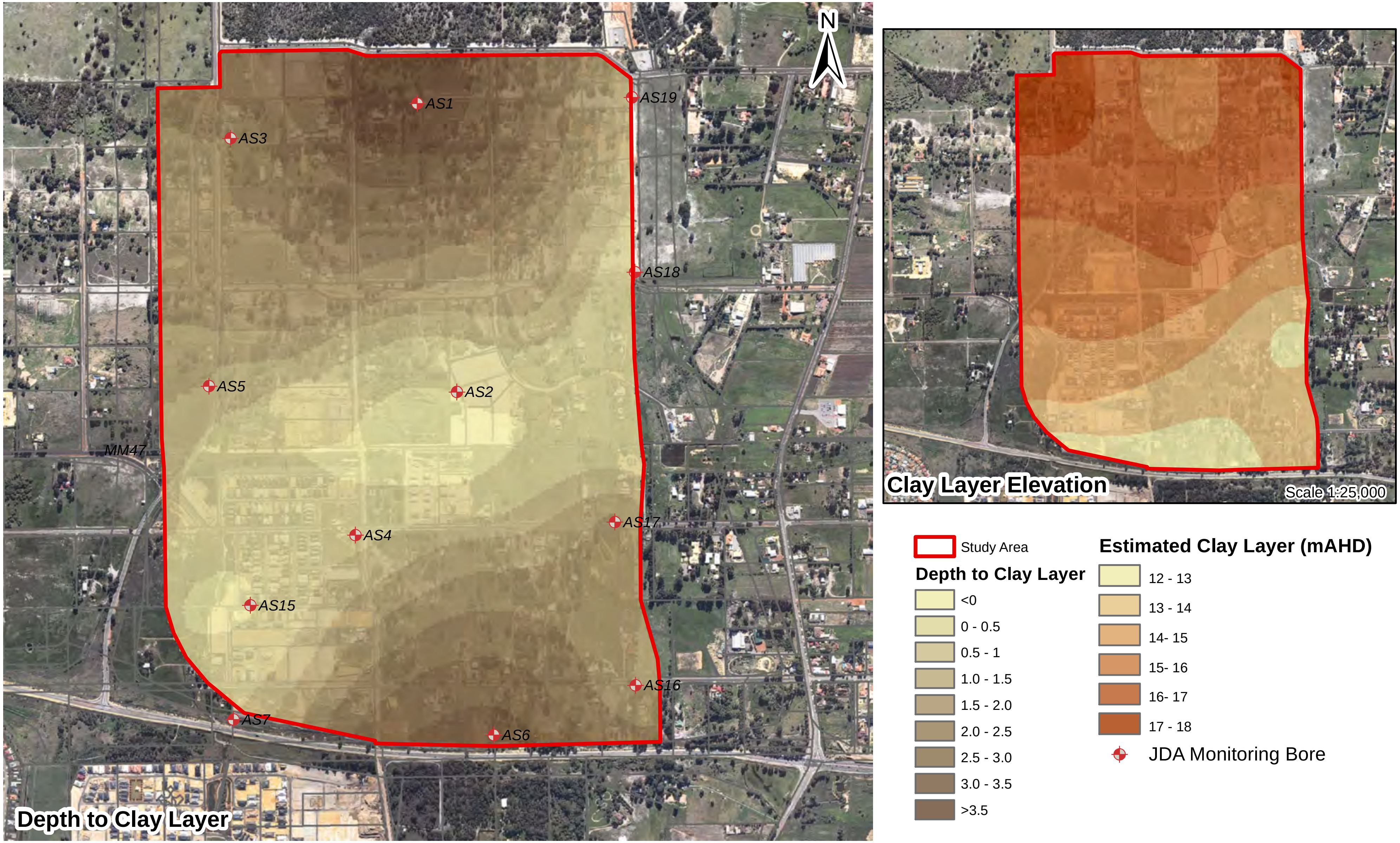
Figure 17: Proposed Stormwater Management: Marshall Road Catchment

Job No: J5132

St Leonards Estate Pty Ltd

West Swan East: LWMS

Figure 18: Wetland Drainage Concept

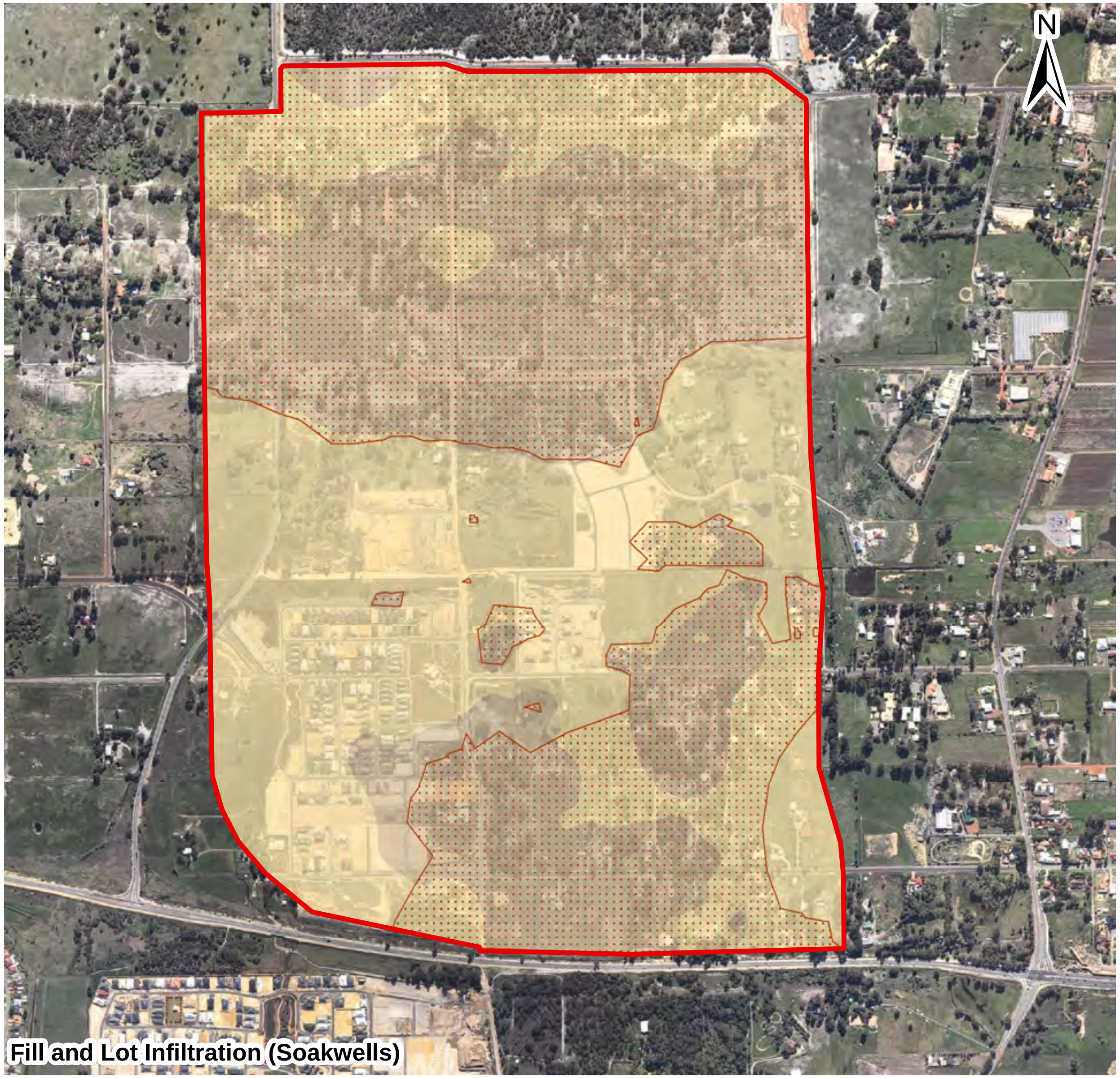


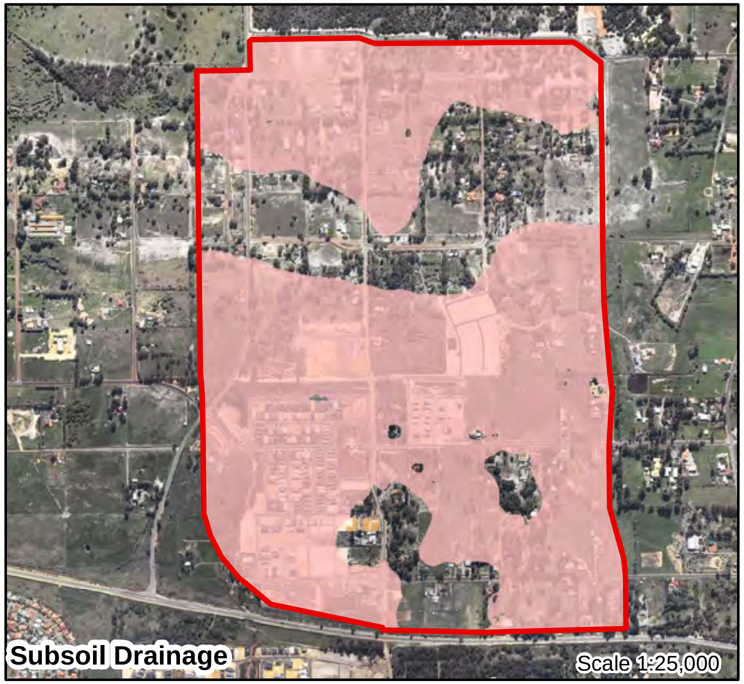
JDA

Job No. J5132
Scale: 1:15,000

0 200 400 600 800 Metres

St Leonards Estate Pty Ltd
West Swan East: LWMS
Figure 19: Depth to Clay Layer





🟥 Study Area
🟥 Subsoil Drainage
🟨 Fill Areas (<1.2)
▨ >1.2
▨ Soakwell Areas

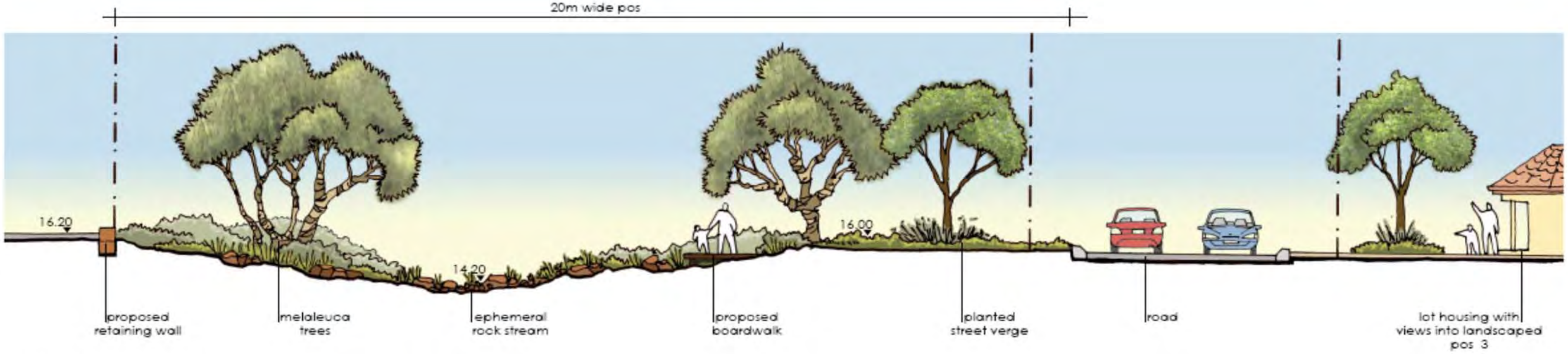
Note: Indicative Area of Subsoil Drainage defined as areas where AAMGL/CGL <1.8m below existing natural surface

Job No. J5132
Scale: 1:15,000

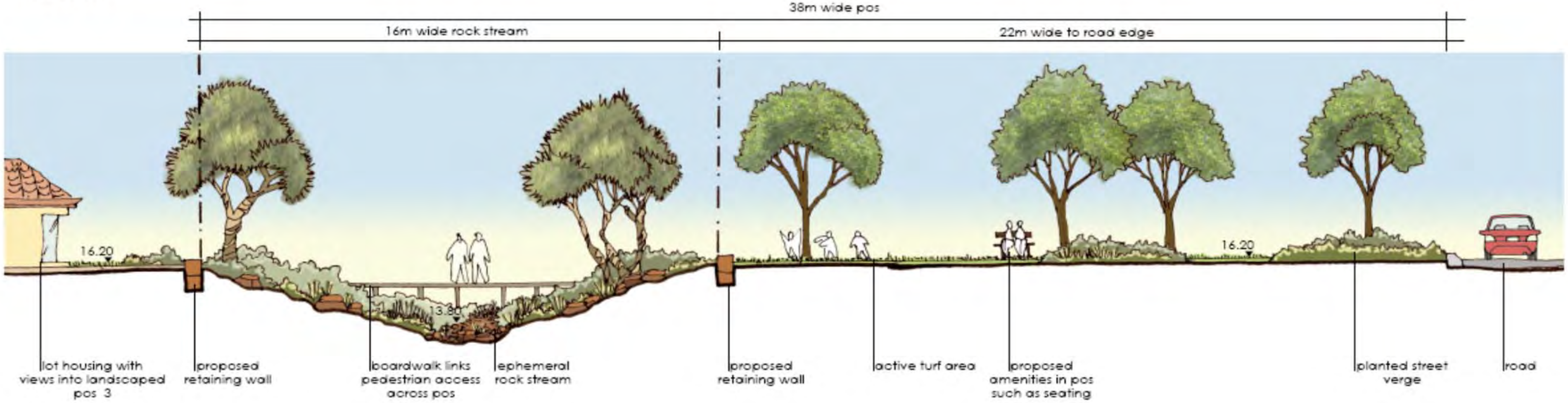
0 200 400 600 800 Metres

St Leonards Estate Pty Ltd
West Swan Property: LWMS

Figure 20: Indicative Areas of Subsoil Drainage



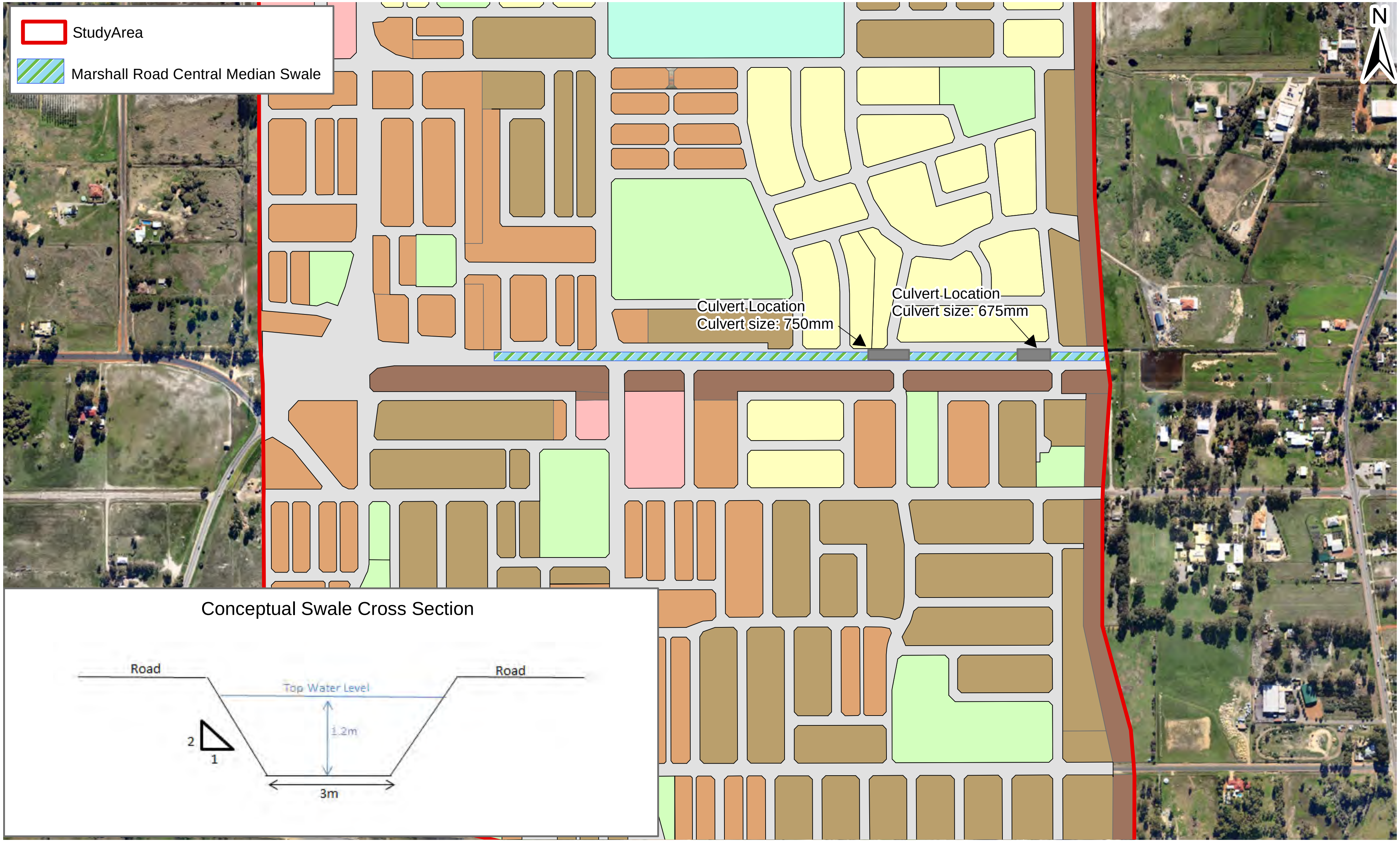
SECTION BB



SECTION CC

Data Source: MNLA 2009

Job No. J5132 Scale: Not to scale	St Leonards Estate Pty Ltd West Swan East: LWMS **Figure 21: Typical Living Streams Schematic**



Job No. J5132

Scale: 1:10,000

0 50 100 150 200 Metres

St Leonards Estate Pty Ltd

West Swan East: LWMS

Figure 22: Marshall Road Central Median Swale Concept

APPENDIX A

Local Water Management Strategy: Checklist for Developers

Checklist for integrated water cycle management assessment of local structure plan or local planning scheme amendment

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

Local water management strategy item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	☒	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		☒	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	☒ ☒	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	☒	
Design criteria			
Agreed design objectives and source of objective		☒	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☒	
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☒	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☒	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	☒	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	☒	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	☒	
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☒	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☒	
Wastewater management		☒	
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	☒ ☒	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	☒	

Local water management strategy item	Deliverable	☑	Comments
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	☒ ☒	
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	☒	
Actions to address acid sulfate soils or contamination		☒	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		☒	
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☒	
Implementation			
Developer commitments		☒	
Roles, responsibilities, funding for implementation		☒	
Review		☒	

APPENDIX B

WA Stormwater Management Objectives, Principles, and Delivery Approach (DoW, 2007) & Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

Western Australian Stormwater Management Objectives

Water Quality
To maintain or improve the surface and groundwater quality within the development areas relative to pre development conditions.

Water Quantity
To maintain the total water cycle balance within development areas relative to the pre development conditions.

Water Conservation
To maximise the reuse of stormwater.

Ecosystem Health
To retain natural drainage systems and protect ecosystem health.

Economic Viability
To implement stormwater management systems that are economically viable in the long term.

Public Health
To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property
To protect the built environment from flooding and waterlogging.

Social Values
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Stormwater Delivery Approach for WA

Protect water quality
Stormwater remains clean and retains its high value

Implement best management practice on-site.
Implement non-structural controls, including education and awareness programs.
Install structural controls at source or near source.
Use in-system management measures.
Undertake regular and timely maintenance of infrastructure and streetscapes.

Protect infrastructure from flooding and inundation
Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed

Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.
Store and detain excess runoff from large rainfall events in parks and multiple use corridors.
Safely convey excessive groundwater to the nearest watercourse.

Minimise runoff
Slow the migration of rainwater from the catchment and reduce peak flows

Retain and infiltrate rainfall within property boundaries.
Use rainfall on-site or as high in the catchment as possible.
Maximise the amount of permeable surfaces in the catchment.
Use non-kerbed roads and carparks.
Plant trees with large canopies over sealed surfaces such as roads and carparks.

Maximise local infiltration
Fewer water quality and flooding problems

Minimise impervious areas.
Use vegetated swales.
Use soakwells and minimise use of piped drainage systems.
Create vegetated buffer and filter strips.
Recharge the groundwater table for local bore water use.

Make the most of nature's drainage
Cost effective, safe and attractive alternatives to pipes and drains

Retain natural channels and incorporate into public open space.
Retain and restore riparian vegetation to improve water quality through bio-filtration.
Create riffles and pools to improve water quality and provide refuge for local flora and fauna.
Protect valuable natural ecosystems.
Minimise the use of artificial drainage systems.

Minimise changes to the natural water balance
Avoid summer algal blooms and midge problems and protect our groundwater resources

Retain seasonal wetlands and vegetation.
Maintain the natural water balance of wetlands.
No direct drainage to Conservation Category Wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.
Recharge groundwater by stormwater infiltration.

Integrate stormwater treatment into the landscape
Add value while minimising development costs

Public open space systems incorporating natural drainage systems.
Water sensitive urban design approach to road layout, lot layout and streetscape.
Maximise environmental, cultural and recreational opportunities.

Convert drains into natural streams
Lower flow velocities, benefit from natural flood water storage and improve waterway ecology

Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.
Accommodate large and infrequent storm events within the floodplain.
Create habitat diversity to support a healthy, ecologically functioning waterway.

Note: Selection of appropriate methods should be determined by site conditions.

Department of Environment

SWAN RIVER TRUST

Swan-Canning Cleanup Program

Decision Process for Stormwater Management in WA
(Department of Environment and Swan River Trust, 2005)

Preamble

The *Decision Process for Stormwater Management in WA* provides a decision framework for the planning and design of stormwater management systems. The methodology outlined in the decision process will result in minimising potential changes in the volume of surface water flows and peak flows which, if not managed, would lead to adverse impacts on water regime, water quality, habitat diversity and biodiversity in receiving water bodies[1] resulting from land development (i.e. residential, rural-residential, commercial and industrial). The process also addresses the management of flood events for the protection of properties. The decision process sits within 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; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

A significant stormwater management measure is to minimise the 'effective imperviousness' of a development area. Effective imperviousness is defined as the combined effect of the proportion of constructed impervious surfaces in the catchment, and the 'connectivity' of these impervious surfaces to receiving water bodies. The purpose of minimising effective imperviousness is to reduce the transportation of pollutants to receiving water bodies and to retain the post development hydrology as close as possible to the pre-development hydrology. This is achieved by 'disconnecting' constructed impervious areas from receiving water bodies and by reducing the amount of constructed impervious areas.

To retain the pre-development hydrology of a site, the order of management priorities is: the magnitude of peak flows; the volume of catchment run-off; and the seasonality of catchment run-off.

Rainfall, for the majority of events occurring each year, should be retained[2] or detained[3] on-site (i.e. as high in the catchment and as close to the source as possible, subject to adequate site conditions). Runoff from constructed impervious areas (e.g. roofs and paved areas) should be retained or detained through the use of soakwells, pervious paving, vegetated swales or gardens. For detention systems, the peak 1 year Average Recurrence Interval (ARI[4]) discharge from constructed impervious areas should be attenuated to the pre-development discharge rate. Events larger than 1 year ARI can overflow 'off-site'.

For larger rainfall events (i.e. greater than 1 year ARI events), runoff from constructed impervious areas should be retained or detained to the required design storm event in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands should be by overland flow paths across vegetated surfaces. Further detention may be required to ensure that the pre-development hydrologic regime of the receiving water bodies is largely unaltered, particularly in relation to peak flow rates and, where practical, discharge volume.

---

[1] Water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

[2] Retention is defined as the process of preventing rainfall runoff from being discharged into receiving water bodies by holding it in a storage area. The water may then infiltrate into groundwater, evaporate or be removed by evapotranspiration of vegetation. Retention systems are designed to prevent off-site discharges of surface water runoff, up to the design ARI event.

[3] Detention is defined as the process of reducing the rate of off-site stormwater discharge by temporarily holding rainfall runoff (up to the design ARI event) and then releasing it slowly, to reduce the impact on downstream water bodies and to attenuate urban runoff peaks for flood protection of downstream areas.

[4] ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For further information, refer to *Australian Rainfall & Runoff* (IEA, 2001) and the Bureau of Meteorology website via <www.bom.gov.au/hydro/has/ari_aep.shtml>.

Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of contaminants such as nutrients and metals with increasing storm sizes. Figure 1 shows that most hydraulic structures can be expected to treat over 99% of the expected annual runoff volume when designed for a 1 year ARI peak discharge. Unlike flood mitigation measures, stormwater quality treatment devices do not need to be designed for rainfall events of high ARI to achieve high hydrologic effectiveness (i.e. the percentage of mean annual runoff volume subjected to treatment) and therefore a high level of beneficial environmental outcomes.

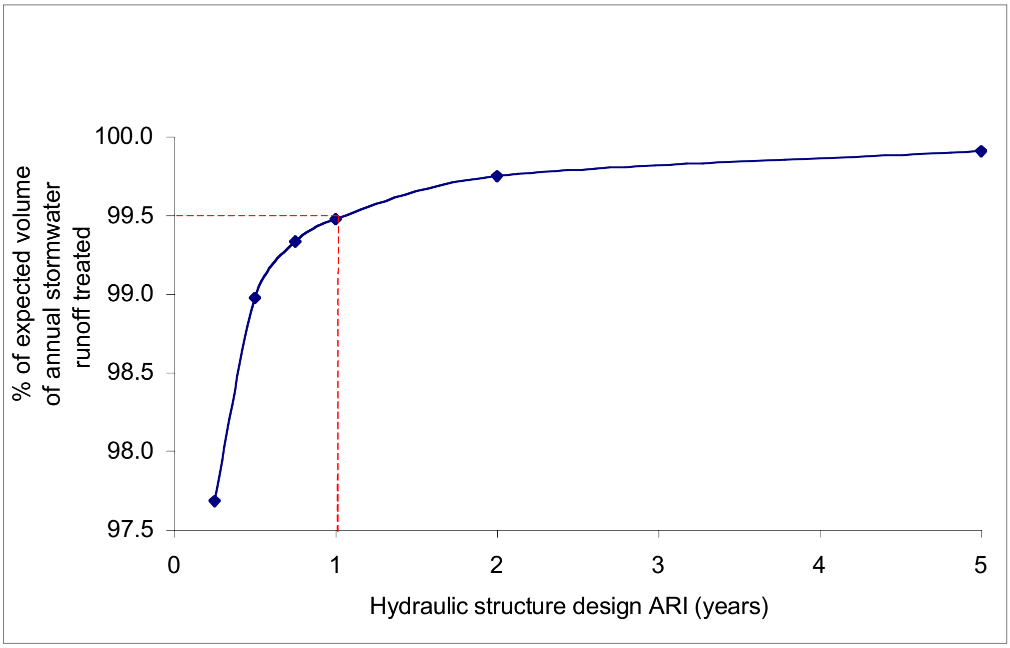


Figure 1. Treatment efficiency of stormwater hydraulic structures for Perth, Western Australia (adapted from Wong, 1999)

Stormwater management systems should be based on adequate field investigations and the conditions of the site. Prior to design, developers should consult with the Department of Environment, local government authority and other relevant stakeholders. For further information, refer to the *Decision Process for Stormwater Management in WA* flow chart.

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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.

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Department of Environment

SWAN
RIVER
TRUST

Swan-Canning Cleanup Program

APPENDIX C

Predevelopment Surface Water Monitoring Data

Appendix C : Predevelopment Surface Water Monitoring Data

Surface Sample	**Date**	pH	Conductivity mS/cm	TDS mg/L	TN mg/L	TKN mg/L	Nox-N mg/L	Ammonia-N mg/L	TP mg/L	FRP mg/L	As mg/L	Cd mg/L	Cr mg/L	Cu mg/L	Hg mg/L	Ni mg/L	Pb mg/L	Zn mg/L
S1	Jul 05	-	-	-	4.7	3.9	0.8	<0.2	-	0.11	<0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.01
S2	Jul-05	7.8	0.9	1300	5.8	5.6	0.21	<0.2	0.73	0.43	0.001	<0.002	0.02	<0.01	<0.0002	<0.01	<0.01	0.03
	Oct-05	7.6	1.21	840	2.3	2.2	0.11	<0.2	0.12	0.12	0.003	<0.002	<0.01	<0.01	<0.0002	0.01	<0.01	0.03
	Aug-06	8.9	0.87	620	4.8	3.9	0.95	<0.2	0.65	0.18	0.001	<0.002	<0.01	<0.01	<0.0002	0.01	0.04	0.01
	Sep-06	7	4.51	490	3.8	3.1	0.68	0.014	0.61	0.23	0.003	<0.001	0.002	0.005	<0.0001	<0.005	<0.001	0.013
All	Samples	4	4	4	5	5	5	5	4	5	5	5	5	5	5	5	5	5
Sites	Minimum	7	0.87	490	2.3	2.2	0.11	<0.2	0.12	0.11	<0.001	<0.001	<0.01	<0.01	<0.0001	<0.005	<0.001	0.01
	Maximum	8.9	4.51	1300	5.8	5.6	0.95	<0.2	0.73	0.43	0.003	<0.002	0.02	<0.01	<0.0002	0.01	0.04	0.03
	Median	7.7	1.05	730	4.7	3.9	0.68	<0.2	0.63	0.18	0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.013
	Mean	7.8	1.87	812	4.28	3.7	0.55	<0.2	0.53	0.21	0.002	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.019

APPENDIX D

Groundwater Bore Logs

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	403036E 6476088E	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS1	Total Depth:	6m
Drill type:	Hollow Auger	R.L. TOC:	21.37mAHD
Hole diameter:	75mm	Natural Surface:	20.82mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA						Brown			Moderate		
						Grey					
		PVC (Class 9)			1m					Moist	
											Bentonite Seal 1.0m - 1.4m
			▽								
						Grey/White					
					2m						
						Brown					Cemented Coffee Rock
							Medium/Fine	Sand			
					3m						
				▤					Low		
				▤						Saturated	
				▤	4m	Dark Brown					
				▤	5m						
				▤		Light Brown		Clayey Sand			
					6m						
					7m						
					8m						
					9m						
					10m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 2.06m

Stickup above NS: 0.55m

WL: 1.51m below NS

JDA Consultant Hydrologists
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Fax: 9381 9279

JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	403147E 6475274N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	AS2	Total Depth:	4.5m
Drill type:	Hollow Auger	R.L. TOC:	16.73mAHD
Hole diameter:	75mm	Natural Surface:	16.18mAHD

						SOIL CHARACTERISTICS					
method	**penetration** 1 2 3	**support**	**water**	**Slot / Screen Depth**	**Depth (metres)**	**COLOUR**	**PARTICLE SIZE**	**TEXTURE**	**ORGANIC CONTENT**	**MOISTURE**	**COMMENTS**
HA			∇					Peaty Sand	Moderate	Moist	
						Dark Grey					
					0.5m						
		PVC (Class 9)									Bentonite Seal 0.4m - 0.9m
					1.0m						
						Grey					
					1.5m						
				▤	2.0m			Clayey Sand	Low	Saturated	
				▤			Medium/Fine				
				▤	2.5m						
				▤	3.0m						
				▤		Light Grey					
				▤	3.5m						
				▤	4.0m						
				▤				Sandy Clay			
					4.5m						
					5.0m						

NOTES ON BORELOG

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Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 0.62m

Stickup above NS: 0.55m

WL: 0.07m below NS

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JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402509E 6475990N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	AS3	Total Depth:	5.5m
Drill type:	Hollow Auger	R.L. TOC:	21.32mAHD
Hole diameter:	75mm	Natural Surface:	20.84mAHD

method	1 2 3 penetration	**support**	**water**	**Slot / Screen Depth**	**Depth (metres)**	**SOIL CHARACTERISTICS** **COLOUR**	**PARTICLE SIZE**	**TEXTURE**	**ORGANIC CONTENT**	**MOISTURE**	**COMMENTS**
HA									Moderate		
						Dark Grey					
		PVC (Class 9)			0.5m						
										Moist	
			▽		1.0m			Sand	Low		
					1.5m	Grey/Brown					
					2.0m						
					2.5m					Saturated	
					3.0m		Medium/Fine				
											Moderately Cemented Coffee Rock
					3.5m			Silty Sand			
						Brown					
					4.0m						
								Sand			
					5.0m						
						Grey/Brown		Clayey Sand			
					5.5m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 1.58m

Stickup above NS: 0.48m

WL: 1.10m below NS

JDA Consultant Hydrologists

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402861E 6474871N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	Proline Driiling
Bore Name:	AS4	Total Depth:	4.5m
Drill type:	Hollow Auger	R.L. TOC:	16.46mAHD
Hole diameter:	75mm	Natural Surface:	15.89mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA									Moderate		
		PVC (Class 9)	▽		0.5m	Grey		Sand			Bentonite
					1.0m		Medium/Fine				
				▤	1.5m	Grey/Yellow		Clayey Sand			
				▤	2.0m				Low		
				▤	2.5m						Yellow mottles, layers of sandy soils <0.2m thick
				▤	3.0m	Grey	Fine	Clay			
				▤	3.5m						
				▤	4.0m						
				▤	4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 1.16m

Stickup above NS: 0.60m

WL: 0.56m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402447E 6475290N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	AS5	Total Depth:	4.5m
Drill type:	Hollow Auger	R.L. TOC:	16.94mAHD
Hole diameter:	75mm	Natural Surface:	16.40mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA									Moderate	Moist	
								Silty Sand			
		PVC (Class 9)	▽		0.5m	Orange/Brown					Bentonite Seal
					1.0m						
					1.5m				Low	Saturated	Gravel Pack
				▤		Brown/Dark Green		Sandy Clay			
				▤			Medium/Fine				
				▤	2.0m						
				▤	2.5m						
				▤	3.0m	Grey/Yellow		Clayey Sand/Sand			
				▤	3.5m						
				▤	4.0m						
				▤	4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

		Tones : solid colour, blemish or mottle
Dark :	Brown, Red, Orange, Yellow, Grey, Blue	
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 0.98m

Stickup above NS: 0.54m

WL: 0.44m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	403251E 6474305N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	Proline Drilling
Bore Name:	AS6	Total Depth:	6.5m
Drill type:	Hollow Auger	R.L. TOC:	18.37mAHD
Hole diameter:	75mm	Natural Surface:	17.75mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)			0.5m	Grey					
					1.0m						
					1.5m		Medium/Fine	Sand			
					2.0m						
			▽		2.5m						Bentonite Seal
					3.0m	Yellow					
				▤	3.5m						
				▤	5.5m	Light Yellow		Clayey Sand			
				▤	6.0m	Grey		Clay			Very stiff clay
				▤	6.5m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 3.16m

Stickup above NS: 0.62m

WL: 2.54m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402517E 6474349N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC
Bore Name:	AS7	Total Depth:	4.5m
Drill type:	Hollow Auger	R.L. TOC:	13.84mAHD
Hole diameter:	75mm	Natural Surface:	13.27mAHD

	1 2 3					SOIL CHARACTERISTICS					
method	penetration	**support**	**water**	**Slot / Screen Depth**	**Depth (metres)**	**COLOUR**	**PARTICLE SIZE**	**TEXTURE**	**ORGANIC CONTENT**	**MOISTURE**	**COMMENTS**
HA									Moderate		
						Dark Grey				Moist	
			∇					Sand			
					0.5m						
		PVC (Class 9)				Grey					
					1.0m						
											Limsetone fragments
				▤	1.5m	Creamy Grey					
				▤						Saturated	Increasing clay content with depth
				▤	2.0m						
				▤				Clayey Sand	Low		
				▤	2.5m						
				▤			Medium/Fine				
				▤	3.0m						
				▤	3.5m	Green/Grey					
				▤	4.0m			Sandy Clay			
				▤	4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 0.90m

Stickup above NS: 0.57m

WL: 0.33m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	403241E 6475536N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS8	Total Depth:	3.60m
Drill type:	HandAuger	R.L. TOC:	20.62mAHD
Hole diameter:	75mm	Natural Surface:	20.06mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA									Moderate		
						Grey/Black					
		PVC (Class 9)			0.5m						
					1.0m		Medium				
								Sand			
						Grey/White					
					1.5m						
										Moist	
									Low		
					2.0m						
					2.5m						
			∇	▤		Orange/Brown					Weak cementation
				▤	3.0m						
				▤			Medium/Fine				Some clay content
				▤		Yellow/Orange				Saturated	
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 3.45m

Stickup above NS: 0.56m

WL: 2.89m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402831E 6475722N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS9	Total Depth:	1.80m
Drill type:	Hand Auger	R.L. TOC:	20.62mAHD
Hole diameter:	75mm	Natural Surface:	20.11mAHD

method	**penetration** 1 2 3	**support**	**water**	**Slot / Screen Depth**	**Depth (metres)**	**SOIL CHARACTERISTICS** COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA						Grey			Moderate		
		PVC (Class 9)			0.5m					Moist	
			∇	▤	1.0m	Grey/White	Medium/Fine	Sand	Low		
				▤	1.5m					Saturated	
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 1.74m

Stickup above NS: 0.51m

WL: 1.23m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402284E 6475551N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS10	Total Depth:	2.21m
Drill type:	Hand Auger	R.L. TOC:	20.46mAHD
Hole diameter:	75mm	Natural Surface:	20.01mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Grey			Moderate		
					0.5m						
										Moist	
					1.0m	White	Medium/Fine	Sand	Low		
				▤	1.5m						
			▽	▤							
				▤	2.0m					Saturated	
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 2.34m

Stickup above NS: 0.45m

WL : 1.89m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/04
Bore location:	402327E 6474893N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS11	Total Depth:	1.22m
Drill type:	Hand Auger	R.L. TOC:	17.24mAHD
Hole diameter:	75mm	Natural Surface:	16.34mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA						Grey			Moderate		
		PVC (Class 9)	▽	▤	0.5m	White	Medium/Fine	Sand	Low	Moist	
					1.0m					Saturated	
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 1.68m

Stickup above NS: 0.90m

WL: 0.78m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/04
Bore location:	402849E 6475270N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS12	Total Depth:	1.1m
Drill type:	Hand Auger	R.L. TOC:	16.46mAHD
Hole diameter:	75mm	Natural Surface:	16.21mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
						SOIL CHARACTERISTICS					
HA		PVC (Class 9)				Dark Grey	Medium/Fine	Sand	Low	Moist	
			▽	▤	0.5m	Grey/White				Saturated	
				▤	1.0m						
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 0.74m

Stickup above NS: 0.25m

WL: 0.49m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	403209E 6474675N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS13	Total Depth:	1.3m
Drill type:	Hand Auger	R.L. TOC:	16.58mAHD
Hole diameter:	75mm	Natural Surface:	16.18mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)	▽			Black	Medium/Fine	Sand	Moderate	Moist	
				▤	0.5m	Grey			Low	Saturated	
				▤	1.0m						
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 0.86m

Stickup above NS: 0.40m

WL: 0.46m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	14/07/05
Bore location:	402937E 6474300N	Hole completed:	14/07/05
Datum:	MGA94/AHD	Logged by:	KC/ASM
Bore Name:	AS14	Total Depth:	1.57m
Drill type:	Hand Auger	R.L. TOC:	17.62mAHD
Hole diameter:	75mm	Natural Surface:	16.46mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Grey/Black	Medium/Fine	Sand	Moderate	Moist	
						Grey/White			Low		
					0.5m						
										Saturated	
			▽	▤	1.0m						
					1.5m	Brown					Partially cemented coffee rock
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/7/05

WL below TOC: 2.09m

Stickup above NS: 1.16m

WL: 0.93m below NS

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LITHOLOGICAL LOG

Client:	Sagecorp Properties Pty Ltd	Job No:	J3648
Project:	Arthur St Development, West Swan	Hole commenced:	20/07/05
Bore location:	402564E 6474672N	Hole completed:	20/07/05
Datum:	MGA94/AHD	Logged by:	ASM/KC
Bore Name:	AS15	Total Depth:	2.08m
Drill type:	Hand Auger	R.L. TOC:	15.48mAHD
Hole diameter:	75mm	Natural Surface:	14.90mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA						Grey			Low		
								Sand		Very Moist	
		PVC (Class 9)	▽		0.5m	Light Grey					
						Brown					
					1.0m		Medium/Fine		Moderate		
											Coffee Rock
								Sandy Clay			
										Saturated	
				▤	1.5m						
				▤		Light Brown					
				▤				Gravelly Clay			Possible limestone fragments within gravelly clay
				▤	2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 20/07/2005

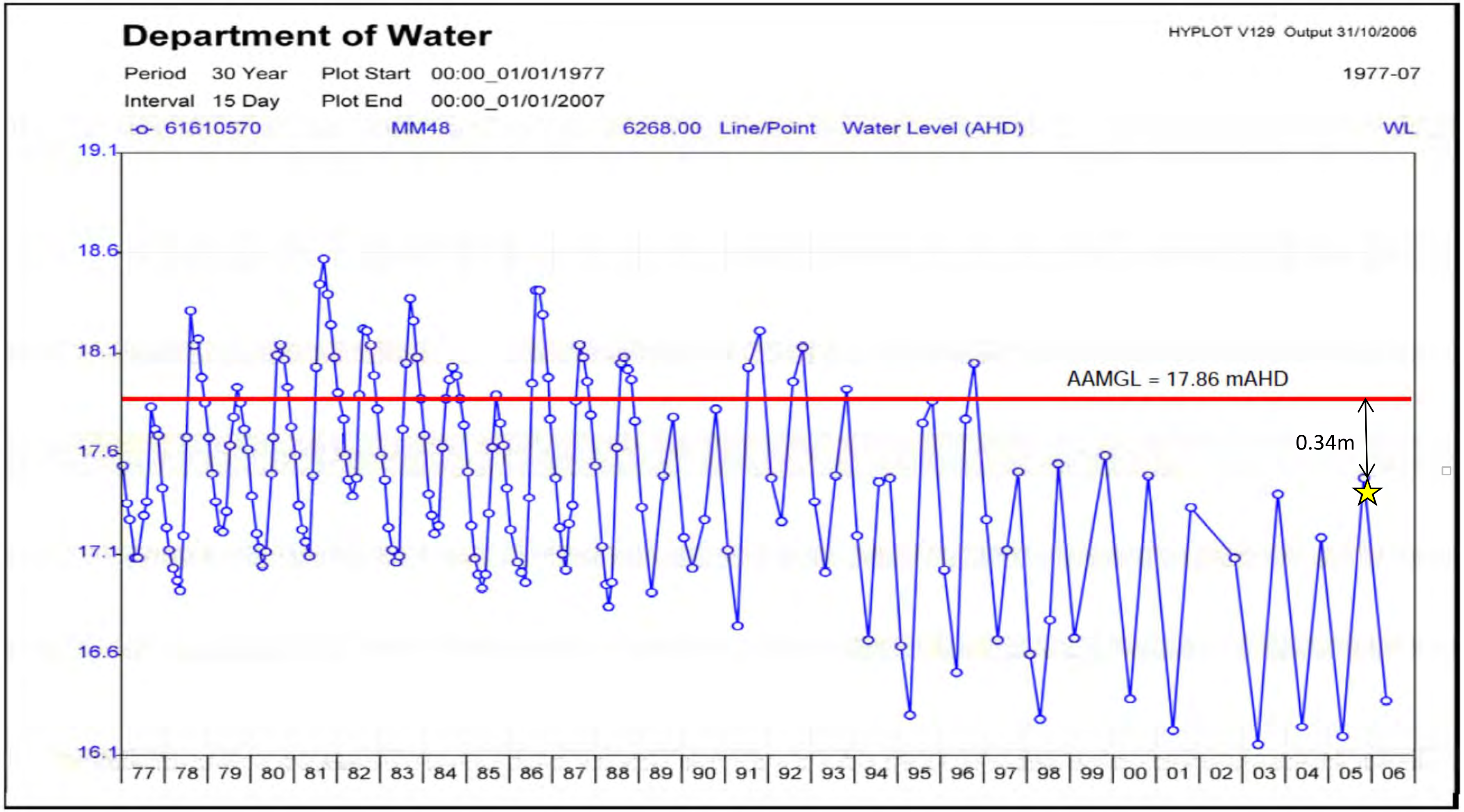
WL below TOC: 1.04m

Stickup above NS: 0.58m

WL: 0.46m below NS

APPENDIX E

Annual Average Maximum Groundwater Level (AAMGL) Calculation



☆W.L. 06/10/2005
17.52mAHD

Job No. J5132

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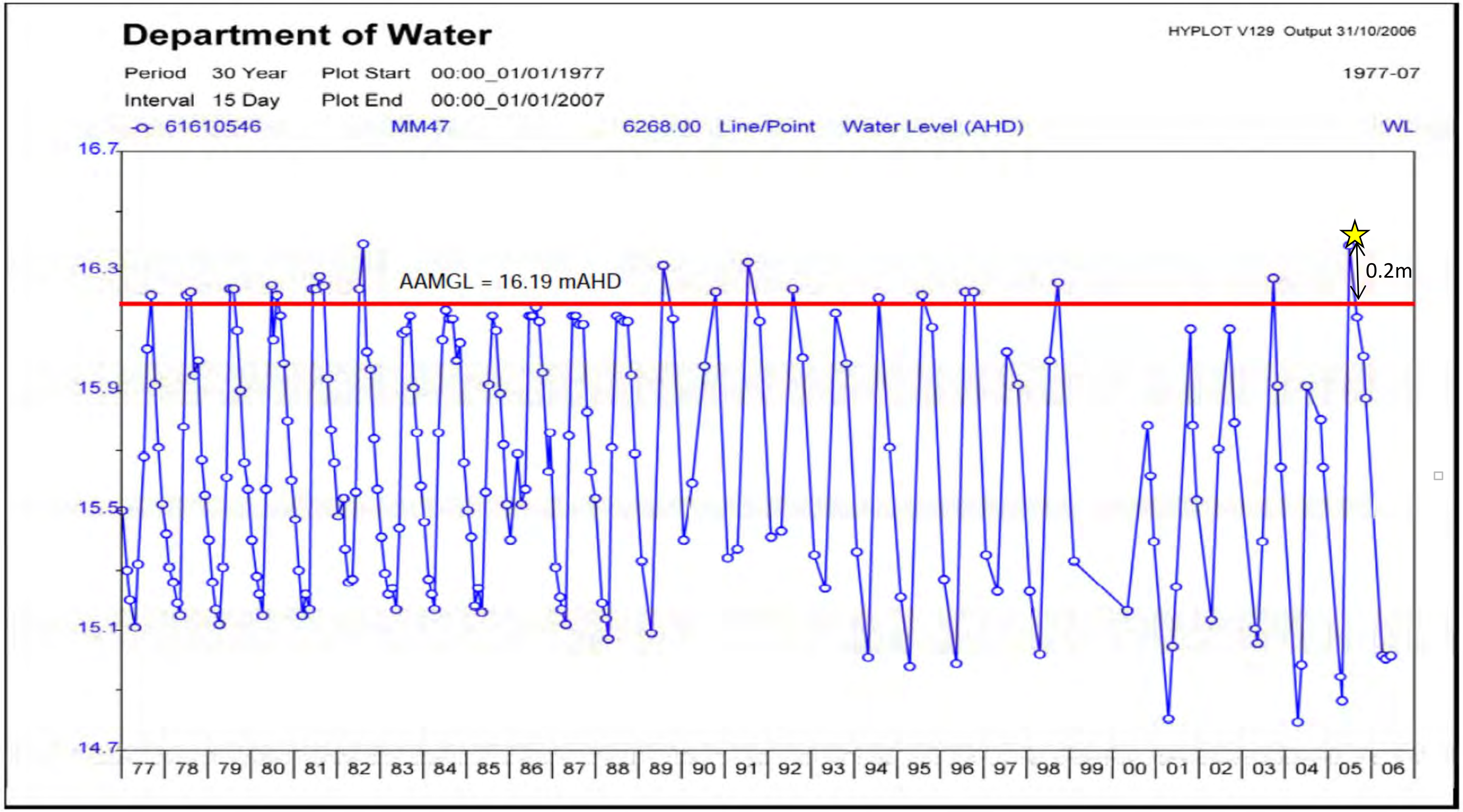
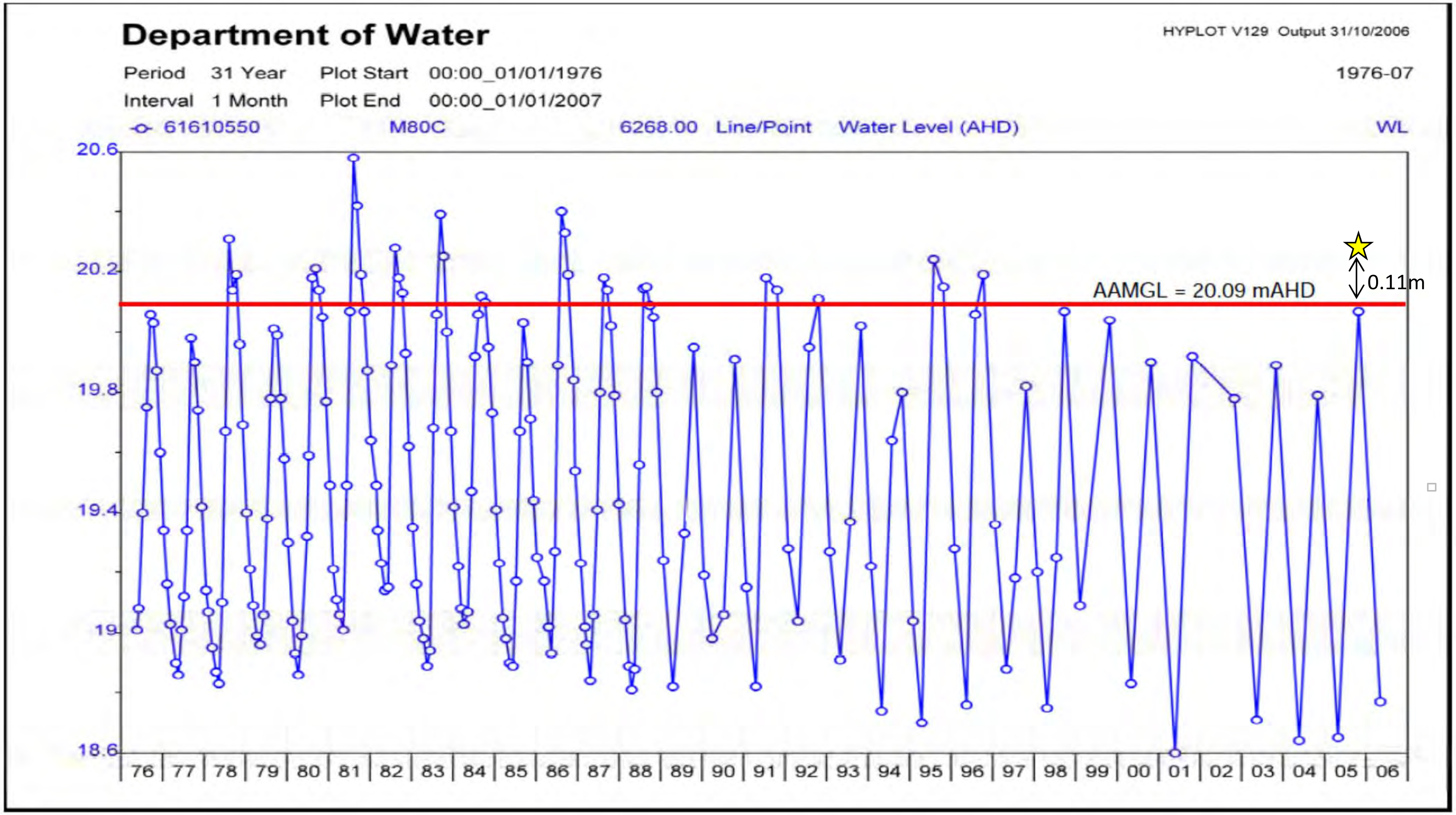
St Leonards Estate Pty Ltd
West Swan East LWMS
Figure E1: MM48 Hydrograph and AAMGL



☆ W.L. 06/10/2005
16.40mAHD

JDA Consultant Hydrologists	Job No. J5132 	St Leonards Estate Pty Ltd West Swan East LWMS **Figure E2: MM47 Hydrograph and AAMGL**



☆ W.L. 06/10/2005
20.20mAHD

Job No. J5132

St Leonards Estate Pty Ltd
West Swan East LWMS

Figure E3: M80C Hydrograph and AAMGL

Table E1. Groundwater Monitoring Sites

Bore	Location (GDA)		Natural Surface	Top of Casing
	Easting	Northing	(m AHD)	(m AHD)
AS1	403036	6476088	20.82	21.37
AS2	403147	6475274	16.18	16.73
AS3	402509	6475990	20.84	21.32
AS4	402861	6474871	15.89	16.46
AS5	402447	6475290	16.40	16.94
AS6	403251	6474306	17.75	18.37
AS7	402517	6474350	13.27	13.70
AS8	403241	6475536	20.06	20.62
AS9	402831	6475722	20.11	20.62
AS10	402284	6475551	20.01	20.46
AS11	402327	6474893	16.34	17.24
AS12	402849	6475270	16.21	16.46
AS13	403209	6474675	16.18	16.58
AS14	402937	6474300	16.46	17.62
AS15	402565	6474672	14.90	15.48
AS16	403652	6474446	15.04	15.93
AS17	403590	6474446	14.96	15.89
AS18	403654	6475612	16.32	17.36
AS19	403639	6476106	19.87	20.16
MM47	402152	6475110	-	16.81
MM48	403262	6475600	-	21.59
M80C	401345	6476123	-	21.54

1. TOC : Top of Casing
2. Survey Conducted 29 July 2005, except AS15-19 surveyed 6 November 2006

Table E2. Drains and Standing Water Sites

Site [1]	Location (GDA)		MAPS Survey Data (m AHD)		
	Easting	Northing	Invert	Water Level 29 July 2005	Nat Surface
SW1	402841	6474375	15.57	15.63	-
SW2	402501	6474808	13.67	14.62	-
SW3	402464	6474973	15.23	15.53	-
D1	402426	6474449	13.00	13.08	13.33
D2	402414	6474386	12.31	12.45	13.08
D3	402521	6474449	13.74	13.98	14.03
D4	402687	6474452	14.53	14.64	14.87
D5	402505	6474876	14.47	14.60	14.95
D6	402671	6474879	14.78	15.02	15.60
D7	402865	6474881	15.09	15.24	15.97
D8	402928	6474882	15.38	15.63	16.27
D9	403048	6474884	15.26	15.61	16.09
D10	402504	6475112	15.20	15.28	16.02
D11	402507	6475097	15.08	15.30	15.49
D12	402852	6475116	14.35	14.48	15.59
D13	402853	6475101	14.48	14.54	16.01
D14	402897	6475121	14.12	14.37	15.49
D15	403295	6475118	13.39	13.76	15.13

1. D : Open Drain Site, SW : Standing Water Site

Appendix E : AAMGL Calculation

Water level monitoring data used for AAMGL is 6/10/05 for bores AS1-AS15 (highest recorded groundwater level during monitoring period)
Recently installed AS16-AS19 based on adjusted levels from 20/10/06

	AAMGL	6/10/2005 Water Level	Difference		20/10/2006 Water Level	Difference	
MM48	**17.86**	17.52	-0.34		16.87	-0.99	
MM47	**16.19**	16.40	0.20		15.77	-0.42	
M80C	**20.09**	20.20	0.11		19.39	-0.70	
			-0.01	**Relative to AAMGL**		-0.70	**Relative to AAMGL**

	6/10/2005 Water Level	Correction to AAMGL	AAMGL	20/10/2006 Water Level	Correction to AAMGL	AAMGL
AS1	19.57	0.01	**19.58**	18.91		
AS2	16.07	0.01	**16.08**	15.45		
AS3	20.10	0.01	**20.11**	19.37		
AS4	15.63	0.01	**15.64**	14.87		
AS5	16.16	0.01	**16.17**	15.55		
AS6	15.53	0.01	**15.54**	14.57		
AS7	13.04	0.01	**13.05**	12.09		
AS8	17.50	0.01	**17.51**	dry		
AS9	19.17	0.01	**19.17**	dry		
AS10	18.27	0.01	**18.27**	dry		
AS11	15.92	0.01	**15.93**	dry		
AS12	15.95	0.01	**15.96**	dry		
AS13	16.06	0.01	**16.06**	dry		
AS14	15.74	0.01	**15.75**	14.96		
AS15	14.40	0.01	**14.41**	13.37		
AS16				13.93	0.70	**14.63**
AS17				12.94	0.70	**13.64**
AS18				16.06	0.70	**16.76**
AS19				17.71	0.70	**18.41**

APPENDIX F

Predevelopment Groundwater Level Monitoring Data

APPENDIX F: Predevelopment Groundwater Level Monitoring Data

Bore	Easting	Northing	TOC	NSL	Stickup	Water level (mBTOC)															
			(mAHD	(mAHD)	(m)	20/7/05	2/9/05	6/10/05	2/11/05	21/12/05	1/2/06	8/3/06	3/4/06	5/5/06	8/6/06	7/7/06	15/8/06	18/9/06	20/10/06	13/11/06	6/12/06
AS1	403036	6476088	21.37	20.82	0.55	2.06	1.96	1.80	2.00	2.23	2.42	2.70	2.87	2.96	3.00	2.94	2.65	2.24	2.46	2.6	-
AS2	403147	6475274	16.73	16.18	0.55	0.62	NM	0.66	0.93	1.24	NM	1.70	1.71	1.67	1.62	1.48	1.1	0.89	1.28	1.49	1.62
AS3	402509	6475990	21.32	20.84	0.48	1.58	1.45	1.22	1.49	1.72	1.99	2.15	2.30	2.38	2.41	2.40	2.04	1.1	1.95	2.06	2.21
AS4	402861	6474871	16.46	15.89	0.57	1.16	1.19	0.83	1.28	1.45	1.92	2.30	2.10	2.41	2.10	2.31	1.71	1.36	1.59	1.73	1.98
AS5	402447	6475290	16.94	16.40	0.54	0.98	0.99	0.78	1.01	1.56	1.82	2.06	2.24	2.16	2.03	1.83	1.01	0.92	1.39	1.59	1.82
AS6	403251	6474306	18.37	17.75	0.62	3.16	2.96	2.84	2.99	3.20	3.52	3.74	3.96	4.15	4.30	4.39	4.14	3.74	3.8	3.89	4.02
AS7	402517	6474350	13.70	13.27	0.43	0.76	0.85	0.80	1.15	NM	1.84	2.08	2.25	2.40	2.39	2.35	1.72	1.22	1.61	1.89	1.98
AS8	403241	6475536	20.62	20.06	0.56	3.45	3.26	3.12	3.26	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
AS9	402831	6475722	20.62	20.11	0.50	1.74	1.62	1.45	1.68	1.87	Dry	Dry	Dry	Dry	Dry	3.92	Dry	1.98	Dry	Dry	Dry
AS10	402284	6475551	20.46	20.01	0.45	2.34	2.27	2.19	2.35	2.58	Dry	Dry	Dry	Dry	Dry	Dry	Dry	2.57	Dry	Dry	Dry
AS11	402327	6474893	17.24	16.34	0.90	1.68	1.65	1.32	1.80	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	2.08	Dry	Dry	Dry
AS12	402849	6475270	16.46	16.21	0.25	0.74	0.73	0.51	0.88	1.29	Dry	Dry	Dry	Dry	Dry	Dry	-	-	-	-	-
AS13	403209	6474675	16.58	16.18	0.40	0.86	NM	0.52	0.88	1.13	Dry	Dry	Dry	Dry	Dry	1.25	Dry	Dry	Dry	Dry	Dry
AS14	402937	6474300	17.62	16.46	1.16	2.09	2.03	1.88	2.12	2.36	2.62	Dry	Dry	Dry	Dry	Dry	Dry	2.51	2.66	Dry	Dry
AS15	402565	6474672	15.48	14.90	0.58	2.19	1.33	1.08	1.65	2.21	Dry	Dry	Dry	Dry	Dry	Dry	2.42	1.69	2.11	2.41	Dry
MM47	402152	6475110	16.82	-	-	0.65	0.66	0.42	0.85	1.23	1.55	1.70	1.80	1.84	1.77	1.70	1.19	0.85	-	1.37	1.52
MM48	403262	6475600	21.59	-	-	4.40	4.20	4.07	4.14	4.40	4.76	4.98	5.10	5.21	5.23	5.24	5.05	4.68	4.72	4.84	5
M80C	401345	6476123	21.54	-	-	1.63	NM	1.34	1.50	1.88	2.26	2.46	2.62	2.72	2.73	2.83	2.58	2.20	2.15	2.36	2.43

TOC : Top of Casing NSL : Natural Surface Level

Bore	Easting	Northing	TOC	NSL	Stickup	Water level (mAHD)																Max	Min
			(mAHD	(mAHD)	(m)	20/7/05	2/9/05	6/10/05	2/11/05	21/12/05	1/2/06	8/3/06	3/4/06	5/5/06	8/6/06	7/7/06	15/8/06	18/9/06	20/10/06	13/11/06	6/12/06	(mAHD)	(mAHD)
AS1	403036	6476088	21.37	20.82	0.55	19.31	19.41	19.57	19.37	19.14	18.95	18.67	18.50	18.41	18.37	18.43	18.72	19.13	18.91	18.77	-	19.57	18.37
AS2	403147	6475274	16.73	16.18	0.55	16.11	-	16.07	15.80	15.49	-	15.03	15.02	15.06	15.11	15.25	15.63	15.84	15.45	15.24	15.11	16.11	15.02
AS3	402509	6475990	21.32	20.84	0.48	19.74	19.87	20.10	19.83	19.60	19.33	19.17	19.02	18.94	18.91	18.92	19.28	20.22	19.37	19.26	19.11	20.22	18.91
AS4	402861	6474871	16.46	15.89	0.57	15.30	15.27	15.63	15.18	15.01	14.54	14.16	14.36	14.05	14.36	14.15	14.75	15.10	14.87	14.73	14.48	15.63	14.05
AS5	402447	6475290	16.94	16.40	0.54	15.96	15.95	16.16	15.93	15.38	15.12	14.88	14.70	14.78	14.91	15.11	15.93	16.02	15.55	15.35	15.12	16.16	14.70
AS6	403251	6474306	18.37	17.75	0.62	15.21	15.41	15.53	15.38	15.17	14.85	14.63	14.41	14.22	14.07	13.98	14.23	14.63	14.57	14.48	14.35	15.53	13.98
AS7	402517	6474350	13.70	13.27	0.43	13.08	12.99	13.04	12.69	-	12.00	11.76	11.59	11.44	11.45	11.49	12.12	12.62	12.23	11.95		13.08	11.44
AS8	403241	6475536	20.62	20.06	0.56	17.17	17.36	17.50	17.36	-	-	-	-	-	-	-	-	-	-	-	-	17.50	-
AS9	402831	6475722	20.62	20.11	0.50	18.88	19.00	19.17	18.94	18.75	-	-	-	-	-	-	-	18.64	-	-	-	19.17	-
AS10	402284	6475551	20.46	20.01	0.45	18.12	18.19	18.27	18.11	17.88	-	-	-	-	-	-	-	17.89	-	-	-	18.27	-
AS11	402327	6474893	17.24	16.34	0.90	15.56	15.59	15.92	15.44	-	-	-	-	-	-	-	-	15.16	-	-	-	15.92	-
AS12	402849	6475270	16.46	16.21	0.25	15.72	15.73	15.95	15.58	15.17	-	-	-	-	-	-	-	-	-	-	-	15.95	-
AS13	403209	6474675	16.58	16.18	0.40	15.72	-	16.06	15.70	15.45	-	-	-	-	-	-	-	-	-	-	-	16.06	-
AS14	402937	6474300	17.62	16.46	1.16	15.53	15.59	15.74	15.50	15.26	15.00	-	-	-	-	-	-	15.11	14.96	-	-	15.74	-
AS15	402565	6474672	15.48	14.90	0.58	13.29	14.15	14.40	13.83	13.27	-	-	-	-	-	-	13.06	13.79	13.37	13.07	-	14.40	-
MM47	402152	6475110	16.82	-	-	16.17	16.16	16.40	15.97	15.59	15.27	15.12	15.02	14.98	15.05	15.12	15.63	15.97	-	15.45	15.30	16.40	14.98
MM48	403262	6475600	21.59	-	-	17.19	17.39	17.52	17.45	17.19	16.83	16.61	16.49	16.38	16.36	16.35	16.54	16.91	16.87	16.75	16.59	17.52	16.35
M80C	401345	6476123	21.54	-	-	19.91	-	20.20	20.04	19.66	19.28	19.08	18.92	18.82	18.81	18.71	18.96	19.34	19.39	19.18	19.11	20.20	18.71

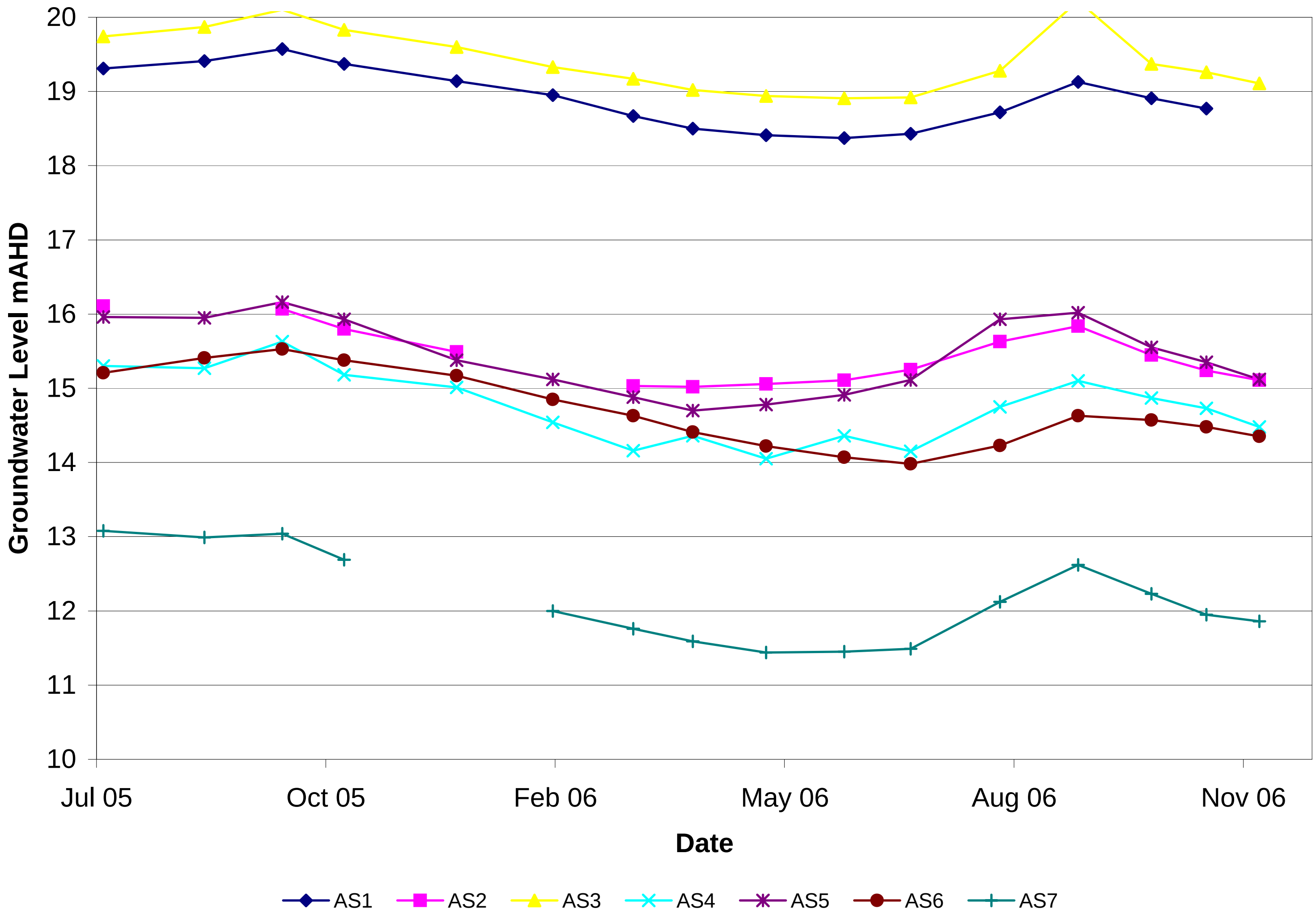


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Figure F1: Time Series Groundwater Levels AS1 to AS7

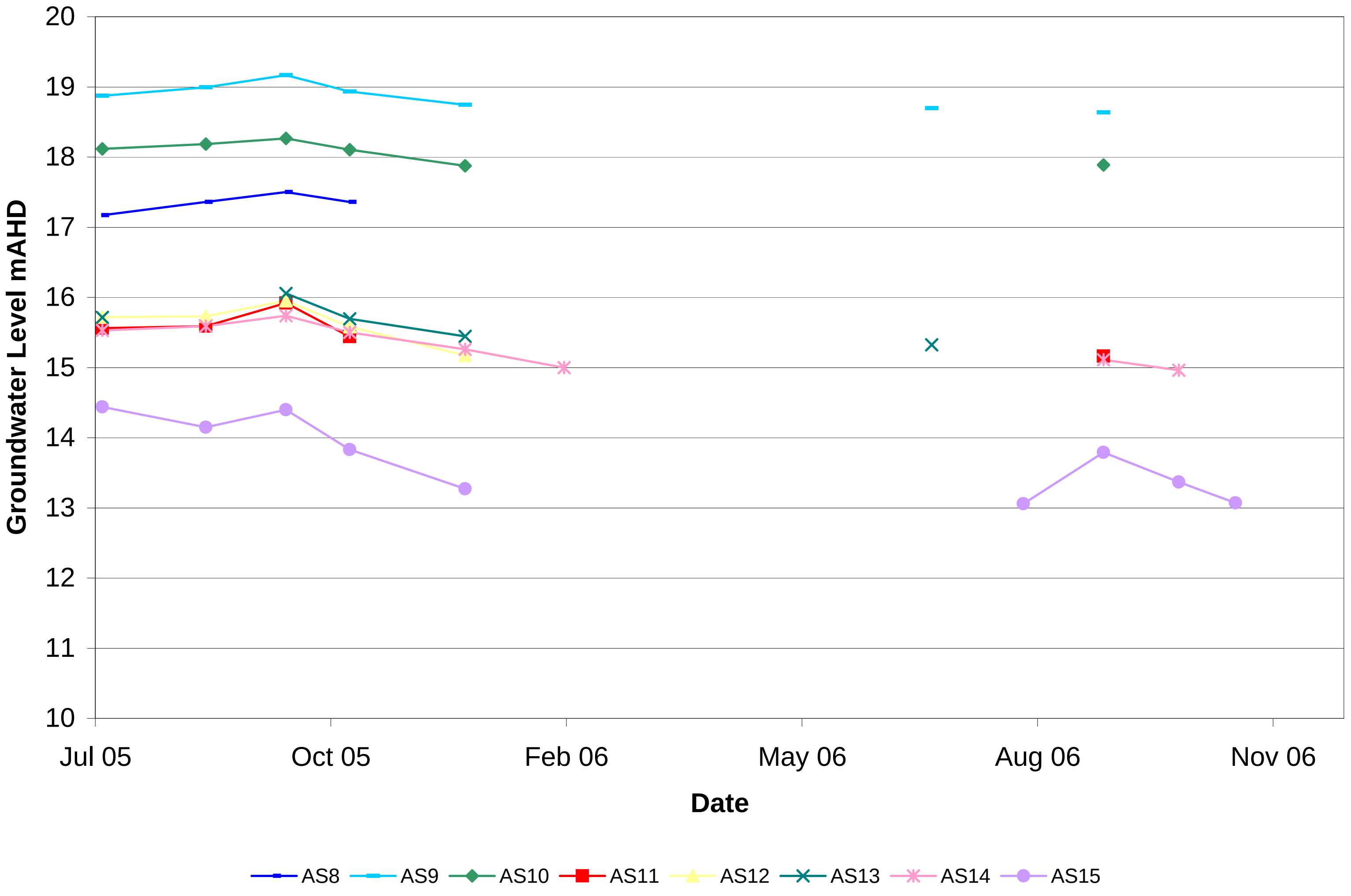

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Figure F2: Time Series Groundwater Levels AS8 to AS15

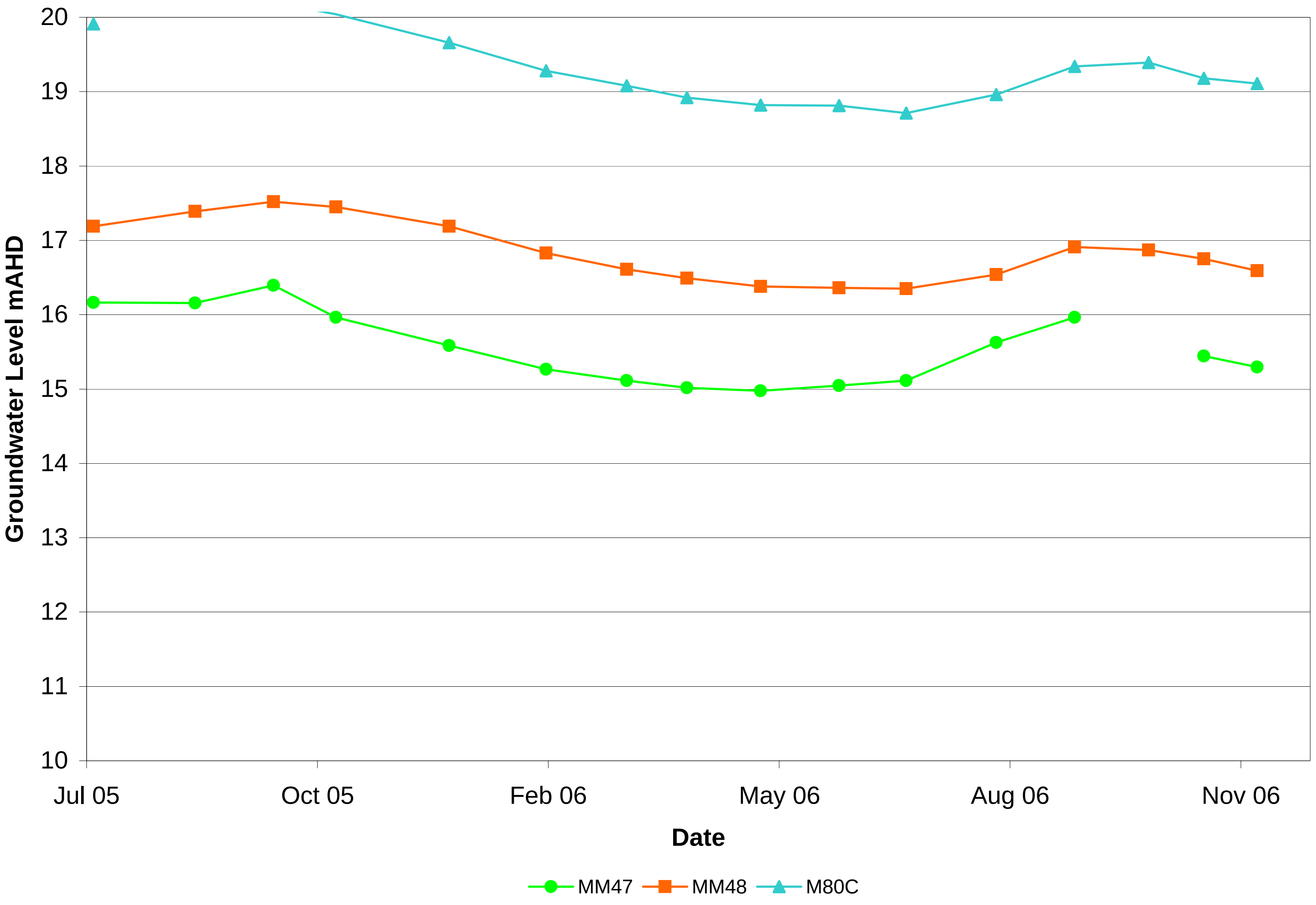

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Figure F3: Time Series Groundwater Levels DoW Bores

APPENDIX G

Predevelopment Groundwater Quality Monitoring Data

APPENDIX G: Predevelopment Groundwater Quality Monitoring Data

Bore	Date	pH	Conductivity mS/cm	TDS mg/L	TN mg/L	TKN mg/L	Nox-N mg/L	Ammonia-N mg/L	TP mg/L	FRP mg/L	As mg/L	Cd mg/L	Cr mg/L	Cu mg/L	Hg mg/L	Ni mg/L	Pb mg/L	Zn mg/L
AS1	Jul 05	5.60	3.70	2200.00	7.00	7.00	-	1.50	0.09	0.07	0.00	<0.002	<0.01	0.01	<0.0002	<0.01	<0.01	0.02
	Oct 05	5.45	2.78	2600.00	4.10	4.10	<0.05	1.80	0.15	0.04	-	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.02
	Feb 06	5.40	2.87	2200.00	5.70	5.60	0.06	1.50	0.41	0.11	0.02	<0.002	0.04	<0.01	<0.0002	<0.01	<0.01	0.01
	Apr 06	5.64	2.43	2500.00	6.10	6.00		2.10	0.34	<0.01	0.00	<0.002	0.01	<0.01	<0.0002	<0.01	<0.01	0.11
	Aug-06	5.36	5.28	2800	6.7	6.7	<0.05	1.8	0.05	0.05	0.002	<0.002	0.01	<0.01	<0.0002	0.01	0.03	0.02
	Nov-06	5.27	5.82	3400	5.5	5.5	<0.01	1.8	0.06	0.037	0.003	<0.002	0.009	0.002	<0.0002	<0.001	0.007	0.057
AS2	Jul 05	7.00	0.38	1500.00	8.10	6.10	2.04	<0.2	0.84	2.20	0.00	<0.002	0.04	0.02	<0.0002	0.07	0.07	0.08
	Oct 05	6.22	0.51	1400.00	7.20	3.80	3.45	<0.2	3.30	1.80	0.00	<0.002	<0.01	0.02	0.00	<0.01	<0.01	0.06
	Feb 06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Apr 06	5.77	0.43	270.00	7.80	1.70	0.52	0.30	2.20	1.00	0.00	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.17
	Aug-06	5.74	1.27	470	3.2	2.6	0.64	<0.2	2	1.4	0.001	<0.002	0.03	<0.01	<0.0002	0.02	0.05	0.14
	Nov-06	5.57	0.28	180	4.7	0.81	3.87	0.045	2	1.9	<0.001	<0.002	0.004	0.004	<0.0002	0.001	<0.001	0.19
AS3	Jul 05	5.10	0.38	230.00	8.20	8.20	-	0.30	2.00	2.40	<0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.01
	Oct 05	5.66	0.28	320.00	3.10	3.10	0.02	0.70	1.20	0.92	0.01	<0.002	<0.01	<0.01	<0.0002	0.01	<0.01	0.01
	Feb 06	5.50	0.21	300.00	16.00	5.30	11.00	0.70	1.10	0.72	0.01	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Apr 06	5.52	0.25	280.00	3.20	3.10		0.90	1.20	0.68	<0.001	<0.002	0.01	<0.01	<0.0002	<0.01	<0.01	0.04
	Aug-06	5.2	0.92	270	4.4	4.3	<0.07	0.5	0.92	0.92	<0.001	<0.002	<0.01	<0.01	<0.0002	0.01	0.03	0.01
	Nov-06	5.23	0.24	110	2.9	2.9	<0.11	0.44	0.86	0.84	<0.001	<0.002	0.003	<0.001	<0.0002	<0.001	<0.001	0.046
AS4	Jul 05	6.90	3.10	1900.00	1.40	1.40	-	<0.2	0.14	0.04	0.00	<0.002	<0.01	0.01	<0.0002	<0.01	<0.01	0.02
	Oct 05	6.69	2.62	1900.00	0.30	0.20	<0.12	<0.2	0.18	0.10	0.00	<0.002	<0.01	0.11	<0.0002	0.01	<0.01	0.05
	Feb 06	6.27	2.95	1600.00	3.70	3.70	0.03	<.2	0.25	0.01	0.01	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.01
	Apr 06	6.35	3.12	2600.00	3.20	3.10		<0.2	0.61	<0.01	0.00	<0.002	0.02	<0.01	<0.0002	0.01	<0.01	0.14
	Aug-06	6.2	4.16	1600	0.7	0.7	<0.02	<0.2	0.07	0.03	0.002	<0.002	<0.01	<0.01	<0.0002	0.02	0.03	<0.01
	Nov-06	6.33	0.88	390	1.4	1.4	<0.11	<0.2	0.19	0.024	0.003	<0.002	0.007	0.01	<0.0002	0.006	<0.001	0.074
AS5	Jul 05	7.00	0.92	550.00	140.00	140.00	-	1.60	0.83	0.29	0.03	<0.002	0.03	0.03	<0.0002	0.09	0.73	0.11
	Oct 05	6.43	1.19	850.00	7.30	2.80	4.54	0.30	0.10	0.10	0.01	<0.002	<0.01	<0.01	<0.0002	0.02	<0.01	0.02
	Feb 06	6.49	0.91	460.00	2.10	2.10	0.04	0.60	4.00	0.32	0.01	<0.002	<0.01	0.01	<0.0002	<0.01	<0.01	0.03
	Apr 06	6.37	0.84	510.00	13.00	12.00	-	0.40	8.90	0.05	0.01	<0.002	0.09	<0.01	<0.0002	0.03	<0.01	0.08
	Aug-06	5.85	4.51	2000	40	5.8	34.02	<0.2	0.11	0.02	0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	0.03	<0.01
	Nov-06	6.24	0.88	490	2.2	2.2	0.1	0.48	0.83	0.069	<0.001	<0.002	0.005	0.008	<0.0002	0.001	0.001	0.059
AS6	Jul 05	6.70	0.34	200.00	14.00	2.20	12.13	<0.2	0.19	0.03	0.00	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.01
	Oct 05	6.21	0.37	370.00	11.00	2.90	8.13	<0.2	0.10	0.07	0.02	<0.002	<0.01	<0.01	<0.0002	0.02	<0.01	0.02
	Feb 06	6.32	0.54	290.00	1.10	1.10	1.90	<0.2	0.16	0.02	0.00	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Apr 06	6.01	0.39	220.00	6.70	1.20		0.30	0.13	0.03	0.00	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Aug-06	5.7	1.5	320	7.7	1.4	6.31	<0.2	0.04	0.03	0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	0.03	<0.01
	Nov-06	6.18	0.35	180	7.1	0.2	7.03	0.009	0.04	0.011	<0.001	<0.002	0.001	0.001	<0.0002	<0.001	0.002	0.035
AS7	Jul 05	7.80	1.30	780.00	14.00	1.80	12.03	<0.2	0.19	0.05	<0.001	<0.002	<0.01	0.01	<0.0002	<0.01	0.01	0.01
	Oct 05	7.14	1.18	850.00	6.50	0.80	<5.78	<0.2	0.07	0.07	0.00	<0.002	<0.01	0.02	<0.0002	0.02	<0.01	0.01
	Feb 06	6.99	1.57	820.00	2.50	2.50	0.92	<0.2	0.06	0.02	0.07	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Apr 06	6.89	1.34	790.00	1.80	0.60		0.40	0.18	0.01	0.00	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Aug-06	5.94	2.9	770	2.3	1.5	0.78	<0.2	0.04	0.03	0.001	<0.002	<0.01	<0.01	<0.0002	0.01	0.03	<0.01
	Nov-06	6.98	1.66	830	3.2	0.98	2.24	0.008	0.12	0.027	0.002	<0.002	0.002	0.003	<0.0002	0.001	<0.001	0.038
All Bores	Samples	41	41	41	42	42	42	41	42	42	41	42	42	42	42	42	42	42
	Minimum	5.1	0.21	110	0.3	0.2	<0.02	<0.2	0.04	<0.01	<0.001	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	<0.01
	Maximum	7.8	5.82	3400	140	140	34.02	2.1	8.9	2.4	0.065	<0.002	0.09	0.11	0.0004	0.09	0.73	0.23
	Median	6.2	1.18	770	5.1	2.7	0.53	<0.2	0.19	0.069	0.002	<0.002	<0.01	<0.01	<0.0002	<0.01	<0.01	0.02
	Mean	6.1	1.65	1030	9.6	6.5	3.1	0.54	0.91	0.44	0.005	<0.002	0.014	0.013	<0.0002	0.0136	0.0315	0.0483

APPENDIX H

Minutes of SRT Meeting May 2012

From: Scott Wills [mailto:Scott@jdahydro.com.au]
Sent: Wednesday, 9 May 2012 6:30 PM
To: Bill Till; James MacIntosh; Howard, Katherine (Katherine.Howard@swanrivertrust.wa.gov.au); jennifer.stritzke@swanrivertrust.wa.gov.au; John Elliott (John.Elliott@swan.wa.gov.au); yoon-kah.wong@swan.wa.gov.au; Robert Cole
Cc: Jim Davies; Riccardo Divita; 'Chris Le (CLe@tabec.com.au)' (CLe@tabec.com.au)
Subject: West Swan East: Minutes of Meeting 8/5/12

Meeting: West Swan East LWMS Revisions and City of Swan Local Drain Upgrade

Date: 8 May 2012
Location: Swan River Trust, East Perth
Present: Rob Cole (Aspen), Bill Till/James McIntosh (DoW), Jennifer Stritzke/Katherine Howard (SRT), John Elliott/Yoon-Kah (CoS), Chris Le (TABEC), Jim Davies/Scott Wills/Riccardo Divita (JDA).

Item 1: Revision of West Swan East LWMS

Points of Discussion

- Due to service easements now identified within Marshall Rd reserve the stormwater storage shown in the approved LWMS for this sub-catchment cannot be achieved.
- Design peak outflows shown in the approved LWMS for the Marshall Rd catchment are lower than the peak flows shown in the Swan Urban Growth Corridor DWMP for the same catchment areas.
- City of Swan has requested JDA to revise the West Swan East LWMS to address the necessary changes to the strategy and provide guidance for all landowners within the West Swan East cell.

Outcome

- To address the constraints within Marshall Rd, the revised LWMS will allow larger peak outflows than the currently approved version. Flows will not be greater than the guidance provided in the DWMP.

Item 2: Upgrade of City of Swan Local Drain

Points of Discussion

- Alignment of the local drain connecting Marshall Rd drain to the Swan River is different from the alignment shown in the DWMP.
- Design of the Marshall Rd drain within West Swan East cell has identified that the drain D/S does not currently have sufficient capacity to convey flows from the West Swan East area.
- Aspen/JDA has worked with the City to assess various options to upgrade the drain so it can meet an appropriate level of service.
- The information circulated to SRT and DoW 30 March provided a summary of the drain upgrade option considered most feasible by the City.
- The SRT and DoW require additional information on the drain in order to understand the proposal for an upgrade.
- Upgrades to the drain will need to ensure the D/S dam is not flooded and erosion is controlled.

Outcome

- The DWMP does not need to be updated. The revised LWMS will identify that the alignment of the local drain is different from the DWMP.

- The revised LWMS will document the current drains arrangement of pipes, open channel and compensation storages.
- The revised LWMS will identify the flow capacity of the current drain.
- The revised LWMS will provide indicative information on the upgrades required to improve the level of service for the drain, consistent with the City's preferred option.

Please advise me if you feel I have missed any key points or if any of the points are not an accurate reflection of the discussion and I will make the necessary changes.

Regards,

Scott Wills | Senior Environmental Hydrologist

JDA CONSULTANT HYDROLOGISTS
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Riccardo Divita

From: MACKINTOSH James <James.MACKINTOSH@water.wa.gov.au>
Sent: Tuesday, 22 May 2012 10:00 AM
To: 'Yoon-Kah Wong'; Scott Wills
Cc: Riccardo Divita; TILL Bill; Howard, Katherine (Katherine.Howard@swanrivertrust.wa.gov.au); jennifer.stritzke@swanrivertrust.wa.gov.au; John Elliott
Subject: RE: West Swan East: Minutes of Meeting 8/5/12

Dear all,

The Department of Water (DoW) has considered the proposal and the additional information recently provided and offers the following advice:

The DoW considers that as the proposal will not increase the volume of stormwater discharging to the River and there is no proposed works to the existing overland flow path (drain/creek) from the compensating dam to the River, then the DoW supports the proposal. However, should investigations into the capacity of this dam highlight the need for additional storage and upgrades to the drain/creek then the DoW would be happy to provide further guidance and assistance.

Please contact me if you require further information.

Regards

James Mackintosh

Department of Water

A/Program Manager

Land Use Planning

Swan Avon Region

T 08 6250 8043 |
E james.mackintosh@water.wa.gov.au
Visit our website www.water.wa.gov.au

From: Yoon-Kah Wong [mailto:yoon-kah.wong@swan.wa.gov.au]
Sent: Wednesday, 16 May 2012 4:05 PM
To: Scott Wills
Cc: Jim Davies; Riccardo Divita; 'Chris Le (CLe@tabec.com.au)' (CLe@tabec.com.au); TILL Bill; MACKINTOSH James; Howard, Katherine (Katherine.Howard@swanrivertrust.wa.gov.au); jennifer.stritzke@swanrivertrust.wa.gov.au; John Elliott; Robert Cole (RobertC@aspengroup.com.au); Philip Russell
Subject: RE: West Swan East: Minutes of Meeting 8/5/12

Scott,

Attached is a plan showing the existing outlet drain and proposed upgrade that may be required. I am confident that the low spot at Section B will be able to cater for the 100 year storm as the existing sections piped outlet is 600mm. This will then retain the status quo of the existing. A photo is attached taken within Section B showing the low point and the dam. The existing vegetated drain from Sections C onwards will not be disturbed.

Regards,

Yoon Kah Wong Engineer Subdivisions & Drainage

Operations

city of swan

ENGINEERS AUSTRALIA
Chartered Professional Engineer
MEMBER

PO Box 196
MIDLAND WA 6936
t 08 9267 9186
m 0408 820 089
f 08 9278 9655
www.swan.wa.gov.au

From: Scott Wills [mailto:Scott@jdahydro.com.au]
Sent: Wednesday, 9 May 2012 6:30 PM
To: Bill Till; James MacIntosh; Howard, Katherine (Katherine.Howard@swanrivertrust.wa.gov.au); jennifer.stritzke@swanrivertrust.wa.gov.au; John Elliott; Yoon-Kah Wong; Robert Cole (RobertC@aspengroup.com.au)
Cc: Jim Davies; Riccardo Divita; 'Chris Le (CLe@tabec.com.au)' (CLe@tabec.com.au)
Subject: West Swan East: Minutes of Meeting 8/5/12

Meeting: West Swan East LWMS Revisions and City of Swan Local Drain Upgrade

Date: 8 May 2012
Location: Swan River Trust, East Perth
Present: Rob Cole (Aspen), Bill Till/James McIntosh (DoW), Jennifer Stritzke/Katherine Howard (SRT), John Elliott/Yoon-Kah (CoS), Chris Le (TABEC), Jim Davies/Scott Wills/Riccardo Divita (JDA).

Item 1: Revision of West Swan East LWMS

Points of Discussion

- Due to service easements now identified within Marshall Rd reserve the stormwater storage shown in the approved LWMS for this sub-catchment cannot be achieved.
- Design peak outflows shown in the approved LWMS for the Marshall Rd catchment are lower than the peak flows shown in the Swan Urban Growth Corridor DWMP for the same catchment areas.
- City of Swan has requested JDA to revise the West Swan East LWMS to address the necessary changes to the strategy and provide guidance for all landowners within the West Swan East cell.

Outcome

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Item 2: Upgrade of City of Swan Local Drain

Points of Discussion

- Alignment of the local drain connecting Marshall Rd drain to the Swan River is different from the alignment shown in the DWMP.
- Design of the Marshall Rd drain within West Swan East cell has identified that the drain D/S does not currently have sufficient capacity to convey flows from the West Swan East area.
- Aspen/JDA has worked with the City to assess various options to upgrade the drain so it can meet an appropriate level of service.
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- The SRT and DoW require additional information on the drain in order to understand the proposal for an upgrade.
- Upgrades to the drain will need to ensure the D/S dam is not flooded and erosion is controlled.

Outcome

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- The revised LWMS will document the current drains arrangement of pipes, open channel and compensation storages.
- The revised LWMS will identify the flow capacity of the current drain.
- The revised LWMS will provide indicative information on the upgrades required to improve the level of service for the drain, consistent with the City's preferred option.

Please advise me if you feel I have missed any key points or if any of the points are not an accurate reflection of the discussion and I will make the necessary changes.

Regards,

Scott Wills | Senior Environmental Hydrologist

JDA

JDA CONSULTANT HYDROLOGISTS
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Direct: (08) 6380 3425 | Reception: (08) 9388 2436 | Fax: (08) 9381 9279 | www.jdahydro.com.au

APPENDIX I

Stage 1 Proposed Living Stream
Current Condition

APPENDIX J

Nutrient Input Modelling Results

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 12-Mar-07

West Swan East	
Total Nutrient Input - No WSUD (kg/yr)	**14,930**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus

● Total Nitrogen

Catchment Name West Swan East

Option Description Existing Land Use

Catchment Area 255 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	3.0%	maintainance of verge by landowners		
Road Reserves : Major	2.0%	maintainance of verge by local authority		
POS : Active	0.0%	grassed areas		
POS : Passive / Basins	5.0%	native vegetation		
Rural : Pasture	90.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**0.0%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	0.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.59	kg/gross ha/yr	150	kg/yr	1.0%
	Minor Roads	132.00		3.96		1,010		6.8%
	Sub Total			4.55		1,160		7.8%
Rural	Pasture	60.00	kg/ha Rural/yr	54.00	kg/gross ha/yr	13,770	kg/yr	92.2%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			54.00		13,770		92.2%
			Total	**58.55**	kg/gross ha/yr	**14,930**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping

☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	4.55	1,160	7.8%
Nutrient Input : Rural Area	54.00	13,770	92.2%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0

Net Nutrient Input	**58.55**	**14,930**	**100.0%**

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 12-Mar-07

West Swan East	
Total Nutrient Input - No WSUD (kg/yr)	**4,748**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

● Total Phosphorus

○ Total Nitrogen

Catchment Name	West Swan East	
Option Description	Existing Land Use	
Catchment Area	255	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	3.0%	maintainance of verge by landowners
Road Reserves : Major	2.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	5.0%	native vegetation
Rural : Pasture	90.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential **0.0%**

Total Area **100.0%**

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.02	kg/gross ha/yr	5	kg/yr	0.1%
	Minor Roads	20.00		0.60		153		3.2%
	Sub Total			0.62		158		3.3%
Rural	Pasture	20.00	kg/ha Rural/yr	18.00	kg/gross ha/yr	4,590	kg/yr	96.7%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			18.00		4,590		96.7%
			Total	**18.62**	kg/gross ha/yr	**4,748**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping

☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.62	158	3.3%
Nutrient Input : Rural Area	18.00	4,590	96.7%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**18.62**	**4,748**	**100.0%**			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

Analysis Type (1,2)	1	TP		0%	% of total residential area as ~R15
Ave lots/net ha		0.0		0%	% of total residential Area as ~R35
Discount Rate	6%				

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse at al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	R35	R zoning specified
Cats	0.90	0.20	0.20	0.24	**0.16**	0.00
Sml Dogs	2.75	0.70	0.70	**0.12**	**0.16**	0.00
Med Dogs	5.50	1.40	1.40	**0.16**	**0.08**	0.00
Lge Dogs	8.25	2.10	2.10	**0.19**	0.00	0.00

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	**12%**	0%
Bins	59%	88%	0%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Total Residential Area	-	ha
Total Number of Lots	-	
Area to Apply	-	ha
Number of Lots to Apply	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	R35	R zoning specified
0.00009	0.00033	0.00033	2	**4.5**	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	**0.059**	**0.027**	0.02700
Lawn	**0.033**	**0.005**	0.00500

	Fertiliser min application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	0.010	0.003	0.00300
Lawn	0.009	0.001	0.00100

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.02400	89%
Lawn	0.024	0.004	0.00400	80%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.00
% lawn	0.28	0.07	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	2.60

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

Rural Land Use Fertiliser

Data Source

Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	20.00

Poultry Farms

Data Source

Estimates via Gerritse (et al) 1992
Based on 14000 hens on 42 ha property

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha farm/yr	kg TP/ha farm/yr	specified
Poultry	175	75	75.00

Street Sweeping

Data Source

Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment
from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream
	TN	TP	specified	WSUD
Sweeping	0.75	0.35	0.35	0%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$206	$/gross ha/yr
Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source

Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr

TN or TP specified
0.40

Gross Pollutant Trap

Data Source

Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	50%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source

TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	50%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$3,912	per kg
Removal	0.0	kg/year
Capital Cost	$0	
Operating	$0	
Total PV Cost	$0	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 12-Mar-07

West Swan East : Post Development	
Total Nutrient Input - No WSUD (kg/yr)	**29,232**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus
● Total Nitrogen

Catchment Name West Swan East : Post Development
Option Description No WSUD Applied
Catchment Area 255 ha

Land Use Breakdown

Residential : ~R15	43.6%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	5.8%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	16.6%	maintainance of verge by landowners		
Road Reserves : Major	8.0%	maintainance of verge by local authority		
POS : Active	13.3%	grassed areas		
POS : Passive / Basins	4.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	4.9%	low density	Total Residential	**49.4%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	3.8%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	59.36	kg/net ha/yr	29.32	kg/gross ha/yr	7,477	kg/yr	25.6%
	Lawn	84.26		41.63		10,615		36.3%
	Pet Waste	14.80		7.31		1,865		6.4%
	Car Wash	0.04		0.02		4		0.0%
	Sub Total			78.28		19,961		68.3%
POS	Garden/Lawn	73.40	kg/ha POS/yr	9.76	kg/gross ha/yr	2,489	kg/yr	8.5%
	Pet Waste	11.93		1.59		405		1.4%
	Sub Total			11.35		2,894		9.9%
Road	Major Roads	29.36	kg/ha RR/yr	2.35	kg/gross ha/yr	599	kg/yr	2.0%
Reserve	Minor Roads	132.00		21.91		5,588		19.1%
	Sub Total			24.26		6,187		21.2%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.74		190		0.6%
	Sub Total			0.74		190		0.6%
			Total	**114.63**	kg/gross ha/yr	**29,232**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	113.89	29,042	99.4%			
Nutrient Input : Rural Area	0.74	190	0.6%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**114.63**	**29,232**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 12-Mar-07

West Swan East : Post Development	
Total Nutrient Input - No WSUD (kg/yr)	**6,625**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

● Total Phosphorus

○ Total Nitrogen

Catchment Name	West Swan East : Post Development	
Option Description	No WSUD Applied	
Catchment Area	255	ha

Land Use Breakdown

Residential : ~R15	43.6%	lower density residential areas (excludes road reserve area)
Residential : ~R35	5.8%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	16.6%	maintainance of verge by landowners
Road Reserves : Major	8.0%	maintainance of verge by local authority
POS : Active	13.3%	grassed areas
POS : Passive / Basins	4.0%	native vegetation
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	4.9%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	3.8%	town centre etc

Total Residential	**49.4%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	27.16	kg/net ha/yr	13.42	kg/gross ha/yr	3,422	kg/yr	51.7%
	Lawn	12.77		6.31		1,608		24.3%
	Pet Waste	3.73		1.84		470		7.1%
	Car Wash	0.13		0.06		16		0.2%
	Sub Total			21.63		5,517		83.3%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.35	kg/gross ha/yr	88	kg/yr	1.3%
	Pet Waste	3.01		0.40		102		1.5%
	Sub Total			0.75		190		2.9%
Road	Major Roads	1.04	kg/ha RR/yr	0.08	kg/gross ha/yr	21	kg/yr	0.3%
Reserve	Minor Roads	20.00		3.32		847		12.8%
	Sub Total			3.40		868		13.1%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.20		50		0.8%
	Sub Total			0.20		50		0.8%
			Total	**25.98**	kg/gross ha/yr	**6,625**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping

☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	25.78	6,575	99.2%			
Nutrient Input : Rural Area	0.20	50	0.8%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**25.98**	**6,625**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 12-Mar-07

West Swan East : Post Dev with WSUD	
Total Nutrient Input - No WSUD (kg/yr)	**29,232**
Reduction due to WSUD (kg/yr)	**15,467**
Percentage Overall Reduction	**52.9%**
Pecentage Development Reduction	**53.3%**
Cost of Selected Program ($/kg/yr)	**$5**

○ Total Phosphorus

● Total Nitrogen

Catchment Name West Swan East : Post Dev with WSUD

Option Description WSUD Measures Applied

Catchment Area 255 ha

Land Use Breakdown

Residential : ~R15	43.6%	lower density residential areas (excludes road reserve area)
Residential : ~R35	5.8%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	16.6%	maintainance of verge by landowners
Road Reserves : Major	8.0%	maintainance of verge by local authority
POS : Active	13.3%	grassed areas
POS : Passive / Basins	4.0%	native vegetation
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	4.9%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	3.8%	town centre etc

Total Residential	**49.4%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	59.36	kg/net ha/yr	29.32	kg/gross ha/yr	7,477	kg/yr	25.6%
	Lawn	84.26		41.63		10,615		36.3%
	Pet Waste	14.80		7.31		1,865		6.4%
	Car Wash	0.04		0.02		4		0.0%
	Sub Total			78.28		19,961		68.3%
POS	Garden/Lawn	73.40	kg/ha POS/yr	9.76	kg/gross ha/yr	2,489	kg/yr	8.5%
	Pet Waste	11.93		1.59		405		1.4%
	Sub Total			11.35		2,894		9.9%
Road	Major Roads	29.36	kg/ha RR/yr	2.35	kg/gross ha/yr	599	kg/yr	2.0%
Reserve	Minor Roads	132.00		21.91		5,588		19.1%
	Sub Total			24.26		6,187		21.2%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.74		190		0.6%
	Sub Total			0.74		190		0.6%
			Total	**114.63**	kg/gross ha/yr	**29,232**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping

☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 30%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	75%	21.99	5,608	19.2%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	30%	12.49	3,184	10.9%	$0	$0	$0.0
Native Gardens (POS)	100%	9.76	2,489	8.5%	$0	$0	$0.0
Community Education : Fertiliser	100%	12.96	3,306	11.3%	$0	$1,093	$0.3
Community Education : Pet Waste	100%	2.67	681	2.3%	$0	$1,626	$2.4
Community Education : Car Wash	100%	0.01	1	0.0%	$0	$1,093	$816.8
Street Sweeping	100%	0.36	91	0.3%	$0	$25,876	$285.3
Totals		**60.24**	**15,361**	**52.5%**	**$0**	**$29,687**	**$1.9**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.42	106	0.4%	$437,692	$16,763	$404.5
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.42**	**106**	**0.4%**	**$437,692**	**$16,763**	**$404.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	113.89	29,042	99.4%
Nutrient Input : Rural Area	0.74	190	0.6%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	60.24	15,361	52.5%	$0	$29,687	$1.9
Removal via In-Transit Control	0.42	106	0.4%	$437,692	$16,763	$404.5
Total Removal	60.66	15,467	52.9%	$437,692	$46,450	$4.7

Net Nutrient Input	**53.98**	**13,765**	**47.1%**

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 12-Mar-07

West Swan East : Post Dev with WSUD	
Total Nutrient Input - No WSUD (kg/yr)	**6,625**
Reduction due to WSUD (kg/yr)	**4,069**
Percentage Overall Reduction	**61.4%**
Pecentage Development Reduction	**61.9%**
Cost of Selected Program ($/kg/yr)	**$18**

● Total Phosphorus

○ Total Nitrogen

Catchment Name	West Swan East : Post Dev with WSUD
Option Description	WSUD Measures Applied
Catchment Area	255 ha

Land Use Breakdown

Residential : ~R15	43.6%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	5.8%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	16.6%	maintainance of verge by landowners		
Road Reserves : Major	8.0%	maintainance of verge by local authority		
POS : Active	13.3%	grassed areas		
POS : Passive / Basins	4.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	4.9%	low density	Total Residential	**49.4%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	3.8%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	27.16	kg/net ha/yr	13.42	kg/gross ha/yr	3,422	kg/yr	51.7%
	Lawn	12.77		6.31		1,608		24.3%
	Pet Waste	3.73		1.84		470		7.1%
	Car Wash	0.13		0.06		16		0.2%
	Sub Total			21.63		5,517		83.3%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.35	kg/gross ha/yr	88	kg/yr	1.3%
	Pet Waste	3.01		0.40		102		1.5%
	Sub Total			0.75		190		2.9%
Road	Major Roads	1.04	kg/ha RR/yr	0.08	kg/gross ha/yr	21	kg/yr	0.3%
Reserve	Minor Roads	20.00		3.32		847		12.8%
	Sub Total			3.40		868		13.1%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.20		50		0.8%
	Sub Total			0.20		50		0.8%
			Total	**25.98**	kg/gross ha/yr	**6,625**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping

☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 30%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	75%	10.06	2,566	38.7%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	30%	1.89	482	7.3%	$0	$0	$0.0
Native Gardens (POS)	100%	0.35	88	1.3%	$0	$0	$0.0
Community Education : Fertiliser	100%	2.75	701	10.6%	$0	$1,093	$1.6
Community Education : Pet Waste	100%	0.67	172	2.6%	$0	$1,626	$9.5
Community Education : Car Wash	100%	0.02	5	0.1%	$0	$1,093	$222.8
Street Sweeping	100%	0.14	35	0.5%	$0	$25,876	$743.3
Totals		**15.88**	**4,050**	**61.1%**	**$0**	**$29,687**	**$7.3**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.08	20	0.3%	$437,692	$16,763	$2,196.9
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.08**	**20**	**0.3%**	**$437,692**	**$16,763**	**$2,196.9**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	25.78	6,575	99.2%			
Nutrient Input : Rural Area	0.20	50	0.8%			
Removal via Source Control	15.88	4,050	61.1%	$0	$29,687	$7.3
Removal via In-Transit Control	0.08	20	0.3%	$437,692	$16,763	$2,196.9
Total Removal	15.96	4,069	61.4%	$437,692	$46,450	$17.9
Net Nutrient Input	**10.02**	**2,555**	**38.6%**			

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