Lots 746-750 & 545 Baldivis Road

Structure Plan

Part One - Statutory Section

OF PLANNING
13 OCT 2015
FILE SPN/0708

September 2015 - *As approved by WAPC (August 2015)*

mirvac

CLE TOWN PLANNING + DESIGN

LOTS 746 - 750 & 545 BALDIVIS ROAD, BALDIVIS STRUCTURE PLAN

PART ONE - STATUTORY SECTION

Prepared by:

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2353Rep29E
September 2015

CERTIFICATION OF APPROVED STRUCTURE PLAN

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF

THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

13 October 2015 .....Date

Signed for and on behalf of the Western Australian Planning Commission

.....

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

M. Wreclaw .....Witness

AND ADOPTED BY

RESOLUTION OF THE COUNCIL OF THE CITY OF ROCKINGHAM ON:

23. Oct 2015 .....Date

.....

Director, Planning & Development Services

Signed under Delegated Authority for and on behalf of the Council of the City of Rockingham

This Structure Plan was prepared under the provisions of the City of Rockingham Town Planning Scheme No.2

EXPIRY DATE: 19 OCTOBER 2030

TABLE OF CHANGES OR DEPARTURES FROM STRUCTURE PLAN

Change or Departure No.	Description of Change or Departure	Date Adopted by the Council	Date Approved by the WAPC (if required)	Date Structure Plan commences operation

EXECUTIVE SUMMARY

The Mirvac Structure Plan allows for the creation of a high amenity, integrated urban community that responds to the surrounding land use context and natural environment.

The Structure Plan area covers approximately 37ha over Lots 746-750 and lot 545 Baldivis Road. The urbanisation and development of the subject land provides further opportunities to maximise the catchment to existing and planned infrastructure through consolidation of urban development in the East Baldivis cell, while satisfying State Government infill housing targets, and recognising the physical attributes of the land.

The Structure Plan responds to the current strategic planning framework provided by the East Baldivis District Structure Plan, and recognises and elaborates on the key principles of this key strategic document to provide a statutory mechanism for its implementation.

The Structure Plan allows for the creation of approximately 530 dwellings over approximately 37 ha of Urban zoned land. Overall the Plan provides the framework for approximately 4 hectares of public open space, achieving an appropriate amount of useable passive open space, as well as recognising significant drainage requirements within public open space reserves. In accordance with Liveable Neighbourhoods, once appropriate credits are applied 10% open space is provided.

Consistent with the East Baldivis District Structure Plan, the Plan provides for a 2ha portion of a primary school site, with the balance of the site being provided by the landowners to the south. The primary school will offer an important community focal point for the Structure Plan area, as well as an opportunity for increased densities, and enhanced streetscapes surrounding the school.

Mirvac WA is a highly regarded land developer, with a reputation for innovative housing. Once developed, the Structure Plan area will provide a broad range of housing choice and a variety of lots. Medium density housing options will be located around key areas of public open space, adjacent to the primary school and planned public transport routes, balanced with transitional densities away from core infrastructure. The Plan has the potential to deliver an overall housing density of approximately 15 dwelling units per gross urban hectare, meeting the objectives of Directions 2031 and Beyond.

The Structure Plan is responsive to the land use considerations identified in the East Baldivis District Structure Plan, including traffic noise, bushfire prevention, drainage, and traffic movement. Appropriate planning controls are established through the statutory section of the Structure Plan to ensure that these land use considerations are addressed appropriately.

The Structure Plan demonstrates and confirms that the subject land can be readily serviced, with essential infrastructure already available in the area. Furthermore, given the larger marjority of the land is in single ownership, cost sharing for provision of infrastructure is not in any way prohibitive to development, and can be addressed through standard agreements with service providers.

As part of the preparation of the Plan, the following reports, assessments and management plans have been prepared, and are summarised in the Structure Plan report, with full copies included as technical appendices.

1. Environmental Assessment Report
2. Transport and Access Strategy
3. Local Water Management Strategy
4. Landscape Concept Plan and Open Space Strategy
5. Earthworks and Servicing Strategy
6. Transportation Noise Assessment
7. Fire Management Plan

These strategies and reports comprehensively address all of the applicable planning considerations, and demonstrate that the subject land is capable of supporting urban development in the form proposed via this Plan.

Consistent with the City's requirements, Table (i) overleaf provides a land use summary of the Plan.

Table i – Land Use Summary

Item	Data	Section number referenced within the Structure Plan Report
Gross Structure Plan Area	37 hectares	1.2.2
Area of each land use proposed Zones [as per the Scheme] - Residential Reserves [as per the Scheme and MRS where applicable] - Road Reserve - Public Open Space Reserve - Public Purposes	 21 hectares 9.89 hectares 4.11 hectares 2 hectares	3.1
Estimated Lot Yield	510 – 540 lots	3.4.1
Estimated Number of Dwellings	510 – 540 dwellings	3.4.1
Estimated Residential Density - dwellings per gross hectare As per Directions 2031 - dwellings per site hectare As per Liveable Neighbourhoods	 15 – 16 dwellings per gross hectare 24 – 25 dwellings per site hectare	3.4.1
Estimated Population	1428 –1512 people @ 2.8 people/household	3.4.1
Number of Secondary Schools	0	3.8
Number of Primary Schools	0.5 (2 hectares)	3.8
Amount of Public Open Space	4.11 hectares (gross) 11.7%	3.2
Composition of Public Open Space - District Open Space - Neighbourhood Parks - Local Park	 0 hectares (0%) 1.36 hectares (33%) 2.75 hectares (67%)	3.2

PART ONE – STATUTORY SECTION

1.0 STRUCTURE PLAN AREA

This Structure Plan shall apply to Lots 746-750 and Lot 545 Baldivis Road being the land contained within the inner edge of the line denoting the structure plan boundary on the Structure Plan Map.

The Structure Plan is identified as the 'Mirvac' Structure Plan.

2.0 STRUCTURE PLAN CONTENT

The Structure Plan comprises the following sections:

(i) Part One – Statutory Section. This section includes the Structure Plan Map and any textual provisions, standards or requirements that require statutory effect.

(ii) Part Two – Explanatory Section (Non-Statutory). This section provides the planning context and justification for the Structure Plan Map and the textual provisions, standards or requirements contained in Part One of the Structure Plan. Part Two is to be used as a reference to guide interpretation and implementation of Part One.

(iii) Appendices – includes all specialist consultant reports and documentation used in the preparation of and to support the land use outcomes of the Structure Plan.

3.0 INTERPRETATION AND RELATIONSHIP WITH TOWN PLANNING SCHEME NO.2

3.1	Terms and Interpretations	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 Rockingham Town Planning Scheme No. 2 ('Scheme') including any amendments gazetted thereto.
3.2	Relationship of the Structure Plan with Town Planning Scheme No.2	This Structure Plan has been prepared under Clause 4.2 of the Scheme as the subject land is zoned 'Development' and contained within Development Area No. 40 which is shown on the Scheme Map and contained within Schedule No. 9. The Structure Plan Map outlines the 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.
3.3	Provisions, Standards or Requirements	Pursuant to Clause 4.2.9.4 of the Scheme, the provisions, standards or 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 case of any inconsistency between the Scheme and any provisions, standards or requirements specified under Part One of this Structure Plan, the Scheme prevails to the extent of any inconsistency.
3.4	Land Use Permissibility	Land use permissibility within the Structure Plan Area shall be in accordance with the corresponding Zone under the Scheme.

4.0 OPERATION

4.1	Operation Date	This Structure Plan commences operation on the date it is adopted by Council pursuant to Clause 4.2.6.15 of the Scheme.
4.2	Change or Departure from Structure Plan	Clause 4.2.7 of the Scheme outlines the manner in which a change to or departure from a Structure Plan is determined.

5.0 LAND USE

5.1	Structure Plan Map	The subdivision and development of land is to generally be in accordance with the Structure Plan and any associated provisions contained in Schedule No. 9.
5.2	Residential Density	Residential densities applicable to the Structure Plan Area shall be those residential densities shown on the Structure Plan Map.

6.0 SUBDIVISION / DEVELOPMENT

6.1	Notifications on Title	In respect of applications for the subdivision of land the Council shall recommend to the Western Australian Planning Commission that a condition be imposed on the grant of subdivision approval for a notification to be placed on the Certificate(s) of Title(s) to advise of the following: - 1. Land or lots deemed to be affected by an identified noise impact as outlined within the Transportation Noise Assessment contained within Appendix 2. 2. Land or lots deemed to be Bushfire Prone as identified in a Fire Management Plan contained within Appendix 1. 3. Building setbacks and construction standards required to achieve a Bushfire Attack Level -29 or lower in accordance with Australian Standards (AS3959-2009): Construction of buildings in bushfire prone areas. 4. Construction standards to achieve quiet housing design in accordance with State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning. 5. Lots affected by the approved Mosquito Management Plan.

6.2	Detailed Area Plans (Also referred to as Local Development Plans)	Detailed Area Plans (DAP's) are required to be prepared and implemented pursuant to Clause 4.23 of the Scheme for lots comprising one or more of the following site attributes: (i) Lots with rear-loaded vehicle access; and/or (ii) Lots with direct boundary frontage (primary or secondary) to an area of Public Open Space; and/or (iii) Lots deemed to be affected by a recognised Bush Fire Hazard, as identified spatially in Appendix10 – Post Development Site Conditions – Bushfire Prone Areas of the accompanying Bushfire Management Plan, under Appendix 1; and/or (iv) Lots deemed to be affected by noise from the Kwinana freeway, as identified spatially in Figure 4-4 of the accompanying Acoustic Assessment, under Appendix 2. This includes a requirement for noise modelling for ground floor and two-storey development as applicable.

6.3	Residential Design Code Variations	1. Table 1 (Residential Medium Density Codes) sets out variations to the Residential Design Codes that are deemed to constitute 'deemed-to-comply' Development within the Structure Plan area and which do not therefore, require neighbour consultation and planning approval. 2. The provisions set out in Table 1 (Residential Medium Density Codes) act as a replacement to existing R-Codes standards for building and garage setbacks (Clauses 5.1.2, 5.1.3 and 5.2.1), open space (Clause 5.1.4), parking (Clause 5.3.3), visual privacy (Clause 5.4.1) and solar access (Clause 5.4.2). All other R-Codes standards apply, where relevant to the proposal, including site area (Clause 5.1.1); building height (Clause 5.1.6); street surveillance, walls, fences and sightlines (Clauses 5.2.3 to 5.2.5); parking space design and vehicular access (Clauses 5.3.4 and 5.3.5); site works, retaining walls and stormwater management (Clauses 5.3.7 to 5.3.9); and outbuildings, external fixtures and utilities and facilities (Clauses 5.4.3 to 5.4.5). 3. Density Code numbers shown on the Structure Plan Map are to correspond with the associated RMD Code number within Table 1.
6.4	Other provisions / standards / requirements	(i) Bushfire Construction Standards This Structure Plan is supported by a Fire Management Plan. Any land falling within 100 metres of a bushfire hazard identified in the Strategy is designated as a Bushfire Prone Area for the purpose of the Building Code of Australia. (ii) The implementation of an approved Mosquito Management Plan is a requirement of subdivision. (iii) An anti-graffiti coating is to be applied to the eastern elevation of the required noise wall.

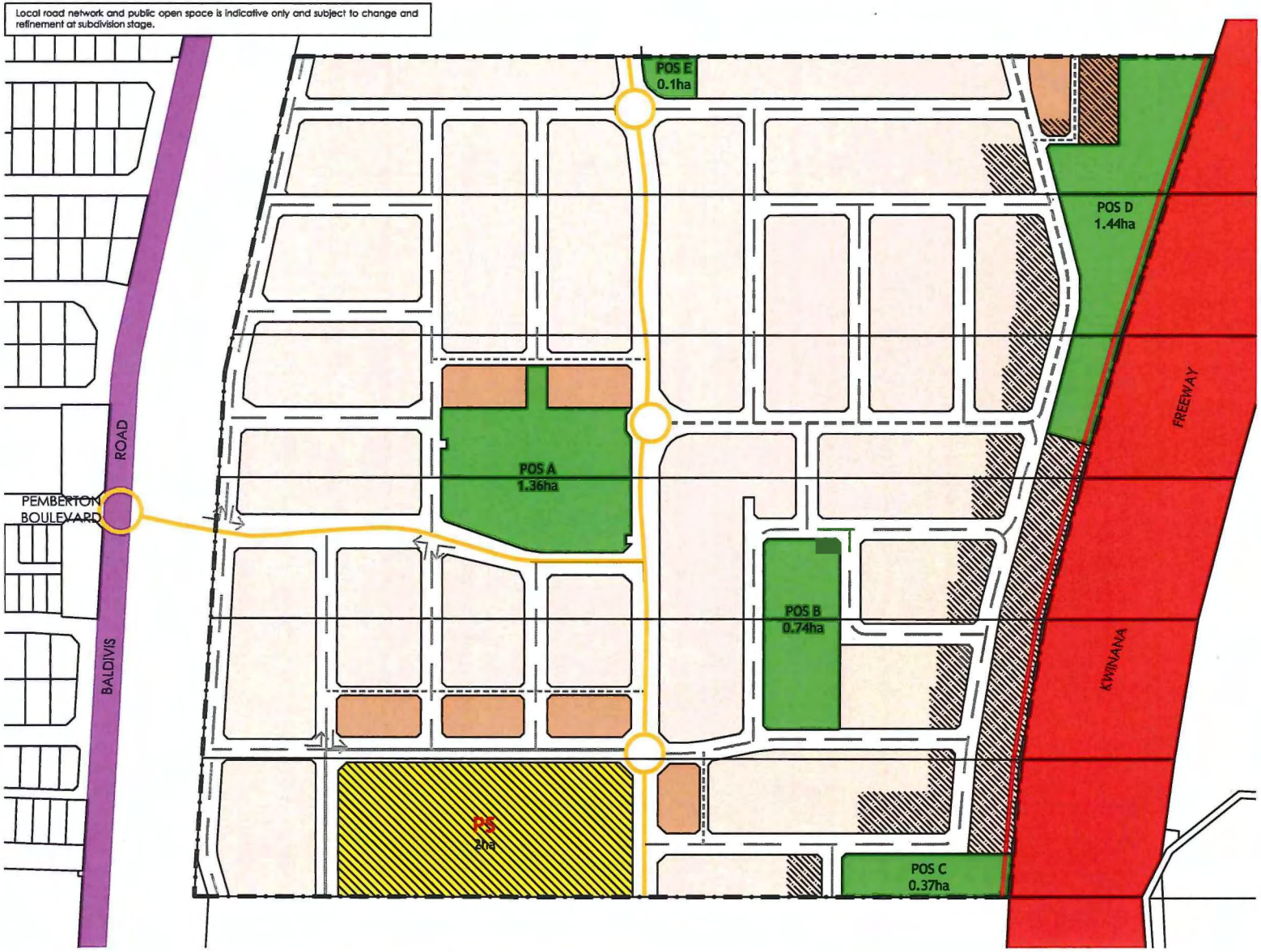
Table 1: Single House (RMD) Standards for Medium Density Housing

R-Code	Street setback and front fences		Lot boundary setback		Open space		Garage setback and width and vehicular access		Parking		Overshadowing		Privacy	
	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision
RMD – R40	4m	2m minimum, no average 1.5m to porch/ veranda, no maximum length 1m minimum to secondary street Front fences within the primary street setback area being a maximum height of 900mm above natural ground level, measured from the primary street side of the front fence	Boundary setbacks 1 to 1.5m for wall height 3.5m and less (subject to wall length and major openings) Boundary walls 2/3 length one side boundary, max 3.5m high and 3m average height	Boundary setbacks 1.2m for wall height 3.5m or less with major openings 1m for wall height 3.5 or less without major openings Boundary walls To both side boundaries subject to: No maximum length to one side boundary, 2/3 max length to second side boundary for wall height 3.5m or less	45% open space (55% site cover) 20m² courtyard 1/3 required OLA area may be covered Minimum dimension 4m	An outdoor living area (OLA) with an area of 10% of the lot size or 20m², whichever is greater, directly accessible from a habitable room of the dwelling and located behind the street setback area At least 70% of the OLA must be uncovered and includes areas under eaves which adjoin uncovered areas The OLA has a minimum 3m length or width dimension No other R-Codes site cover standards apply	Rear load Nil – provided laneway is minimum 6m wide Front load 4.5m or 0.5m behind dwelling alignment subject to averaging requirements	Rear load 0.5m garage setback to laneway Front load 4.5m garage setback from the primary street and 1.5m from a secondary street The garage setback from the primary street may be reduced to 4m where an existing or planned footpath or shared path is located more than 0.5m from the street boundary For front loaded lots with street frontages between 10.5 and 12m, a double garage is permitted to a maximum width of 6m as viewed from the street subject to: • garage setback a minimum of 0.5m behind the building alignment; • a major opening to a habitable room directly facing the primary street; • an entry feature consisting of a porch or veranda with a minimum depth of 1.2m; and, • no vehicular crossover wider than 4.5m where it meets the street Lots with a frontage less than 10.5m or not compliant with the above require single or tandem garaging	Two on-site bays	As per R-Codes	35% of the adjoining site area	No maximum overshadowing for wall height 3.5m or less No maximum overshadowing for wall height greater than 3.5m where overshadowing is confined to the front half of the lot. If overshadowing intrudes into rear half of the lot, shadow cast does not exceed 35%	4.5m to bedrooms and studies 6.0m to all other major openings 7.5m to balconies or similar	With the exception of RMD60, R-Codes clause 5.4.1 C1.1 applies to RMD 40, 30 & 25, however the setback distance is 3m to bedrooms and studies, 4.5m to major openings to habitable rooms other than bedrooms and studies and 6m to unenclosed outdoor active habitable spaces

R-Code	Street setback and front fences		Lot boundary setback		Open space		Garage setback and width and vehicular access		Parking		Overshadowing		Privacy	
	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision	R-Codes	R-MD provision
RMD – 25	6m	3m minimum 1.5m to porch/ veranda, no maximum length 1.5m minimum to secondary street Front fences within the primary street setback area being a maximum height of 900mm above natural ground level, measured from the primary street side of the front fence	<u>Boundary setbacks</u> Wall height 3.5m & less: 1m/1.5m (subject to wall length and major openings) <u>Boundary walls</u> 2/3 length one side boundary, max 3.5m high and 3m average height	<u>Boundary setbacks</u> 1.2m for wall height 3.5m or less with major openings 1m for wall height 3.5 or less without major openings <u>Boundary walls</u> To both side boundaries subject to: 2/3 length to one side boundary, 1/3 max length to second side boundary for wall height 3.5m or less	50% open space (50% site cover) 30m² courtyard 1/3 required OLA area may be covered Minimum dimension 4m	An outdoor living area (OLA) with an area of 10% of the lot size or 20m², whichever is greater, directly accessible from a habitable room of the dwelling and located behind the street setback area At least 70% of the OLA must be uncovered and includes areas under eaves which adjoin uncovered areas The OLA has a minimum 3m length or width dimension No other R-Codes site cover standards apply	<u>Rear load</u> Nil – provided laneway is minimum 6m wide <u>Front load</u> 4.5m or 0.5m behind dwelling alignment subject to averaging requirements	<u>Rear load</u> 0.5m garage setback to laneway <u>Front load</u> 4.5m garage setback from the primary street and 1.5m from a secondary street The garage setback from the primary street may be reduced to 4m where an existing or planned footpath or shared path is located more than 0.5m from the street boundary For front loaded lots with street frontages between 10.5 and 12m, a double garage is permitted to a maximum width of 6m as viewed from the street subject to: • garage setback a minimum of 0.5m behind the building alignment; • a major opening to a habitable room directly facing the primary street; • an entry feature consisting of a porch or veranda with a minimum depth of 1.2m; and, • no vehicular crossover wider than 4.5m where it meets the street Lots with a frontage less than 10.5m or not compliant with the above require single or tandem garaging	Two on-site bays	As per R-Codes	25% of the adjoining site area	No maximum overshadowing for wall height 3.5m or less No maximum overshadowing for wall height greater than 3.5m where overshadowing is confined to the front half of the lot. If overshadowing intrudes into rear half of the lot, shadow cast does not exceed 25%	4.5m to bedrooms and studies 6.0m to all other major openings 7.5m to balconies or similar	With the exception of RMD60, R-Codes clause 5.4.1 C1.1 applies to RMD 40, 30 & 25, however the setback distance is 3m to bedrooms and studies, 4.5m to major openings to habitable rooms other than bedrooms and studies and 6m to unenclosed outdoor active habitable spaces

CLE TOWN PLANNING + DESIGN

Local road network and public open space is indicative only and subject to change and refinement at subdivision stage.



LEGEND

ZONES

- Residential - R25
- Residential - R40

RESERVES

- Public Open Space
- Public Purposes - Primary School
- Primary Regional Road

OTHER

- Structure Plan Boundary
- District Distributor B
- Neighbourhood Connector
- Access Street B
- Access Street C
- Local Road (Access Street D)
- Laneway
- Noise Wall (3m)
- Quiet House Design (Package A)
- Left in Left out
- Roundabout

STRUCTURE PLAN

2353-31F-01 (28.08.2015), Not to scale

Lots 746-750 & 545 Baldivis Rd, East Baldivis - City of Rockingham

Lots 746-750 & 545 Baldivis Road

Structure Plan

Part Two - Explanatory Report

October 2014

mirvac

CLE TOWN PLANNING + DESIGN

LOTS 746 - 750 & 545 BALDIVIS ROAD, BALDIVIS STRUCTURE PLAN

PART TWO - EXPLANATORY REPORT

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2353Rep16C
October 2014

DEVELOPER

Mirvac WA

PROJECT TEAM

Town Planning - CLE Town Planning + Design

Environmental - RPS

Hydrology - RPS

Civil Engineering - Development Engineering Consultants

Landscape Design - Emerge Associates

Acoustic Assessment - Lloyd George Acoustics

Bushfire - Bushfire Safety Consulting / Emerge Associates

Traffic & Transport Assessment - Transcore

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Appendix 3: Environmental Assessment Report - RPS

Appendix 4: Local Water Management Strategy - RPS

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Appendix 7: Transport Assessment - Transcore

SITE PLAN AND ORTHOPHOTO

2353-32-01 (15.08.2014), 1:5000@A4

Figure 1

1.0 PLANNING BACKGROUND

1.1 Introduction and Purpose

This Structure Plan applies to lots 746-750 and lot 545 Baldivis Road. The Structure Plan has been prepared by CLE Town Planning + Design, on behalf of Mirvac WA and is lodged in accordance with Clause 4.2 of the City of Rockingham Town Planning Scheme No.2 which requires a structure plan for 'Development' zoned land.

The Structure Plan provides a statutory planning framework to guide future subdivision and development of the subject site and refines the level of planning detail provided in the East Baldivis District Structure Plan (DSP). The Structure Plan draws on the key elements of the DSP, whilst ensuring that all environmental, social, economic and infrastructure issues are comprehensively addressed.

The format of the Structure Plan accords with the Western Australian Planning Commission's (WAPC) Structure Plan Preparation Guidelines (August 2012) and provides a framework for future subdivision and development for the site.

The Structure Plan consists of three parts:

Part 1: Statutory Section - contains the Structure Plan Map and the statutory planning provisions and requirements that will facilitate the various initiatives described in the Explanatory Section. These provisions are given the force and effect of the Scheme, pursuant to Clause 4.2.9 of the City of Rockingham Town Planning Scheme No.2.

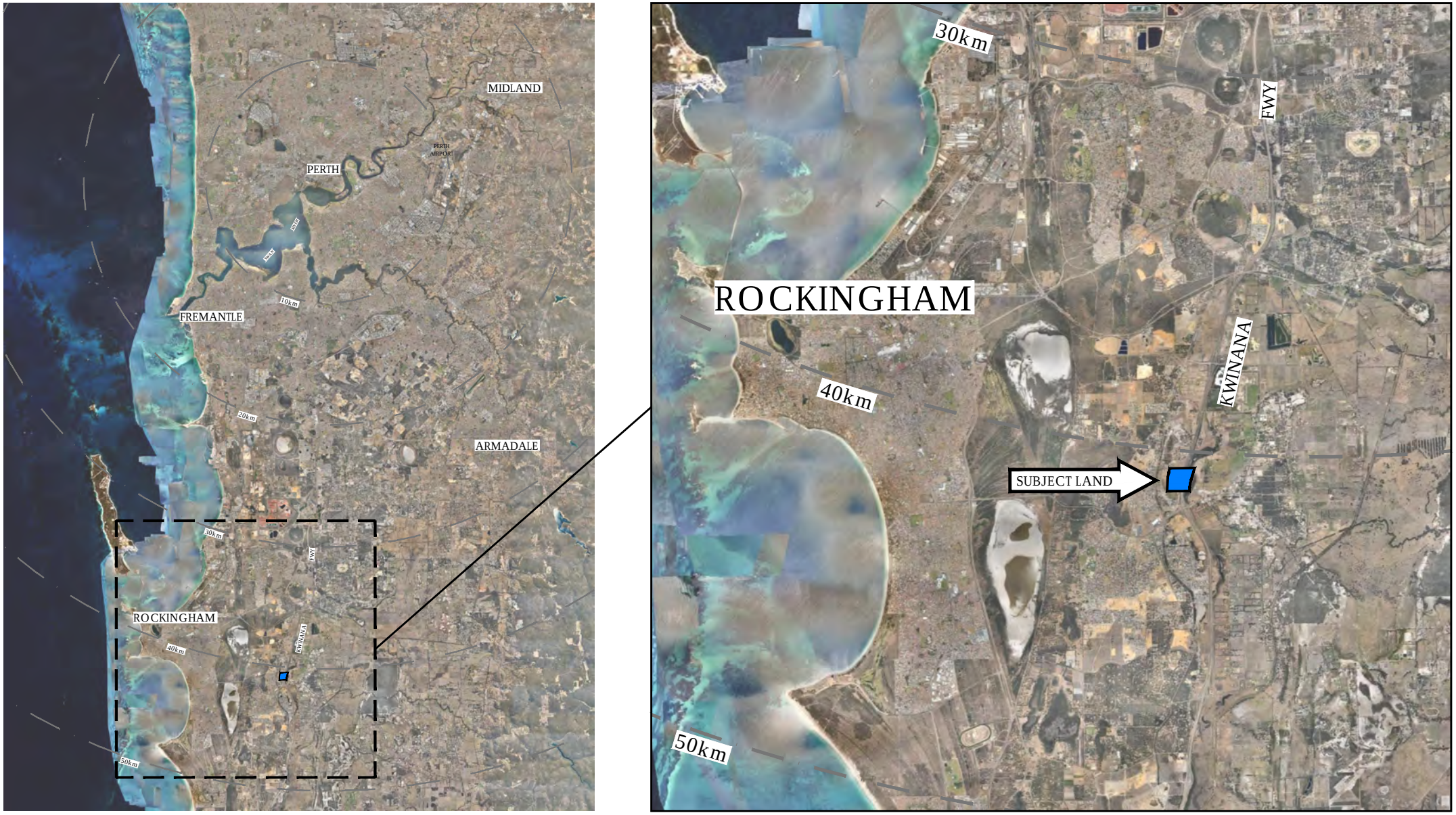
Part 2: Explanatory Section - discusses the key outcomes and planning implications of the background and technical reports and describes the broad vision and more detailed planning framework which will be developed. Part 2 is based on a detailed site specific analysis of opportunities and constraints and the following technical reports and strategies:

- Environmental Assessment Report, including Vegetation Management Strategy and Fauna Management Strategy;
- Transport Noise Assessment;
- Fire Management Strategy;
- Transport & Access Strategy;
- Landscape Concept Plan and Descriptions;
- Local Water Management Strategy; and
- Servicing and Infrastructure Strategy.

Part 3: Technical Appendices – includes the technical reports and supporting plans and maps outlined above.

The Structure Plan will facilitate growth of the emerging Baldivis community through the creation of approximately 510 - 540 dwellings. The Structure Plan will allow for a portion of a primary school (2ha), contribute to the extensive public open space network and expand and connect into the existing local road network.

Preparation of the Structure Plan has involved extensive consultation with the City of Rockingham, Department of Planning and relevant service authorities in accordance with the Structure Plan Preparation Guidelines (the Guidelines).



LOCATION PLAN

2353-33-01 (15.08.2014), Not to scale

Figure 2

1.2 Land Description

The Structure Plan area encompasses all of lots 746 – 750 and lot 545 Baldivis Road, Baldivis. A site plan and orthophoto is Figure 1.

The following sections provide a detailed description of the land and surrounds.

1.2.1 Location

The Structure Plan area is located within the City of Rockingham, approximately 40km south of the Perth CBD, and 1.5km north-west of the Baldivis District Centre, as identified in State Planning Policy 4.2 – Activity Centre for Perth and Peel.

The Structure Plan is broadly bounded by Australand's lot 544 Baldivis Road to the north, the Kwinana Freeway to the east, Baldivis Road to the west and Perron Development's lot 921 Baldivis Road to the south. The existing Parks and Recreation (Tramway) reserve is located within the Baldivis Road reserve and abuts the western boundary of the Structure Plan.

The western side of Baldivis Road and southern side of Safety Bay Road are both currently being developed for urban (residential) purposes, whilst the first stage of a district level retail centre has been developed to the south-west of the Structure Plan area, on the north side of Safety Bay Road.

The Kwinana Freeway is located to the east of the Structure Plan which can be readily accessed from the Freeway via the Safety Bay Road interchange to the south, or Mundijong Road interchange to the north. A location plan is included as Figure 2.

1.2.2 Area and Land Use

The Structure Plan provides a gross area of 37ha comprising of six lots ranging from 5.7ha to 6.4ha in area.

The land has been extensively cleared and only remnant scatterings of vegetation remain. All buildings and other structural improvements have been removed from the land - refer Figure 1.

1.2.3 Legal Description and Ownership

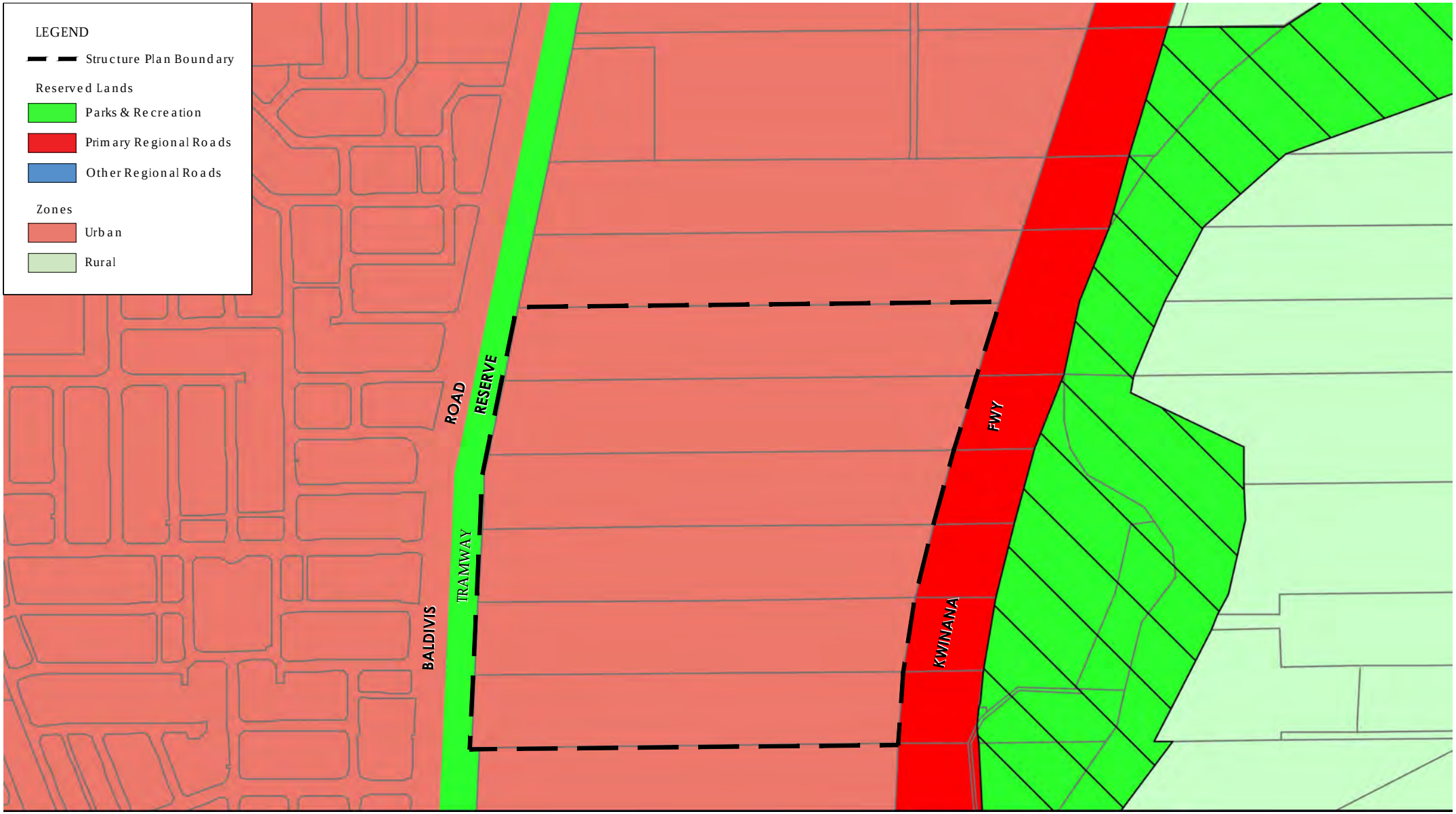
The Structure Plan area comprises of lots 746 – 750 and lot 545 Baldivis Road, Baldivis. Mirvac is the landowner of lots 746 – 750, while lot 545 is under seperate private ownership. The landowner of lot 545 has been consulted throughout the preparation of this Structure Plan and is supportive of having lot 545 included in the Structure Plan.

The legal description and ownership of the lots within the Structure Plan is demonstrated in Table 1.

Table 1 – Land Ownership and Legal Description

Lot No.	Owner	Land Area	Plan	Volume/Folio
746	Mirvac WA	6.4548ha	P25777	2213/ 770
747	Mirvac WA	6.3553ha	P25777	2213/ 771
748	Mirvac WA	6.0880ha	P25777	2213/ 772
749	Mirvac WA	5.9084ha	P25777	2213/ 773
750	Mirvac WA	5.7423ha	P25777	2213/ 774
545	Graham Cramphorn*	6.4272ha	P202744	2054/ 363

** under contract to Rockingham Park*



METROPOLITAN REGION SCHEME ZONING

2353-34-01 (15.08.2014), Not to scale

Figure 3

1.3 Planning Framework

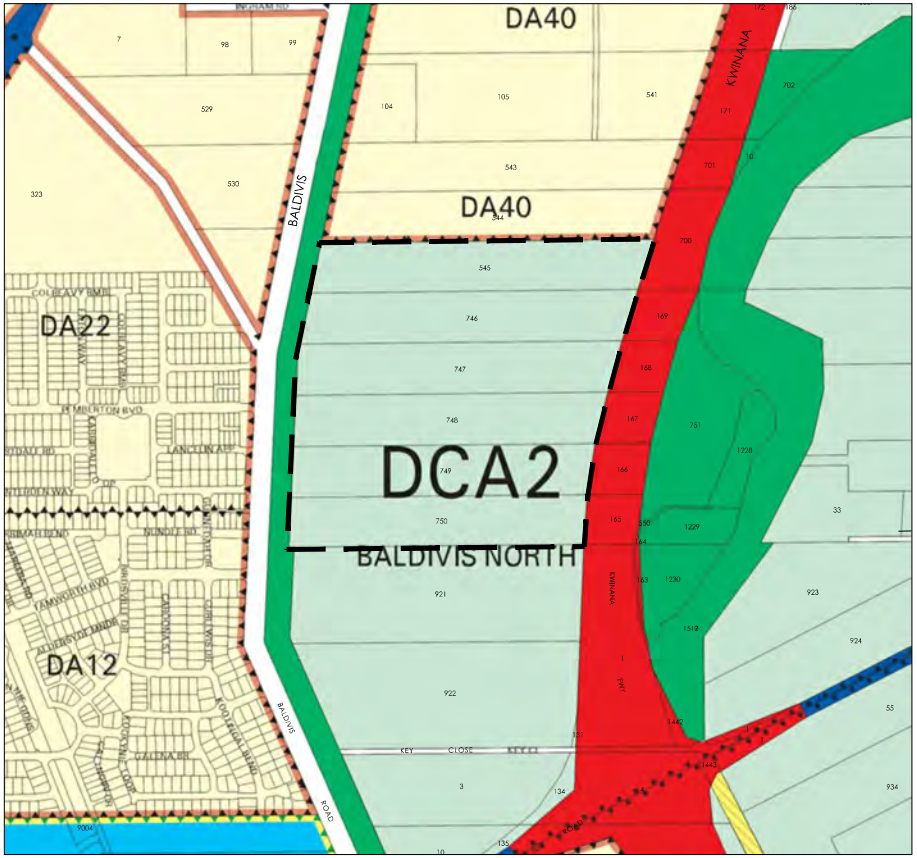
1.3.1 Zoning and Reservation

Metropolitan Region Scheme Zoning

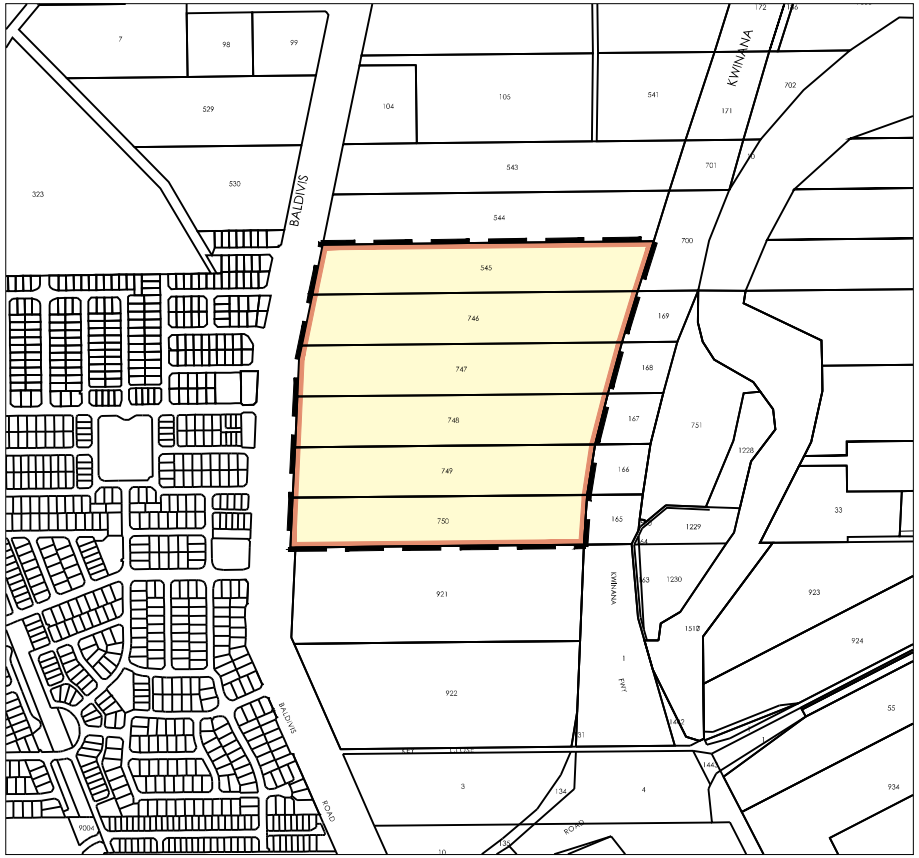
The Structure Plan area forms part of a broader precinct that was recently transferred from the 'Urban Deferred' to 'Urban' zone under the Metropolitan Region Scheme (MRS), with a publication in the *Government Gazette* notifying of the lifting of the urban deferment from the land on 18 March 2014. A plan depicting the current MRS zoning of the Structure Plan area and surrounds is Figure 3.

The immediately abutting land to the east of the Structure Plan area is reserved as Primary Regional Road and accommodates the Kwinana Freeway. The land to the east of Structure Plan area on the opposite side of the Kwinana Freeway is zoned 'Rural'.

The 'Tramway Reserve' is located within the Baldivis Road reserve and forms the western boundary to the Structure Plan area. The Tramway Reserve is reserved under the MRS for the purpose of Parks and Recreation.



Existing Zoning



Proposed Zoning

LEGEND

MRS Reserves
- Parks & Recreation
- Primary Regional Roads
- Other Regional Roads

Zones
- Development
- District Town Centre
- Rural

Other
- DA1 Development Area (see Scheme Text)
- DCA2 Development Contribution Area No. 2 (see Scheme Text)
- EC2 Environmental Conditions (see Scheme Text)

City of Rockingham Town Planning Scheme No. 2

The Structure Plan area is currently zoned Rural under Town Planning Scheme No.2 (TPS2), although the City is currently progressing a scheme amendment to include the Structure Plan area and broader surrounds within the Development zone (Amendment number 145). The amendment proposes to expand the existing Development Area "DA40" that is identified in Schedule 9 of the Scheme to include the Structure Plan area. The current and future TPS2 zoning for the area is Figure 4.

Schedule 9 sets out the requirements / special conditions for each Development Area. The provisions for DA40 include requirements to address / include the following matters as a detail of a Structure Plan:

- A Fire Management Plan; and
- An Acoustic Consultant Report prepared by a suitably qualified acoustic consultant to demonstrate how sensitive land uses will not be adversely impacted by noise generated by the Kwinana Freeway.

The bushfire hazard and the Structure Plan response is discussed further in section 3.3 of this report, while the Fire Management Plan, prepared by Emerge Associates, is included in full as Appendix 1.

Acoustic impacts and the Structure Plan response is discussed further in section 3.6, while the Acoustic Assessment, prepared by Lloyd George and Associates, is Appendix 2.

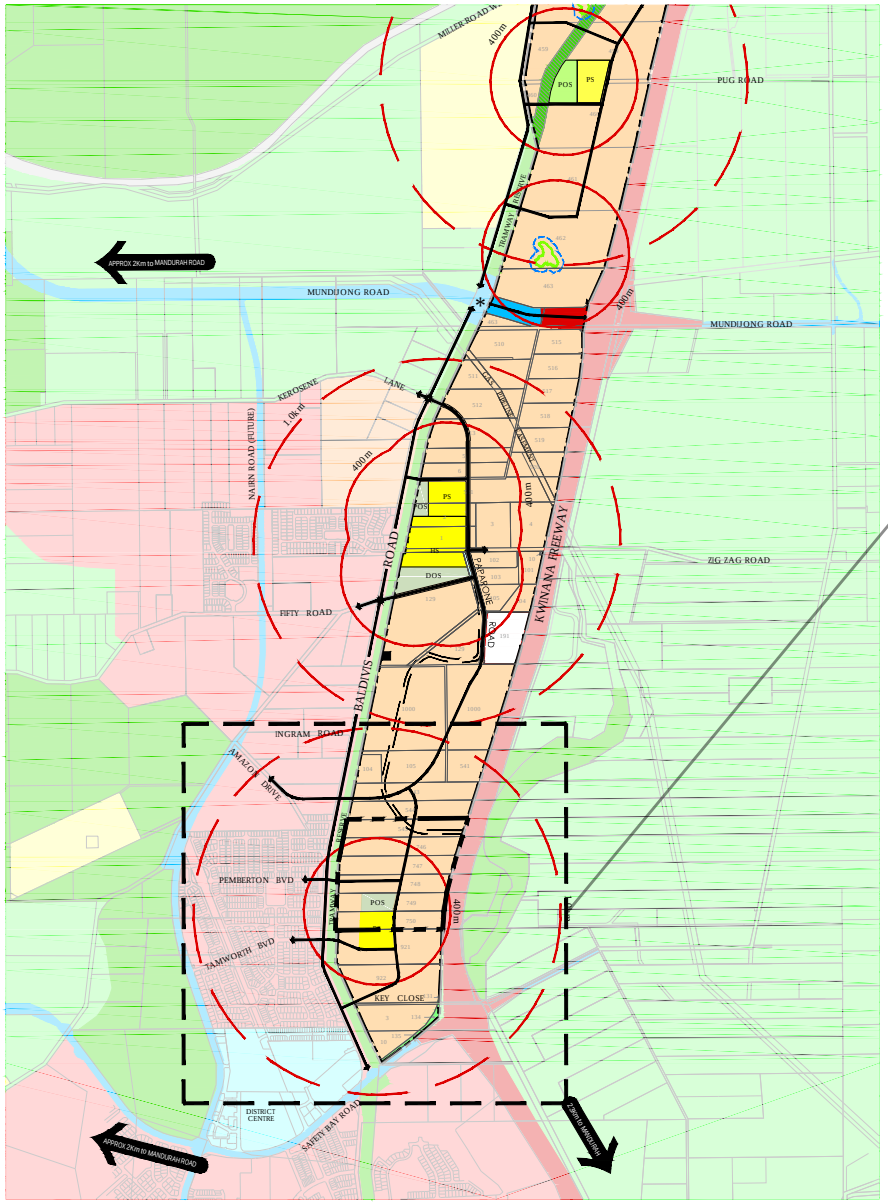
1.3.2 Higher Order Structure Plans

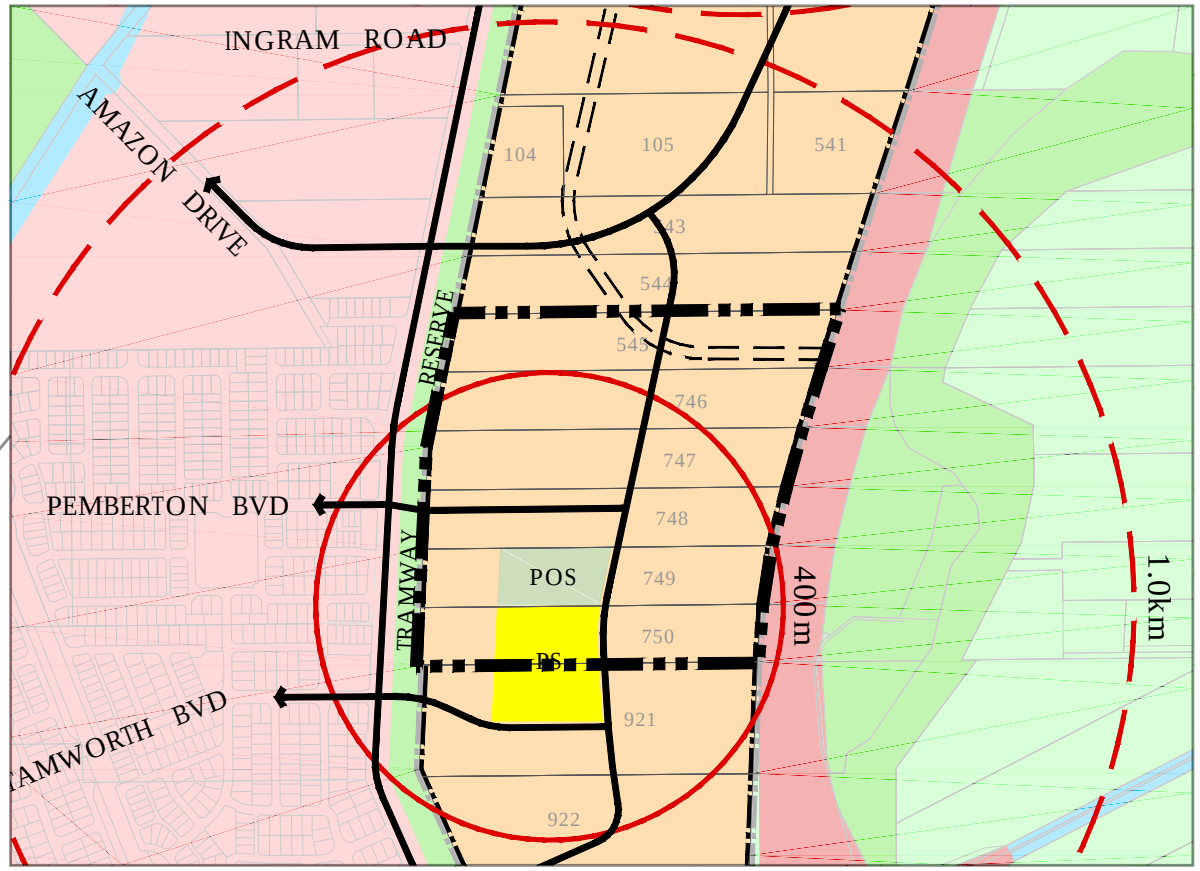
Draft Southern Metropolitan Sub-Regional Structure Plan (2009)

The draft Southern Metropolitan Sub-Regional Structure Plan (the Sub-Regional Structure Plan) was prepared by the WAPC and released for public comment in June 2009. The Sub-Regional Structure Plan is a strategic document that will guide the planning and growth of land within the southern metropolitan and Peel regions.

The Structure Plan area has been identified as being suitable for urban development, being shown as 'Future Urban' under the Sub-Regional Structure Plan.

It is understood that the WAPC is currently reviewing the Sub-Regional Structure Plan in light of the recommendations of Directions 2031 and Beyond and will be re-released as a draft in mid 2014. It is expected that the Sub-Regional Structure Plan will reflect the statutory zoning of the Structure Plan area and surrounding land.





LEGEND

- SUBJECT LAND
- NEIGHBOURHOOD CONNECTOR ROADS
- DRAINAGE ROUTE
- PUMP STATION
- RESIDENTIAL
- FUTURE FREEWAY SERVICE CENTRE
- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS
- PS — PRIMARY SCHOOL
- HS — HIGH SCHOOL
- KEY PUBLIC OPEN SPACE (Must be shown on Local Structure Plans in this location and provided)
- TRAMWAY RESERVE
- RESOURCE ENHANCEMENT WETLAND (Indicative Buffer)
- * FUTURE STAGGERED T-JUNCTIONS (from Baldivis onto Mundijong Road, with Mundijong Road as the priority route.)

POS DISTRIBUTION

- LOCAL @ 150 - 300m CATCHMENT
- NEIGHBOURHOOD @ 400m CATCHMENT
- DISTRICT @ 600 - 1000m CATCHMENT

EAST BALDIVIS DISTRICT STRUCTURE PLAN

2353-35-01 (15.08.2014), Not to scale

Figure 5

East Baldivis District Structure Plan

The Structure Plan is included within the area covered by the East Baldivis District Structure Plan (EBDSP), a strategic district structure plan prepared by the respective landowners within the East Baldivis corridor. The EBDSP was advertised for public comment by the City of Rockingham in late 2013 and was adopted by the City as a strategic structure plan in February 2014.

The EBDSP broadly identifies the subject land and surrounds as predominantly residential, with a portion of a primary school located on lot 750 at the southern extent of the Structure Plan. The EBDSP is Figure 5.

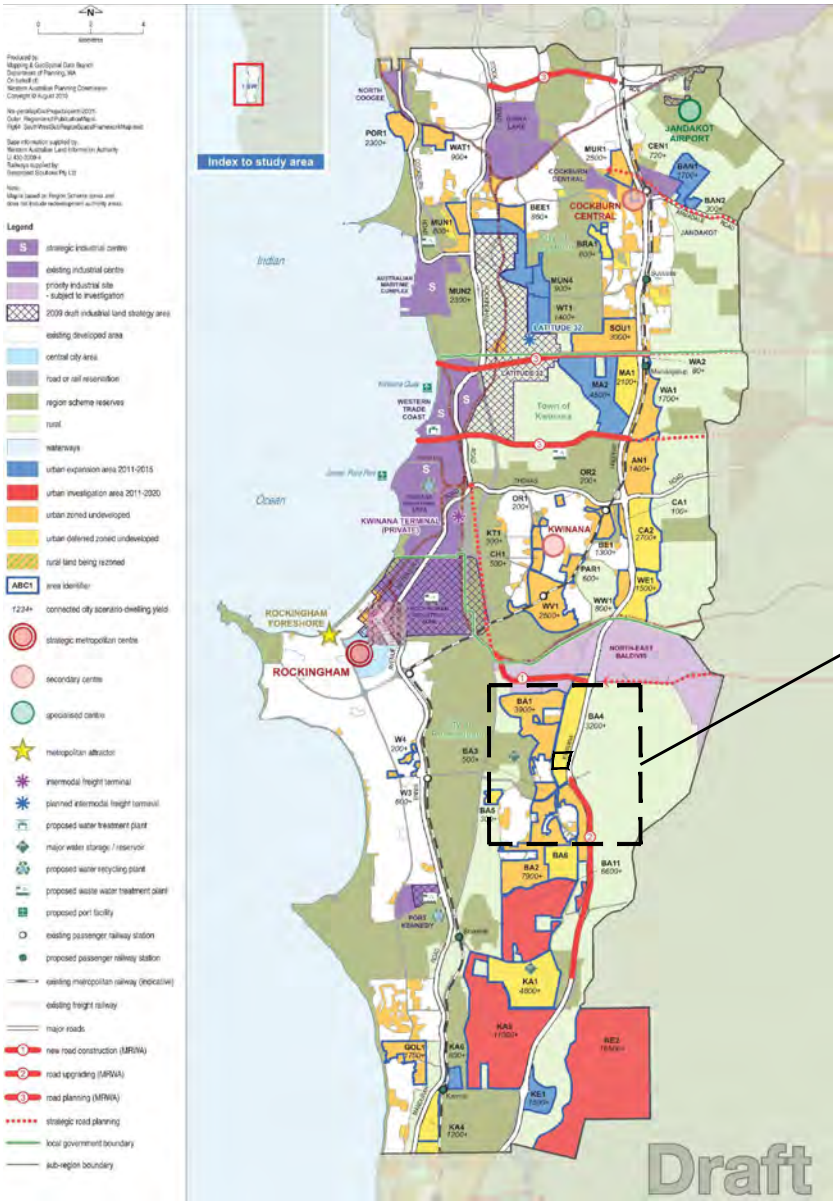
The EBDSP is supported by the following technical reports, which assist to define the key land use principles and inform subsequent stages of planning:

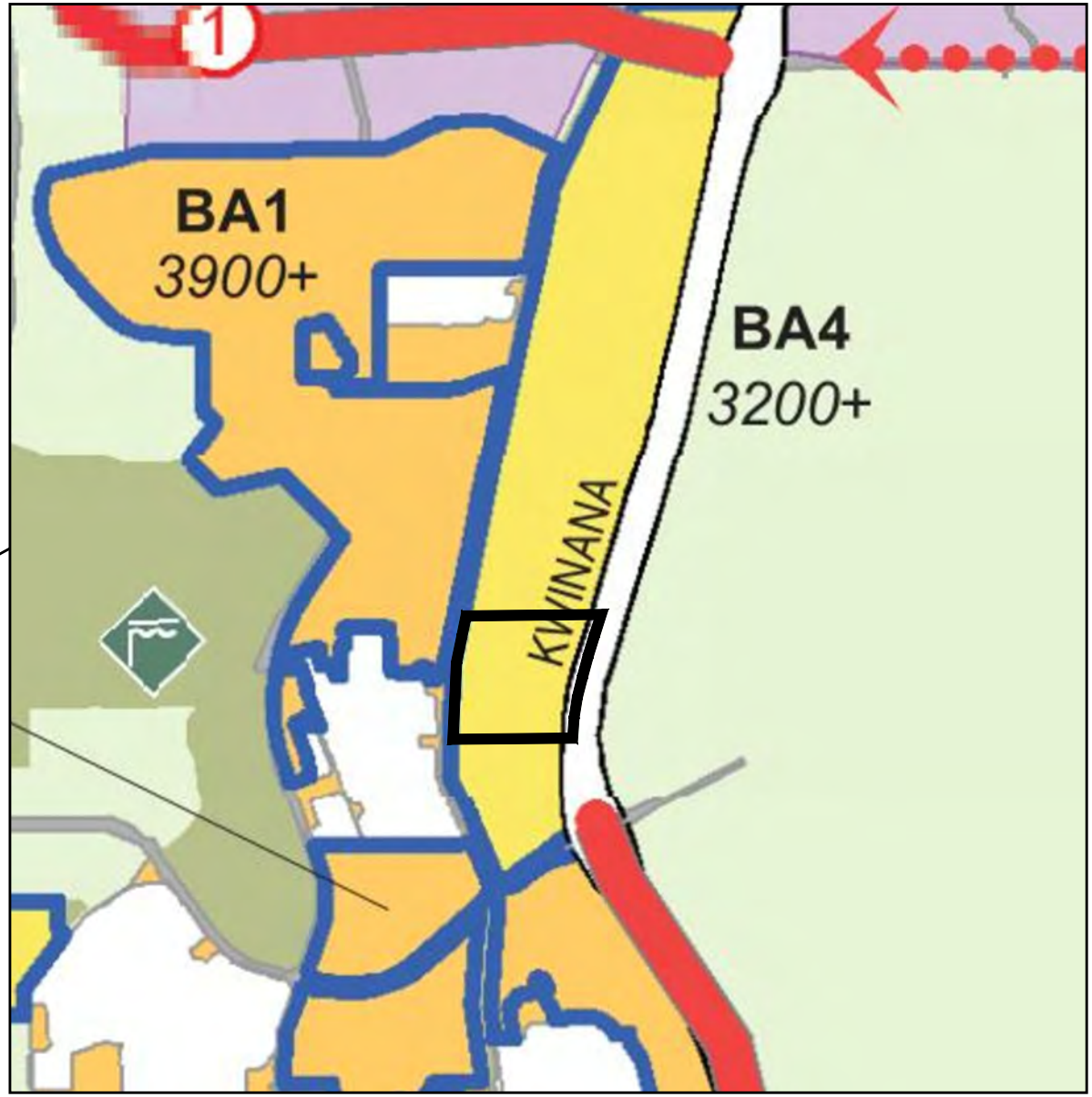
- Environmental Assessment Report
- Servicing Report
- Traffic and Transport Report
- Hydrological Report
- Acoustic Report
- Commercial and Community Facilities Report
- Bushfire Hazard Assessment Report

The Structure Plan is entirely consistent with the key land use principles of the EBDSP and refines and expands upon these principles to create a more specific plan for this area.

Baldivis Activity Centre Structure Plan (2012)

The Structure Plan area is approximately 1.5km north of the Baldivis Activity Centre Structure Plan (BACSP) which outlines the high-level objectives and intended growth of the centre. The Structure Plan area is in relative close proximity to the 'Northern' precinct as identified by the BACSP and is well connected to the activity centre by Baldivis Road.





DRAFT SOUTH WEST SUB-REGIONAL SPATIAL FRAMEWORK

2353-36-01 (15.08.2014), Not to scale

Figure 6

1.3.3 Planning Strategies

Directions 2013 and Beyond (August 2010)

Directions 2031 and Beyond is the regional spatial framework and strategic plan that establishes a vision for the future growth of the Perth Metropolitan Region for the delivery of housing, infrastructure and essential services.

Directions 2031 includes the Structure Plan area within the South-West Sub Region. This region is identified as experiencing considerable economic and population growth, with population expected to grow by 34% (278,000 people) by the year 2031. Directions 2031 also recommends a housing density target of 15 dwellings per gross urban zoned hectare. The need for density targets to encourage more efficient and effective housing is acknowledged however, it is important that the application of these targets recognises the impact of site specific constraints and market conditions on the ability to deliver density.

Directions 2031 is supported at a sub-regional level by the draft Outer Metropolitan Perth and Peel Sub-Regional Strategy.

Draft Outer Metropolitan Perth and Peel Sub-Regional Strategy (2010)

The draft Outer Metropolitan Perth and Peel Sub-Regional Strategy (the Sub-Regional Strategy) provides additional information about the level of expected population growth and highlights development opportunities throughout the metropolitan area and Peel region.

The Structure Plan area is located in the south-west sub-region where the Sub-Regional Strategy identifies 99,260 dwellings being provided through Greenfield development. Consistent with the statutory zoning at the time, the Sub-Regional Strategy identifies the East Baldivis cell, including the Structure Plan area as 'urban deferred zone undeveloped'.

A copy of the Sub-Regional Strategy (South-West Region) is included at Figure 6.

City of Rockingham Urban Growth Programme (2009)

The City of Rockingham Urban Growth Programme (the Programme) was prepared to assist Council in understanding the likely patterns of urban growth within the City of Rockingham and considered existing population and dwelling statistics, existing structure plans and forecast future urban growth patterns. The programme provides the City with a summary of expected urban development areas to help guide Council in its decision making processes.

The Structure Plan area falls within Precinct 3 of Baldivis North. It identifies this area as being 'Future Development' but with no structure plan in place. The Programme suggests that development of the entire Precinct 3 area is expected to accommodate approximately 5,000 dwellings over the next fifteen years.

The EBDSP and Structure Plan represent the fulfilment of the expected urban growth within Baldivis North, as projected by the Programme.

1.3.4 Policies

The following sections summarise those government policies and strategies that are relevant to the urbanisation and development of the Structure Plan area.

SPP 5.4 – Road and Rail Transport Noise and Freight Considerations in Land Use Planning

The eastern boundary of the Structure Plan abuts the Kwinana Freeway – an existing primary regional road and major transport corridor. As such, the proposal must be considered in the context of SPP 5.4, which guides noise sensitive development in proximity to major transport routes. A Transportation Noise Assessment has been prepared by Lloyd George Acoustics in accordance with SPP 5.4 and the requirements of Schedule 9 of TPS 2 - refer Appendix 2.

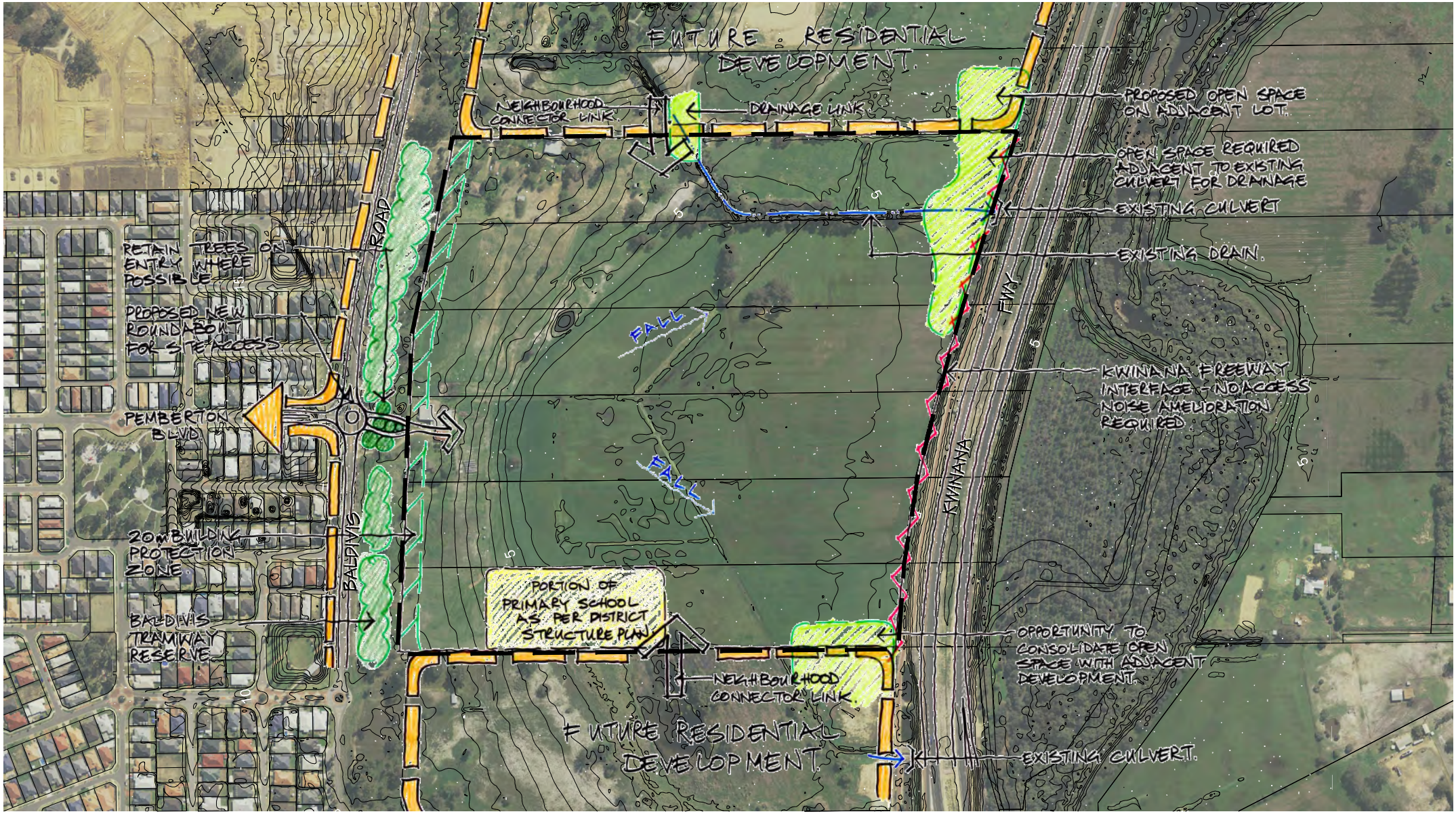
Planning for Bushfire Protection Guidelines

The WAPC and Fire and Emergency Services Authority (FESA) released the Planning for Bush Fire Protection Guidelines in May 2010 as a means of outlining the matters that need to be addressed through the planning process in order to protect life and property in the event of a bush fire. A draft State Planning Policy and revised draft Guidelines were published by the WAPC for public comment in May 2014 and have also been considered in the context of this Structure Plan.

The Structure Plan includes a Fire Management Plan - refer section 3.3 and Appendix 1, that has been prepared in accordance with the Guidelines and draft State Planning Policy.

1.3.5 Other Approvals and Decisions

The recent decision of the WAPC to transfer the land from the Urban Deferred zone to the Urban zone under the MRS was gazetted on 13 May 2014. The area of land the subject of the application to amend the MRS included all of the Structure Plan area.



OPPORTUNITIES AND CONSTRAINTS MAP

2.0 SITE CONDITIONS AND CONSTRAINTS

The following sections outline the site conditions and constraints apparent within the Structure Plan area. This summary is informed by previous planning undertaken via the EBDSP, the various technical reports prepared in support of the EBDSP and the current technical inputs into the Structure Plan. An opportunities and constraints map that summarises the following sections is Figure 7.

2.1 Biodiversity and Natural Assets

The Local Structure Plan area is relatively unconstrained and the environmental factors affecting the land, including groundwater, drainage, contamination and bushfire management can be adequately managed via standard practices.

An Environmental Assessment Report has been undertaken for the Structure Plan area by RPS and is included in full as Appendix 3.

2.1.1 Flora and Vegetation

The Structure Plan area does not contain any Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) and is therefore well suited for urban development.

Due to historical land uses, particularly agricultural activities, the Structure Plan area has been extensively cleared of native vegetation.

The condition of vegetation that remains on site is classified as 'completely degraded' based on the 'Bush forever vegetation condition scale'.

2.1.2 Fauna

The majority of the Structure Plan area has been cleared of vegetation and is in a 'completely degraded' condition. This, combined with a lack of understorey, means that little protected habitat is available to native fauna.

2.2 Landform and Soils

2.2.1 Landform and Topography

The topography and soil types within the Structure Plan area are similar to surrounding urban areas and are not constraints to development. The ultimate earthworks design will respect the current landform through the minimisation of retaining walls and recognition of the general fall of the site from west to east, whilst balancing the need to provide adequate clearance to groundwater and flood protection.

The Structure Plan area slopes gently from west to east with maximum heights ranging from 9m AHD to 3.5m AHD in the north-east corner, with approximately 5 metres of fall across the site. The relatively flat nature of the site ensures that the site can be drained and serviced without the need for substantial earthworks, retaining, or significant changes to the topography / pre-development hydrology.

2.2.2 Soil Types

Soil types within the Structure Plan area include Guildford Clay and Bassendean Sand and have good drainage capacity overall. These soil types are typical of the East Baldivis precinct and are not constraints to development. Further discussion on soil types and drainage is provided in section 3.7 and the Local Water Management Strategy at Appendix 4.

The Structure Plan is located in an area identified as 'moderate to low risk of ASS occurring within 3m of the natural soils surface (or deeper)' and is therefore suitable for urban development. An ASS Management Plan may be required to be prepared in the usual manner prior to any excavation or dewatering as part of the subdivision, although this will be subject to confirmation of fill levels and detailed design of service infrastructure.

2.3 Groundwater and Surface Water

2.3.1 Existing Conditions

Management of ground and surface water is comprehensively addressed through the Local Water Management Strategy (LWMS) at Appendix 4 and is not a constraint to development. The LWMS is consistent with the DWMS, which was prepared by Parsons Brinkhoff in 2007(pre-dating the WAPC's Better Urban Water Management Framework) and accepted by the Department of Water.

The Perth Groundwater Atlas (DoW 2014) estimates groundwater levels at approximately 2m below the natural surface. Pre-development observations indicate the site has the potential to become inundated in the winter months.

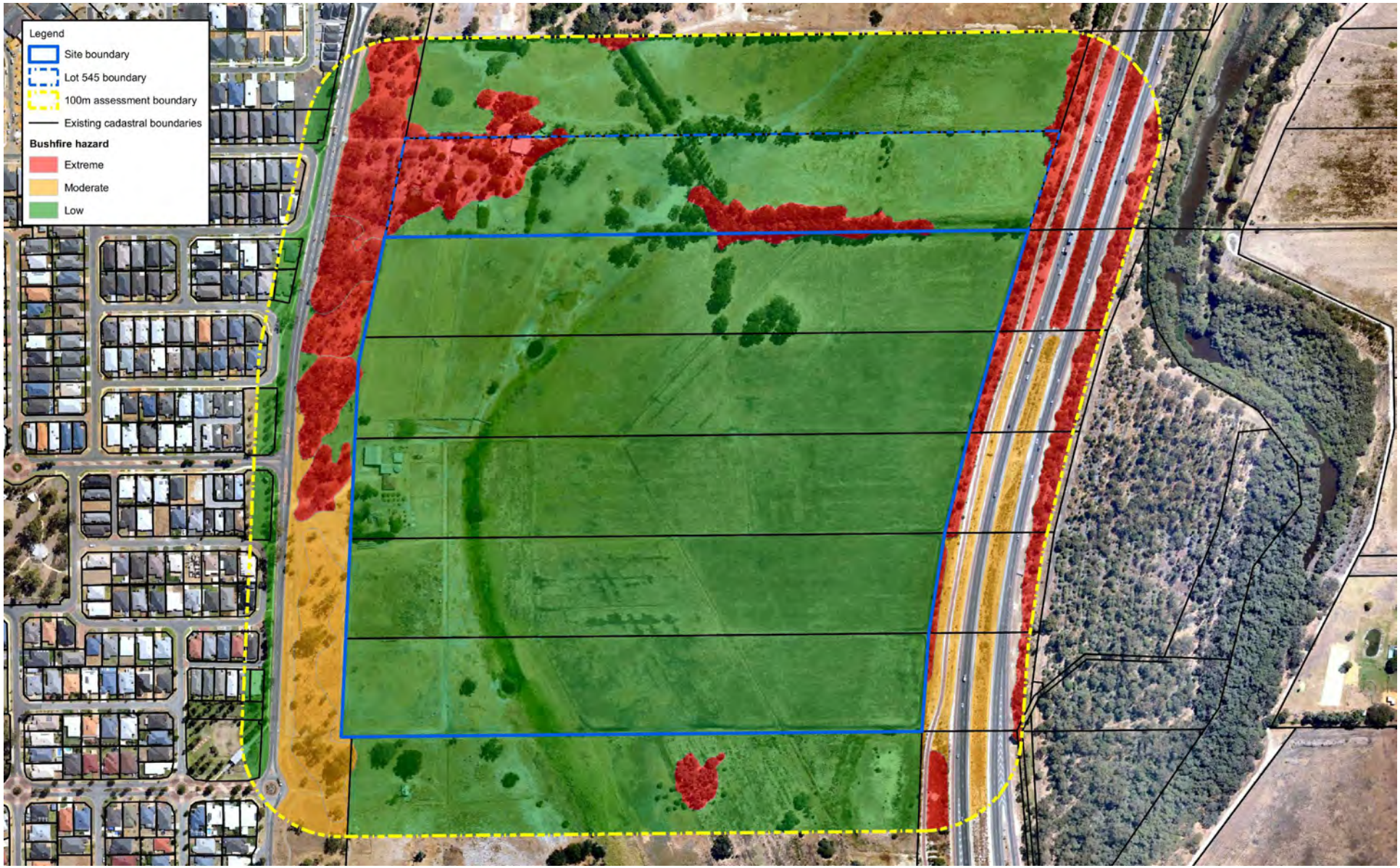
As acknowledged, the depth to groundwater is shallow and levels are expected to rise even further in winter, and further again with urban development due to the increase in shedding surfaces and higher infiltration rates associated with imported sand material. On this basis, groundwater levels will need to be controlled by a combination of fill material and subsurface drainage, which is a typical development strategy for these conditions and is not a constraint to development.

Groundwater monitoring results show groundwater levels range from 3.5 metres Australian Height Datum (m AHD) to 4.4 m AHD. Local groundwater flow is generally towards the Sub H or F drains.

The LWMS and Structure Plan will recognise pre-development flow rates to ensure that water quality and quantity is not adversely affected in downstream areas.

2.3.2 Wetlands and Waterways

There are no mapped 'Conservation' or 'Resource Enhancement' category wetlands within the Structure Plan area. The south east of the Structure Plan area is mapped as 'Multiple Use' meaning that it has few attributes which still provide an important wetland function, with management objectives focused on use, development and management.



Source: Bushfire Safety Consulting / Emerge Associates

2353-42-01 (25.08.2014), Not to scale

BUSHFIRE HAZARD MAP

Figure 8

2.4 Bushfire Hazard

In accordance with the WAPC's 'Planning for Bushfire Protection Guidelines' and Schedule 9 of TPS 2, a Fire Management Plan has been prepared by Emerge Associates and is included as Appendix 1. A Bushfire Hazard Map showing pre-development hazards is Figure 8. There are opportunities to remove or reduce some of these hazards as part of the development process.

The Assessment concludes that bushfire is not a constraint to development in the Structure Plan area, subject to appropriate interface treatments and building protection zones being provided adjacent to the hazards identified. The Structure Plan response to the identified bushfire hazards is discussed further in section 3.3.

2.5 Heritage

2.5.1 Aboriginal Heritage

The Department of Indigenous Affairs Aboriginal Heritage Sites database lists no registered Aboriginal heritage sites within the structure plan area.

2.5.2 European Heritage

The State Register of Heritage Places does not contain any heritage listings of European significance within the Structure Plan area.

2.6 Other Land Use Opportunities and Constraints

2.6.1 Traffic Noise

A Transportation Noise Assessment has been prepared by Lloyd George Acoustics in accordance with SPP 5.4. The Assessment identifies that the eastern portion of the Structure Plan area is affected by traffic noise generated by the Kwinana Freeway. The Structure Plan area is no different from other urban development abutting the Kwinana Freeway and other high frequency traffic routes. Whilst noise attenuation is generally required, traffic noise is not a constraint to development and can be addressed via standard noise attenuation measures.

The Transportation Noise Assessment recommends that sound attenuation measures be implemented that include an increased noise wall height of 2.2m – 3m where required, notifications being placed on the titles for lots that are exposed to higher levels of noise and 'quiet house design' for certain lots to assist in alleviating the freeway noise. Noise attenuation is discussed further in section 3.6 and Appendix 2.

2.6.2 Availability of Services and Infrastructure

Civil engineer Development Engineering Consultants (DEC) has been engaged to undertake a preliminary review of infrastructure requirements, including staging and funding requirements. DEC has advised that the land is capable of being provided with essential services in a timely manner. This is reflected in the WAPC's recent decision to lift the 'Urban Deferred' status over the land. A detailed Earthworks and Servicing Strategy has been prepared by DEC, refer section 3.10 for a summary of the servicing strategy, with a full copy provided as Appendix 5.

2.6.3 Baldivis District Centre

The Baldivis Activity Centre Structure Plan covers a 77.4ha area located approximately 1-1.5km south-west of the Structure Plan area. The immediate proximity of the Activity Centre to the subject land provides an excellent opportunity for residential development in close proximity to essential services and employment opportunities. The Structure Plan area is ideally located to deliver a mix of housing types and densities and will provide the Baldivis District Centre with the necessary population to drive and sustain commercial development.

2.6.4 Baldivis District Open Space

The East Baldivis District Structure Plan identifies an area of district open space adjacent to Zig Zag Road to the north of the Structure Plan area. The district open space will provide an area for active recreation and organised sport which will be easily accessible via a neighbourhood connector road from the Structure Plan area. Residential development of the Structure Plan area and surrounds will provide a catalyst for the development and ongoing use of the district open space which will provide a long-term community benefit.

2.6.5 Dampier-Bunbury Gas Pipeline

The Dampier to Bunbury Gas Pipeline is located 1.3km north of the Structure Plan. The minimum recommended setback as required within the WAPC Planning Bulletin – Pressure Gas Transmission Pipelines in the Perth Metropolitan Region is 70m. The Structure Plan's proximity to the gas pipeline therefore is not a constraint to development.

2.6.6 Primary School

The EBDSP identifies a public primary school and co-located open space that straddles the southern boundary of the Structure Plan area. This presents an opportunity for the plan to provide an urban form and housing densities that recognise the context of the primary school and respond accordingly. There are also opportunities to increase the size of the school site from 3.5ha to 4ha and to redistribute the public open space.

This plan is an indicative Concept Only and depicts one potential development option for the land and is provided for general information purposes only.
Lot boundaries, building footprints, road networks, land uses and all other detail will be refined as part of the formal structure planning, development application, subdivision application and other processes, and will vary from the detail shown on this plan. This plan remains the property of CLE.

DEVELOPMENT CONCEPT PLAN

2353-41A-01 (25.09.2014), Not to scale

Figure 9

3.0 LAND USE AND SUBDIVISION REQUIREMENTS

3.1 Plan Overview and Land Use

The Structure Plan delivers a robust and integrated residential development that is responsive to the key environmental and land use considerations outlined in section 2 of this report. The Structure Plan recognises the broader context of the East Baldivis precinct, as well as providing full integration with the planned developments to the north and south of the Structure Plan area.

The Development Concept Plan, shown as Figure 9, demonstrates one way the development could take place on the site, based on the structure plan principles and requirements. The Development Concept Plan demonstrates the coordinated nature of the Structure Plan design, ensuring that developments to the north and south of the Structure Plan area are fully integrated with the Structure Plan area itself. The Structure Plan Map shown as Figure 10 is the statutory framework which will implement the Development Concept Plan. It is important to note that the Development Concept Plan represents only one manner in which development could occur and will be refined further at the time of subdivision.

The key principles of the Structure Plan are to:

- Enable the creation of a diverse range of high quality housing choices that will appeal to a broad range of the market.
- Provide a robust urban form that responds to the site's location within the wider Baldivis locality and integrates with surrounding development.
- Provide accessible, attractive and multi-functional open space that addresses drainage requirements as well as offering a range of recreational opportunities.
- Extend the necessary services and infrastructure in a timely and coordinated manner, to support the future development.
- Ensure an integrated and interconnected road network that facilitates safe and efficient vehicle, cyclist and pedestrian movement throughout the Structure Plan and the broader locality.
- Put in place a framework that allows for the timely delivery of the public primary school in order to ensure that the timing for delivery is consistent with the community demand and the Department of Education's forward planning.

LEGEND

ZONES

- Residential - R25
- Residential - R40

RESERVES

- Public Open Space
- Public Purposes
  - Primary School

OTHER

- Structure Plan Boundary
- Primary Regional Road
- District Distributor B
- Neighbourhood Connector
- Access Street B
- Access Street C
- Local Road (Access Street D)
- Laneway
- Noise Wall (3m)
- Quiet House Design (Package A)
- Left in Left out

NOTES

1. Public Open Space areas are indicative only and subject to further detail design and drainage considerations.
2. All access streets are indicative only and are subject to refinement as part of the detailed subdivision process.
3. Street block configuration is for display purposes only and is subject to refinement as part of the detailed subdivision process.

2353-50A-01 (25.09.2014), Not to scale

STRUCTURE PLAN

Figure 10

Based on these key principles, the Structure Plan provides the framework for:

- Approximately 510-540 dwellings across the structure plan area, with residential densities ranging from R25 to R40. Higher densities are focused around areas of high local amenity and closer to the primary school at the southern end of the Structure Plan area.
- A portion of a public primary school measuring approximately 2ha in area, with the balance (also 2ha) being provided by the landowners to the south – consistent with the EBDSP.
- A permeable network of access roads that are responsive to the existing road networks surrounding the structure plan area, while providing opportunities for future public transport, cyclist and pedestrian networks.
- A centrally located local public open space measuring approximately 1.3 hectares that meets recreational and drainage objectives, as well as providing a high amenity focal point for the future community.
- An evenly distributed network of useable, multi-functional local parks, meeting the requirements of Liveable Neighbourhoods and providing important recreational and drainage functions for the community.
- A landscaping strategy that guides the development of the centrally located public open space, as well as providing an integrated drainage response.
- A preliminary earthworks strategy that recognises the significant landform of the site.
- A managed interface to both the Tramway Reserve and Kwinana Freeway, ensuring that noise and bushfire hazards are adequately addressed.

PLAYFUL

COMFORTABLE

CONSIDERED

CONNECTED

LEGEND

1. ENTRY AREA
2. WIDENED LANDSCAPE VERGE
3. PROPOSED GATHERING SPACE
4. OPEN KICKABOUT SPACE
5. DRAINAGE SWALES
6. PRIMARY SCHOOL OVAL
7. DESIGN TO ADJACENT POS

Source: Emerge

2353-51A-01 (06.10.2014), Not to scale

LANDSCAPE MASTER PLAN

Figure 11

3.2 Open Space

The Structure Plan establishes a comprehensive framework for the delivery of a high amenity, integrated open space network. The following sections outline the key principles of the open space network and elaborate on the design intent for each individual open space.

3.2.1 Open Space Provision and Schedules

The Structure Plan makes provision for approximately 4ha of gross public open space across the Structure Plan area. This includes a range of open space types, including areas that enable passive and informal active recreation, as well as providing high amenity community focal points.

In order to demonstrate the distribution and function of the open space areas throughout the Structure Plan, a landscape Master Plan has been prepared by Emerge Associates. This Landscape Master Plan and Public Open Space Concepts can be found in its entirety at Appendix 6, with an overall Master Plan included as Figure 11.

Once Liveable Neighbourhoods credits are applied, the open space provision equates to 10.1% of the gross subdivisible area, satisfying the minimum 10% credit public open space required, as shown in Table 2.

The following outlines the key aspects of public open space provision based on Liveable Neighbourhoods requirements, with the detailed description of each open space types outlined in Section 3.2.2 below.

- Based on a Gross Subdivisible Area (Gross Site Area less 2 ha portion of primary school and 1 in 1 year drainage storage area) of 34.4 ha, the 10% open space requirement is 3.4 ha.
- The Structure Plan provides 4 ha of gross open space, with open space areas serving a shared drainage function, whilst not compromising the active and passive recreational uses.
- Approximately 0.6 ha of open space will receive drainage for events occurring more frequently than the 1 in 1 year (1 hour) event and as such, is a deduction from the Gross Subdivisible Area in accordance with Liveable Neighbourhoods.
- Liveable Neighbourhoods allows up to 2% of the 10% open space requirement to comprise of restricted use open space. The balance of restricted use open space becomes a deduction.
- Based on the requirements of Liveable Neighbourhoods, a maximum of 0.7 ha (2%) can be restricted use open space and a minimum of 2.8 ha (8%) unrestricted open space.
- Approximately 0.07 ha of open space will receive drainage from the 1 in 1 year to 1 in 5 year drainage event in landscaped infiltration basins and bio-retention areas, in accordance with water sensitive urban design principles and the City's policies. The 1 in 1 to 1 in 5 year drainage event is treated as restricted use open space in accordance with Liveable Neighbourhoods.

Table 2 – Public Open Space Schedule (all areas are in hectares)

Site Area		37.0
Deductions		
Primary School	2.0	
Restricted Use (above 2%)	0.0	
Total Deductions	2.0	
Net Site Area		35.0
Other Deductions		
1:1 Drainage within POS	0.6	
Gross Subdivisible Area		34.4
POS @ 10%		3.4
Public Open Space Requirement		
May Comprise:		
Min 8% unrestricted POS	2.8	
Max 2% restricted POS	0.7	
TOTAL POS REQUIRED		3.4
Public Open Space Provided	Unrestricted POS Area	Restricted POS Area
Central Park A	1.18	0.02
Central Park B	0.59	0.02
Local Park South-East	0.30	0.01
Neighbourhood Park North-East	1.23	0.02
Local Park North	0.11	0.00
TOTAL (ha)	3.40	0.07
Additional Deductions		0.0
Restricted Open Space Surplus		
Public Open Space Contribution		
Min 8% unrestricted POS	3.40	9.9%
Max 2% restricted POS	0.07	0.2%
Total Creditable POS Provided	3.5	10.1%

1. Site Area is the total area of the LSP boundary, including all lots and road reserves within the boundary.

2. In accordance with Liveable Neighbourhoods: the area subject to indunation more frequently than a one year average recurrance interval rainfall event is not included as restricted or unrestricted open space and is a deduction from the net site area (LN R33); areas for the detention of stormwater for a greater than one year average recurrance interval up to the five year recurrance interval is restricted open space up to 20%, the area greater than 20% is a deduction (not applicable in this case) (LN R26 & Table 11); areas for the dentention of stormwater for a greater than five year average recurrance interval is within unrestricted open space (LN R25).

3.Drainage areas are based on advice from Development Engineering Consultants - ref BDVMIR01 - L04A (DEC 2014).

4. All POS areas are indicative only and are subject to refinement and detailed design at subdivision stage.

3.2.2 Active Public Open Space

The Structure Plan area is surrounded by existing and planned areas of district open space for formal and organised sporting activities. As such, the Structure Plan does not provide any formal active POS due the sufficient provision of these types of POS within the locality and the competing demands within the Structure Plan area. This approach has been discussed and agreed with City's officers early in the Structure Plan preparation process.

Opportunities for formal recreation and organised sporting activities for residents of the Structure Plan are provided via the following:

- The future sporting oval that will be provided on the primary school site in the south of the Structure Plan, refer Figure 21 – Primary School Concept Plan;
- The future area of district open space as identified on the EBDSP; and
- The existing area of district open space immediately south-west of the Structure Plan that abuts the western boundary of Baldivis Road and is north of Fifty Road.

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

3.2.3 Description of Open Space Areas

The landscape strategy behind the public open space development is to provide a readily useable, aesthetic and liveable environment for residents from day one, refer Figure 11 – Landscape Master Plan. Landscaped open space areas will incorporate features and facilities to encourage residential growth and provide public, aesthetic and site character building amenities to residents.

The following provides a brief overview and description of the proposed landscape function, distribution and design throughout the Structure Plan area.

POS TYPOLOGY
- Feature Park (A)

SIZE (excluding verges)
- 1.36 Hectares

CONCEPT
- Provide a large active turf space for the broader community
- Large accessible play space with interest for all ages
- Provide safe pedestrian and cycle linkages
- Exercise circuit linking the functions within the POS
- Provide shaded picnic facilities & bbqs
- Community focal area with space for small events/ markets

FUNCTIONS
- Turf - Larger turf areas for informal recreation
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Picnic Facilities for family/friend & community gatherings
- Play elements for all age groups
- 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

DRAINAGE CONSIDERATIONS

1:1	628 m3 storage required
1:5	1006 m3 storage required
1:10	1024 m3 storage required
1:100	2360 m3 storage required

Note: Figures to be finalised during detailed design.

Source: Emerge

2353-52-01 (29.08.2014), Not to scale

POS A LANDSCAPE CONCEPT

Figure 12

POS A

POS A is the main community focal point for the Structure Plan area. POS A is located on the main entry road from Baldivis Road and at 1.3 ha, will deliver a high amenity, multi-purpose landscaped park. It is intended that POS A will be delivered in the early stages of the project, ensuring local amenity is delivered upfront.

The northern boundary of POS A is framed by some narrow cottage lots with direct frontage to the open space. It is Mirvac's intention to build out these lots with a customised built form response. This interface will deliver a high quality built form outcome, as well as ensuring passive surveillance over the park.

POS A will be landscaped to a high standard and will include a designated children's play area, shelter, turfed kick-about space, fitness nodes, planted areas and a small, landscaped bio-retention basin.

With the exception of the bio-retention area, which is treated as a deduction consistent with Liveable Neighbourhoods requirements, POS A is unrestricted open space. An indicative landscape concept plan for POS A is Figure 12.

POS B

POS B is a local park located centrally within the residential area to the east of the main neighbourhood connector road. At approximately 7,500m², POS B provides an additional focal point for this portion of the estate, as well as enabling passive recreation, children's play, kick-about and provides an important drainage function.

POS B is easily accessible from all sides via a local street network and footpath connections. A row of laneway lots will flank a portion of the eastern edge of POS B, ensuring high quality built form and passive surveillance.

POS B forms part of the structure plan's drainage network, and includes a small bio-retention area in the south eastern corner of the park. This bio-retention area will include high quality, low maintenance landscaping in accordance with the City's standards.

POS C

POS C is approximately 3,700m² and forms a continuation of a 2.1ha area of open space within the landholding to the south, providing a combined park of approximately 2.5ha.

POS C forms an important part of the broader drainage network for the structure plan area and is designed and located to detain stormwater to match pre-development flows, prior to discharging through a culvert under the Kwinana Freeway. Whilst the drainage component of POS C is important, the area required for drainage detention and treatment (up to 1 in 10 year event) makes up only 20% of this open space area, with the remaining open space being fully functional, useable open space.

POS C will be designed and landscaped such that it is fully integrated with the balance of the park to the south. Mirvac is in discussions with the adjoining landowners to confirm specific design levels and requirements. A landscape concept of POS C is Figure 13.

POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .37 Hectares (Mirvac land holding)
- 2.5 Hectares total area

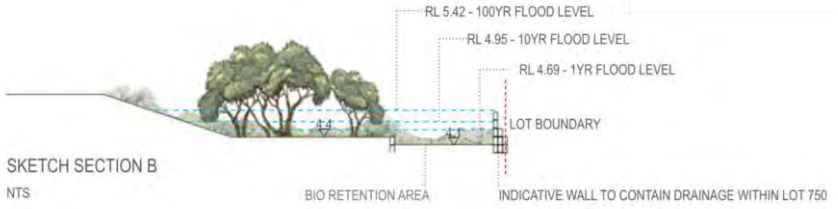
CONCEPT
- Provide a northern extension of a large neighbourhood park to cater for residents within a 150m-300m catchment
- Deliver a fully integrated design response ensuring that the broader area of open space is seamless in its transition between the two residential estates
- Provide large areas of useable kick-about space that is not compromised by drainage infrastructure
- Create a safe local park which is intended to be heavily planted with shade trees and provides low key picnic facilities, recreational facilities and nodes for exercise.
- Provide safe pedestrian and cycle linkages to broader path network linkages.

FUNCTIONS
- Connecting expanses of turf
- Native, water wise planting.
- Maximise shade trees with emphasis on native species
- Retain existing vegetation where possible
- Limited picnic facilities
- Internal path network
- Path network connecting into the broader path network

ENVIRONMENTAL CONSIDERATIONS
- Waterwise native planting
- Planting design to be zoned according to irrigation requirements
- 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
- 1:1 250 m3 storage required
- 1:5 399 m3 storage required
- 1:10 437 m3 storage required
- 1:100 1109 m3 storage required

Note: Figures to be finalised during detailed design.



Source: Emerge

2353-53A-01 (03.10.2014), Not to scale

POS C LANDSCAPE CONCEPT

Figure 13

POS D

At approximately 1.4ha, POS D is the largest public open space within the structure plan area and will deliver significant opportunities for functional spaces and passive recreation within a high amenity landscaped setting.

POS D forms a continuation of the planned open space within the 'Baldivis Parks' estate to the north and will be designed so as to fully integrate with the adjoining estate. There are opportunities through the planned development to the north to introduce laneway lots with a direct interface onto the park, encouraging passive surveillance in this area.

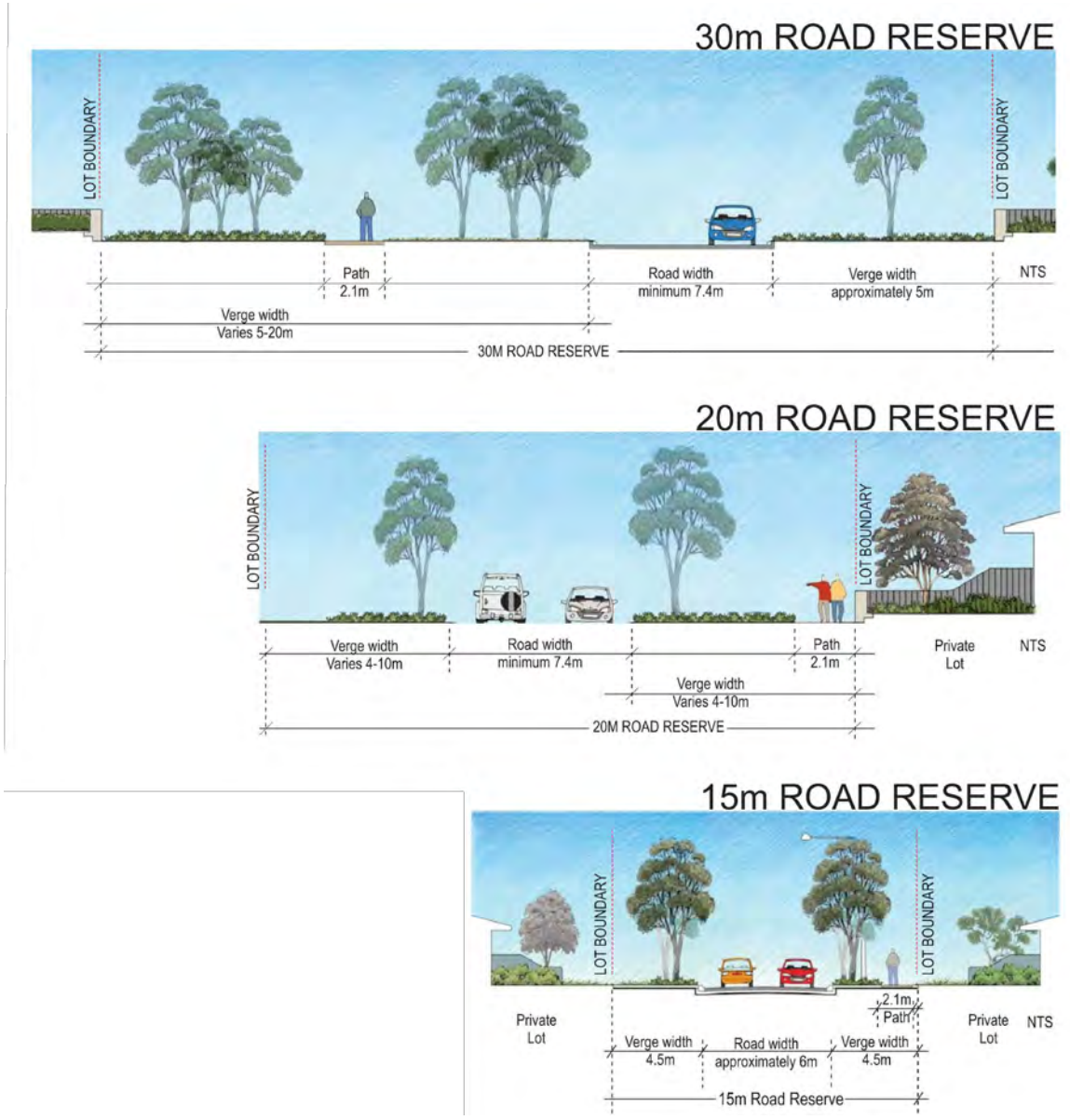
POS D is aligned with an existing culvert that passes under the Kwinana Freeway and drains into the Peel Main Drain on the eastern side of the freeway. It is a requirement of the Department of Water for development to match pre-development flow rates. This park serves an important function in this regard, as outlined further in the LWMS at Appendix 4, by detaining and treating stormwater before allowing it to be discharged into the regional network.

Despite its important role in the broader drainage network, POS D will be a highly useable, high amenity local park that maximises both aesthetic and functional uses. POS D serves a Neighbourhood Park function and is likely to provide a range of play equipment, fitness nodes and turfed areas.

POS E

Located adjacent to the northern boundary of the structure plan area, POS E is a 1,100m² extension of an approved park located within the 'Baldivis Parks' estate. Given its location adjacent to the main north-south neighbourhood connector, POS E provides an important entry feature to the structure plan area for southbound traffic. The landscape design of POS E will be fully integrated with the parkland to the north, ensuring a seamless transition with respect to amenity and maintenance.

This park will provide opportunities for passive recreation and will include extensive landscaping, shade trees, and a low level entry statement to denote arrival within the structure plan area. POS E does not form part of the drainage network and is therefore unrestricted open space in accordance with Liveable Neighbourhoods.



Source: Emerge

2353-54-01 (29.08.2014), Not to scale

KEY STREETSCAPES LANDSCAPE CONCEPT

Figure 14

3.2.4 Streetscapes

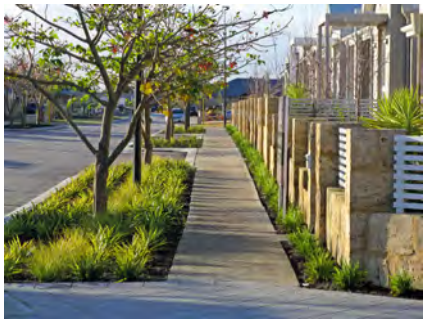
Whilst not usually acknowledged as traditional public open space pursuant to Liveable Neighbourhoods and recognised under Table 2, streetscapes make up an important component of the public realm and the quality of landscaping within key streets assists to deliver a true sense of place within new urban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

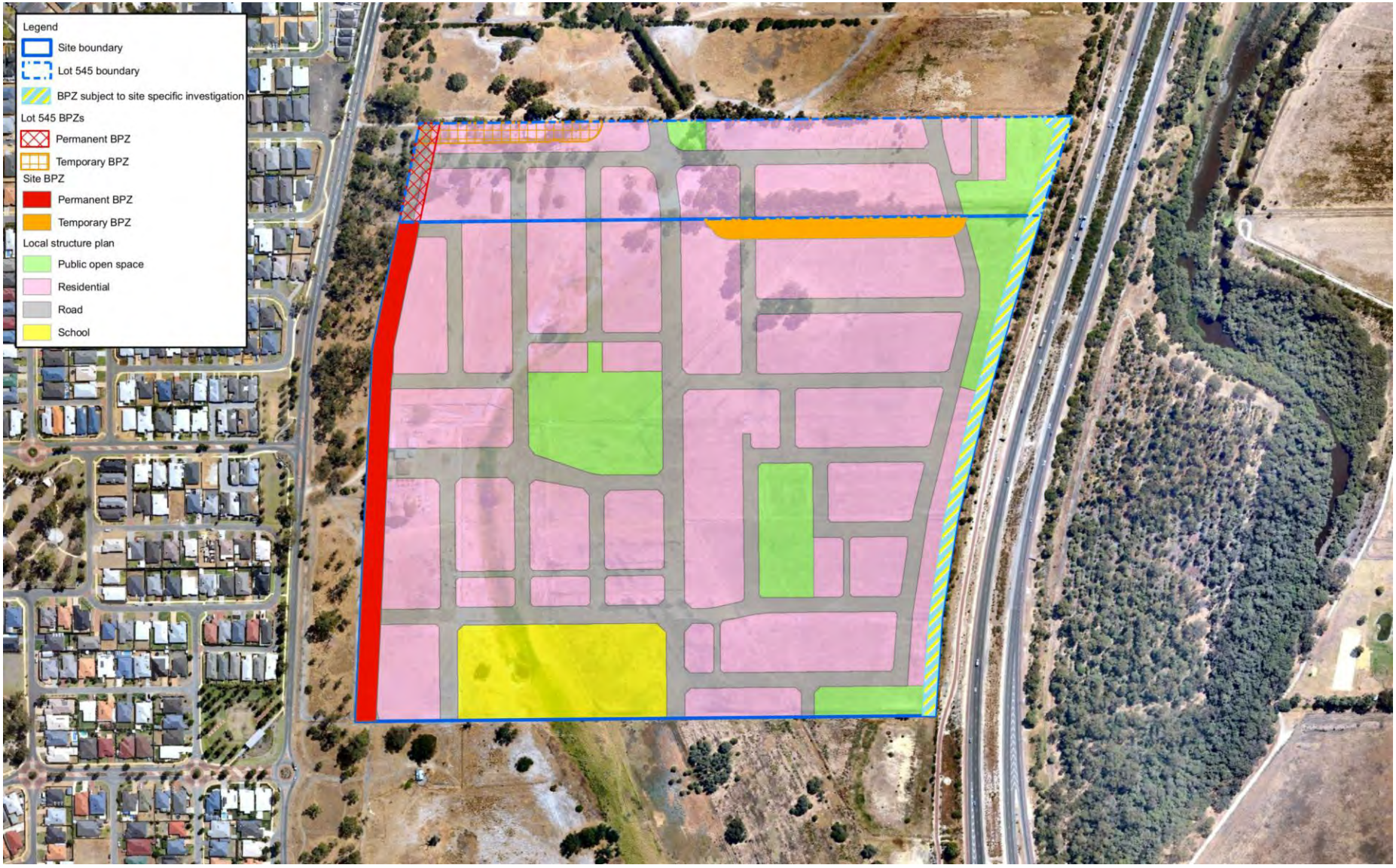
The structure plan enables opportunities for a higher standard of landscaping along two key streets:

- The main entry from Baldivis Road, where a combination of retained, mature trees and wider landscaped verges will promote a sense of place upon arrival, as well as forming a key view corridor from the entry road to POS A. Driveways will be designed such that they form a key part of the verge landscaping and promote an attractive, low speed environment.
- The north-south neighbourhood connector road that traverses the centre of the structure plan area provides sufficient width for an off-set carriageway and additional verge landscaping / planting to highlight the importance of the road, whilst also promoting a low speed environment with high quality landscaping throughout.

Indicative cross sections of these key streets, including indicative landscape concepts are depicted at Figure 14, while the detailed engineering design and landscaping schedule will be determined in consultation with the City at subdivision stage.

Further details on the street tree planting strategy are provided in Appendix 6.





Source: Emerge

2353-57-01 (02.10.2014), Not to scale

BUSHFIRE PROTECTION ZONES

Figure 15

3.3 Bushfire Management

The Structure Plan provides a comprehensive statutory and design response to address potential bush fire hazards and demonstrates that bushfire risk over the site can be managed through a combination of dwelling setbacks and construction standards, consistent with the State planning framework.

A Fire Management Plan (FMP) has been prepared by Emerge Associates to support the Structure Plan, refer Appendix 1. The FMP has been prepared in accordance with the WAPC's Planning for Bushfire Protection Guidelines and includes a detailed Bushfire Hazard Assessment. The Hazard Assessment demonstrates that the permanent bushfire threat and hazard will be restricted to vegetation surrounding the perimeter of the site, namely the remnant bushland to the west within the Baldivis Tramway Reserve and to a lesser extent, the intermittent vegetation within the Kwinana Freeway Reserve. Vegetation management and hazard mitigation within the Kwinana Freeway Reserve is being clarified with Main Roads and DFES to determine the long-term hazard implications however, the current agreed understanding is that Main Roads will reduce and maintain fuel loads at 8 tonnes per hectare of less, and will provide a minimum 3m wide cleared firebreak adjacent to the LSP boundary and within the freeway reserve, in accordance with the current operational policy.

Landholdings in the north only pose temporary hazards that will be removed as development progresses.

The FMP provides an indication of the setback distances required between dwellings and bushfire hazards (Building Protection Zone) to achieve a Bushfire Attack Level (BAL) rating of 29 or lower. The Structure Plan provides a Building Protection Zone (BPZ) of 20 metres from the western boundary of the Structure Plan, adjacent to the identified Tramway Reserve hazard. This 20m BPZ comprises of a combination of a minimum 15m wide road interface and building setbacks within the affected lots (to be controlled by Detailed Area Plans), refer Figure 15.

A 13m BPZ is required to the eastern boundary in response to the existing vegetation within the Kwinana Freeway Reserve. This requirement for a 13m BPZ will be subject to further discussions with Main Roads and FESA with regards to managing the fuel load within the Kwinana Freeway Reserve and will be further refined in the future BAL Assessment which will be prepared as a condition of subdivision approval.

Any dwellings that fall within 100m of the recognised Bushfire Prone areas will be subject to higher construction standards to mitigate any reduced setback distances consistent with Australian Standards. Development within these areas will need to be more closely examined at the subdivision design stage in the form of a BAL Assessment to determine whether higher dwelling construction standards or minor realignment of roads will be the most equitable outcome for the developer and prospective buyers in terms of providing adequate bushfire protection.

All areas of POS will be designed and landscaped to a 'low threat' standard under the Australian Standards and will not pose a bushfire hazard to development within the site.

Bushfire construction standards, including any increased front setback areas will be implemented via DAPs as a condition of subdivision approval.

3.4 Residential

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

The delivery of quality housing is a key objective for Mirvac, ensuring the housing style and character reflects the amenity and attributes of the area. Key to this is the delivery of housing that addresses and surveys public spaces, incorporation of solar passive design principles for private outdoor living areas and ensuring garages / carports are appropriately located. This will be implemented through Detailed Area Plans, discussed in section 3.4.3, as well as potentially via Design Guidelines (to be determined by the proponent).

3.4.1 Dwelling Yields and Density Targets

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

The Structure Plan has the potential to realise approximately 510-540 residential dwellings, at densities ranging from R25 to R40, based on the following principles:

- The majority of the Structure Plan area has a density code of R25, providing opportunities to deliver traditional front loaded lots, ranging in size from approximately 300 m² – 600 m².
- Medium density R40 coded lots are located adjacent to the school precinct and high amenity areas of public open space. This coding provides opportunities to deliver contemporary cottage style housing with front or rear lane access, as well as grouped / multiple housing options in appropriate locations. Single house lot sizes will generally range from 180 m² up to 360 m².

Directions 2031 and Beyond recommends a housing density target of 15 dwellings per gross urban zoned hectare. The need for density targets to encourage more efficient and effective housing is acknowledged. However, it is important that the application of these targets recognises the impact of site specific constraints and geographical context on the ability to actually deliver density.

The Structure Plan recognises the need to deliver specific densities and balances this with the recognition of the site specific land use constraints and in particular, the 2ha portion of the primary school located within the Structure Plan.

Once the school site is taken into consideration, the actual developable residential area is 2ha less than the gross urban area of 37ha.

In addition, consistent with the existing strategic planning framework, the Structure Plan does not include any provision for larger activity centres, rail stations or employment generators which would warrant a higher density response.

Notwithstanding the land use constraints, the Structure Plan delivers the potential for approximately 15 dwellings per gross urban hectare, once the 2ha primary school is deducted from the urban zoned area. This density is commensurate with the broader context in which the site is located.

Table 3 – Typical Lot / Dwelling Types

	Traditional Home Sites	Contemporary Front Loaded Lots	Compact Front Loaded Lots	Rear Loaded Cottage Lots
Typical Lot Width	17m+	10m - 17m	12.5m – 15m	7.5m – 10m
Typical Lot Depth	30m+	30m	20m - 25m	30m
Lot Area	500m²+	300m² - 500m²	250m² – 375m²	225m² - 300m²
Vehicle Access	Street	Street	Street	Rear lane
Typical Location	Mid block, end of block Areas that might require greater setbacks to address specific site constraints e.g. bushfire, traffic noise etc Typically located in areas with no specific density drivers	Mid block, end of block Typically where no specific density drivers Lot frontages are normally 'salt and peppered' along the street block to ensure streetscape amenity and housing diversity	End of street blocks, adjacent to POS, primary schools and other areas of high amenity Where more traditional module depths are not achievable	Adjacent to neighbourhood connectors and boulevards where street access is constrained. Adjacent to , schools and public open space to avoid driveway conflicts Directly abutting, high amenity POS.
Residential Density Code	Residential R25 - R30	Residential R25 - R30	Residential R30 – R40	Residential R40
Built Form Control	Residential Design Codes Design Guidelines (by developer)	Residential Design Codes Detailed Area Plans Design Guidelines (by developer)	Residential Design Codes Detailed Area Plans Design Guidelines (by developer)	Residential Design Codes Detailed Area Plans Design Guidelines (by developer)
Built Form Character and Delivery	Single dwellings Typically sold as land only	Single dwellings Typically sold as land only	Single dwellings Land only or house and land Appearance of traditional front loaded dwelling from the street	Single and grouped dwellings Typically built out and sold as a house and land package

3.4.2 Lot / Dwelling Types

A diverse mix of lot and housing typologies will be achieved. There may be opportunities for the proponent to build out pockets of medium density housing to deliver a range of housing types and amenity. Table 3 provides a brief description of the housing typologies that could be delivered within the Structure Plan area.

Source: Celebration Homes

Compact Front Loaded (15m x 20m)

Source: ABN

Contemporary Front Loaded (10m x 30m)
Source: Plunkett Homes

Contemporary Front Loaded (12.5m x 30m)

Rear Loaded Cottage (7.5m x 30m)

Table 4 – R-Code Variations

General Variations (single houses R30 – R40)

- Primary Street Setback - 2.0m minimum - 4.0m maximum
- Garage Setback - 4.5m minimum.
- Garage doors, and supporting structures, not to exceed 50% of the frontage at the setback line as viewed from the street (can be increased to 60% for two storey dwellings, as per clause 5.2.2 of R Codes).
- Rear-loaded Garage Setback - 0.5m to Laneway.
- Lots with a street frontage of 10m a double garage may be permitted subject to it being setback a minimum of 1m behind the main building line of the dwelling, the front door and major opening to a habitable room of the dwelling is to be visible to the street, and two or more of the following be provided to the front elevation:

  a) Portico attached to the front of the dwelling
  b) Porch with a separate roof
  c) Veranda
  d) Gable / gablet
  e) Projecting sill courses and / or contrasting sills
  f) A feature blade wall, or feature wall of contrasting colours or materials

Nil Setback Boundary Wall Variations

Rear-Loaded lots less than 350m² - walls not higher than 3.5m, with an average of 3m, for 75% of the length of the boundary to both sides.
Front-loaded lots - as per R Codes or clause 5.6 of PP 3.3.20.

Solar Access

R Codes requirements removed, other than where a property abuts a lot greater than 350m² in which case R Code requirements apply.

Open Space Variations (by lot size)

Less than 180m²	180m² - 220m²	221m² - 260m²	261m² - 375m²	More than 375m²
30% open space subject to minimum 16m² outdoor area living with 4m minimum dimension.	30% open space subject to minimum 20m² outdoor living area with 4m minimum dimension.	Lots with depth greater than 25m - 30% open space subject to minimum 24m2 outdoor living area with 4m minimum dimension. Lots with a depth of 25m or less - 35% open space subject to an outdoor living area being provided that has a minimum total area of 30m² with a minimum uncovered portion of 20m² subject to satisfying all other provisions of Part 5.3.1 of the R-Codes.	Lots with depth greater than 25m - 35% open space subject to minimum 24m2 outdoor living area with 4m minimum dimension. Lots with a depth of 25m or less - 40% open space subject to an outdoor living area being provided that has a minimum total area of 30m² with a minimum uncovered portion of 20m² subject to satisfying all other provisions of Part 5.3.1 of the R-Codes.	As per R Codes.

PRELIMINARY

3.4.3 Detailed Area Plans

Detailed Area Plans (DAPs) will be prepared as condition of subdivision approval for select lots to ensure appropriate noise and / or bushfire mitigation measures. DAPs will also assist in delivery of quality built form and allow for variations to the 'deemed to comply' criteria of the Residential Design Codes in order to facilitate affordable medium density housing. It is envisaged that a single DAP will be prepared over the entire Structure Plan area and will include provisions for:

- Where it is desirable to provide enhanced streetscapes for R25 - R40 coded lots;
- All lots accessed via a rear lane;
- All lots with an area less than 375m²;
- Lots directly abutting public open space;
- Lots deemed to be affected by freeway noise; and
- Lots designated as Bushfire Prone.

A series of R Code variations have been developed to support the delivery of the standard medium density housing typologies as described in the previous section. These variations have been workshopped extensively with the building and development industry and are now prevalent across the large majority of new urban areas in Perth. The variations have since been further refined in conjunction with the City of Rockingham, resulting in an agreed set of R-Code provisions that will address the shortcomings of the R-Codes for delivery of medium density housing, whilst still addressing the City's objectives around streetscapes and site cover.

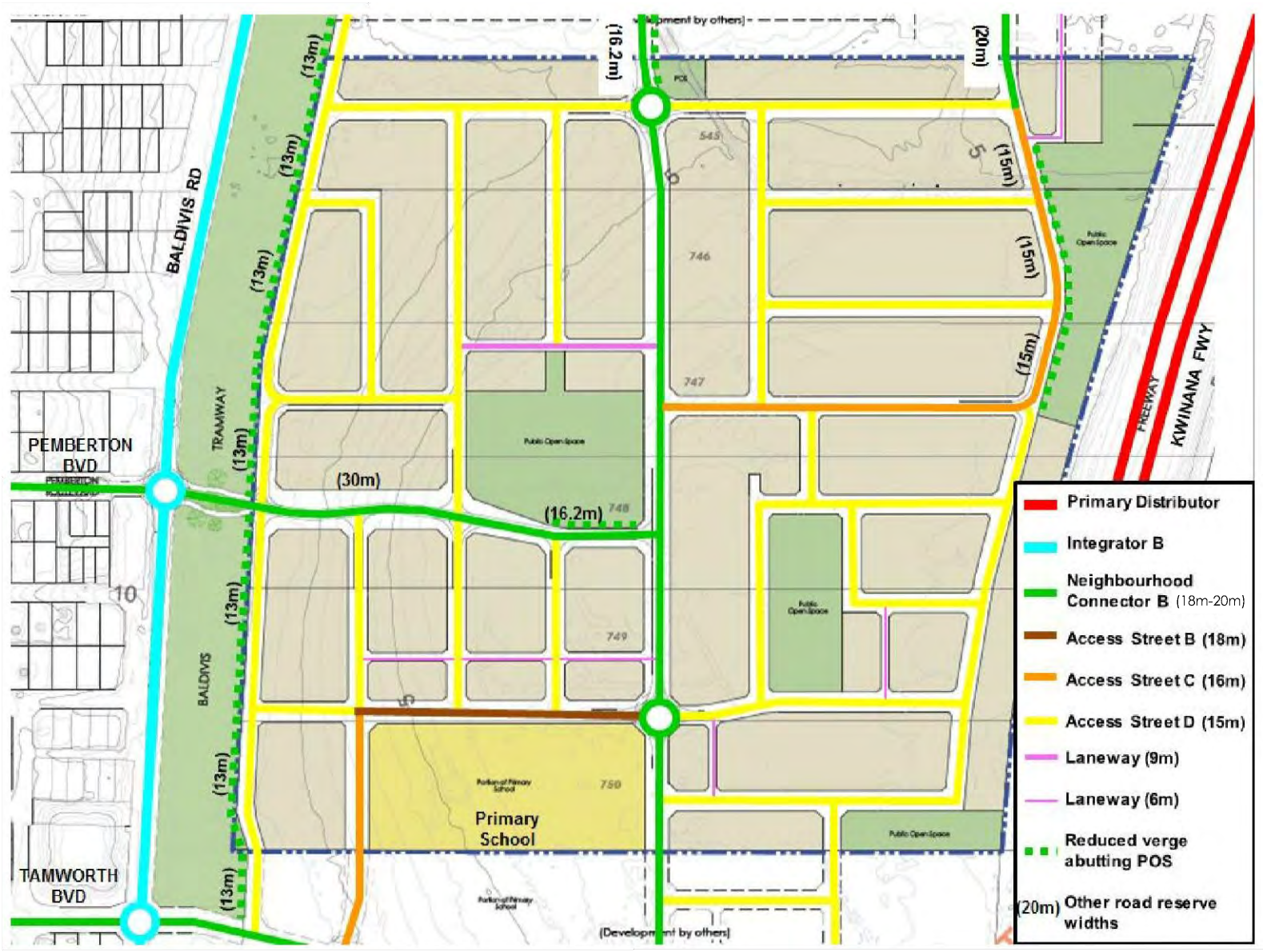
These provisions are subject to further discussion and refinement to determine optimum built form outcomes for the development and DAPs will require approval by the local authority at subdivision stage.

Table 4 provides an overview of the likely key R-Code variations as workshopped and agreed with the City of Rockingham.

These variations are a reasonable representation of the likely R-Code variations that will be incorporated into DAPs at subdivision stage and facilitate the efficient and timely delivery of affordable, medium density housing within the Structure Plan area.

As well as varying provisions of the R-Codes, the DAPs will include specific design provisions for lots that share a rear or side boundary with public open space. These specific design provisions will include:

- A requirement for visually permeable fencing for the full length of a rear boundary and for 2/3 of the length of a side boundary to encourage passive surveillance;
- A requirement for an outdoor living area and/or major openings to habitable rooms to address the open space;
- A restriction on clothes drying areas and external fixtures such as plumbing installations; and
- Mandatory setbacks to POS boundaries to promote an approachable interface.



Source: Transcore

2353-43A-01 (26.09.2014), Not to scale

ROAD HIERARCHY PLAN

Figure 16

3.5 Movement Networks

A Transport Assessment has been prepared by traffic consultants, Transcore, to identify projected traffic volumes and suggested road hierarchies in and adjacent to the site, refer Appendix 6.

The Transcore assessment is entirely consistent with the land use and traffic principles established via the EBDSP, as well as the local structure plans for the areas to the north and south of the Structure Plan area and refines these principles to produce a more comprehensive overview of the traffic network. The key findings are summarised in the following sections.

3.5.1 Regional Road Network

The Structure Plan and broader East Baldivis cell is well supported by an existing and planned regional road network, including:

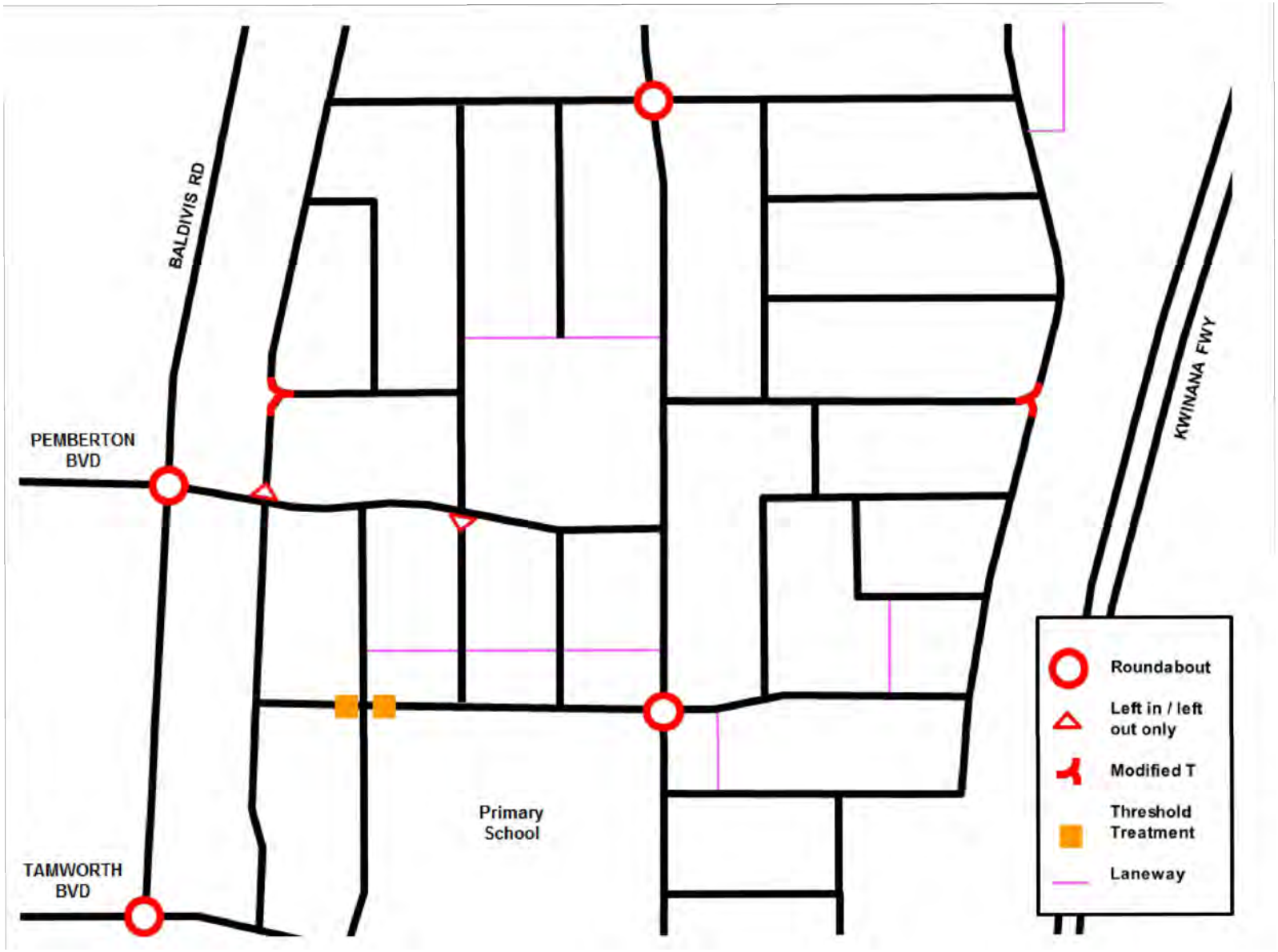
- **Kwinana Freeway** is classified as a Primary Distributor and is reserved as a Primary Regional Road under the MRS. It is currently constructed as dual 2-lane carriageways where is abuts the Structure Plan and has a posted speed limit of 100km/h. The closest freeway interchanges are at Safety Bay Road approximately 500m south of the Structure Plan area and Mundijong Road approximately 2.8km north of the Structure Plan area.
- **Safety Bay Road** and **Mundijong Road** provide key east-west links connecting key employment areas to the Kwinana Freeway. Both roads are reserved as Other Regional Roads under the MRS.
- **Baldivis Road** abuts the western boundary of the Structure Plan area and is constructed as a single carriageway, two-lane, rural road. It provides north south access through Baldivis for connections to the Kwinana Freeway at Mundijong Road, Safety Bay Road and Karnup Road. Baldivis Road currently carries approximately 6,500 vehicles per day. Consistent with the EBDSP, Transcore identifies Baldivis Road as a future Integrator B road, ultimately carrying approximately 10,800-11,100vpd adjacent to the Structure Plan area.
- **Nairn Drive** is planned to form the main north-south district distributor road through Baldivis and Karnup and is reserved as 'Other Regional Road' (also referred to as a blue road) under the MRS.

The Structure Plan recognises and respects the planned regional road network and ensures that its operation will not be unduly compromised through the inclusion of excessive traffic volumes or vehicle access points.

3.5.2 District, Neighbourhood and Local Road Network

The Structure Plan proposes a comprehensive district, neighbourhood and local road network that is consistent with the EBDSP and Liveable Neighbourhoods, refer Figure 16 - Road Hierarchy Plan. The Structure Plan road network is based on the following key principles:

- Identification of Baldivis Road as an Integrator B road, with a forecast daily traffic volume of 10,800-11,100vpd adjacent the Structure Plan area at full development.



Source: Transcore

2353-44-01 (26.08.2014), Not to scale

INTERSECTION TREATMENTS

Figure 17

- A north-south Neighbourhood Connector B road that connects with the adjoining land to the north and south, serving a key transport linkage within East Baldivis and providing an important connection to the primary school site. This Neighbourhood Connector B road is forecast to carry approximately 1,150 vpd at full development and has an indicative reserve width of 18m consistent with Liveable Neighbourhoods standards.
- A second north-south road that connects to the easternmost Neighbourhood Connector Road identified on the Structure Plan to the north, ensuring good permeability through the Structure Plan area and providing direct connections to the education precinct to the north. This road is forecast to carry relatively low traffic volumes of less than 1,000 vpd and as such, is classified as a local access street C consistent with Liveable Neighbourhoods.
- A single access point to Baldivis Road at Pemberton Boulevard towards the centre of the Structure Plan area. This will form the main access to the Structure Plan area and will be controlled by a four-way roundabout linking in to Pemberton Boulevard. Further intersection analysis is provided in Section 3.7.3 below.
- A permeable grid of local access streets with reserve widths of 15m-18m consistent with Liveable Neighbourhoods, including higher order access streets surrounding the northern and eastern periphery of the planned primary school. The precise location and alignment of local access streets will be determined at subdivision stage as part of further detailed design.

3.5.3 Intersection Analysis

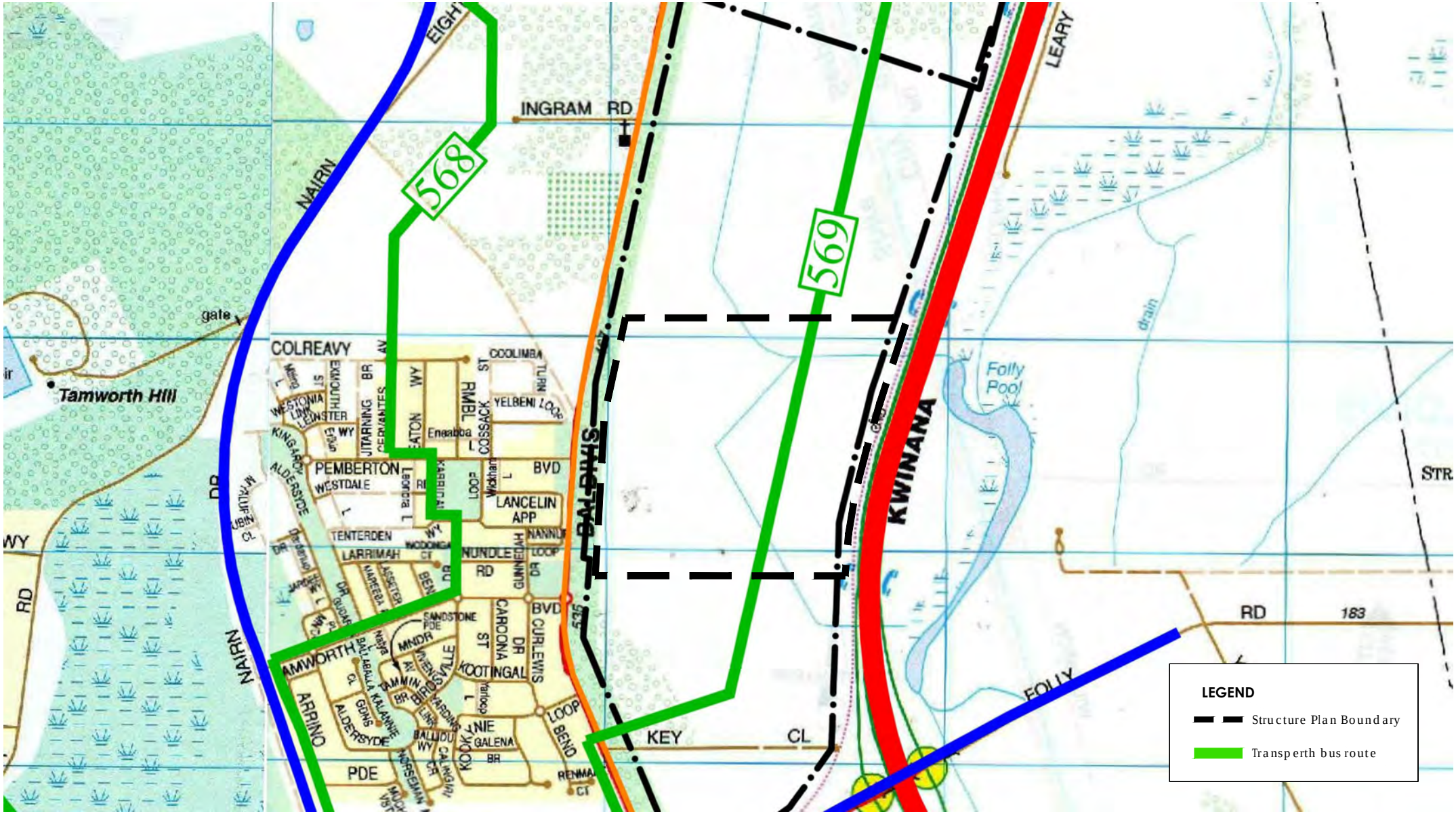
The Transport Assessment at Appendix 6 includes a detailed analysis of each of the key intersections proposed in the Structure Plan. A plan depicting the key intersection treatments is Figure 17, whilst the key recommendations of Transcore's analysis are summarised below.

Baldivis Road Intersections

The Structure Plan provides safe and efficient access to the regional road network via Baldivis Road. Access to the Structure Plan area will be provided by one 4-way intersection with Baldivis Road linking into the existing Pemberton Boulevard – consistent with the access arrangements detailed in the endorsed EBDSP. This intersection will be roundabout controlled, ensuring safe and efficient vehicle movements to and from the Structure Plan area.

Capacity analysis of this intersection has been undertaken by Transcore using the SIDRA computer software package.

The SIDRA analysis indicates that the proposed roundabout at the intersection of Baldivis Road/Pemberton Boulevard will operate satisfactorily in both peak periods upon full development of Baldivis. This roundabout will operate at level of service (LOS) A or B overall (the best possible level of service in this type of analysis) and the through movements on Baldivis Road will all operate efficiently with minimal queuing delays during peak periods.



Source: Baldivis Road Study Update, January 2012

2353-48-01 (28.08.2014), Not to scale

PLANNED PUBLIC TRANSPORT ROUTE

Figure 18

Internal Intersections

The precise nature and function of all internal intersections will be determined at the detailed design stage once the location and alignment of local roads is determined. At present, roundabouts are proposed at two internal four-way intersections to manage turning traffic flows and assist with speed management adjacent to the primary school.

The use of Pedestrian Access Ways has been avoided as they are not supported by the City of Rockingham,

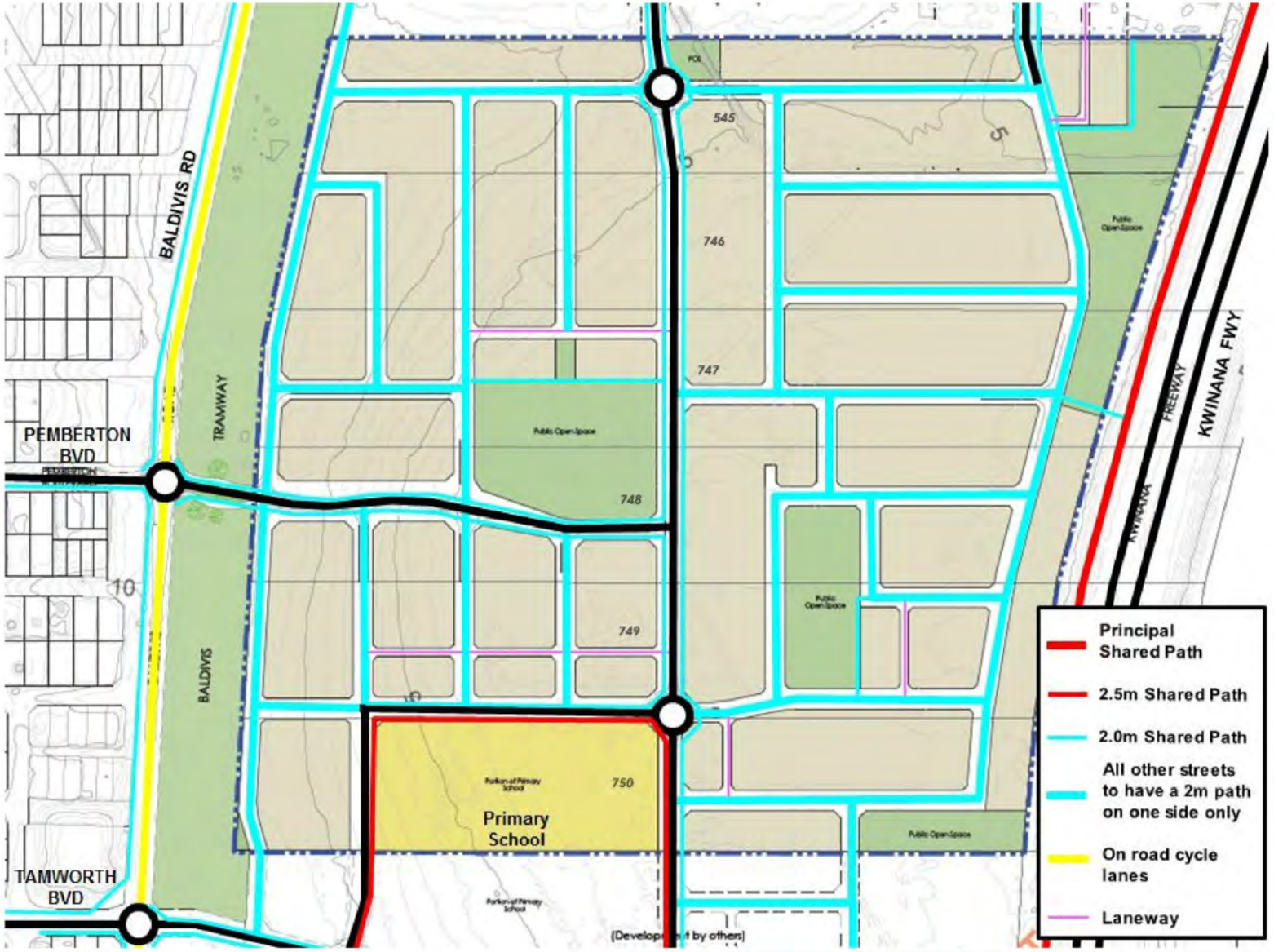
The Structure Plan includes two additional four-way intersections on the east-west entry road to provide a road interface to the Tramway Reserve, and promote pedestrian connectivity to the primary school. It is proposed that one side road at each intersection will be restricted to 'left in – left out' via a 'seagull island' treatment or similar.

All intersection spacings and treatments will be consistent with Liveable Neighbourhoods requirements, with detailed design to be confirmed at subdivision stage.

3.5.4 Public Transport

The Structure Plan road network is capable of supporting an internal bus network consistent with that identified as part of the EBDSP. The planned north-south Neighbourhood Connector B road provides sufficient pavement and reserve width to accommodate future bus-related infrastructure commensurate with the surrounding urban environment.

A proposed future bus route is proposed along the north-south Neighbourhood Connector road as identified in the Transperth Service Development Plan prepared by the Public Transport Authority, refer Figure 18. The bus route is currently shown as terminating immediately south of Zig Zag Road however, this route will need to be extended north through the Structure Plan area and connect with Baldivis Road. Approximately two-thirds of the land area within the Structure Plan will be within a 400m walkable catchment of this future bus route. It is understood that additional bus services in the area will be added once a sufficient population is established and a demand generated that warrants such services.



Source: Transcore

2353-45-01 (26.08.2014), Not to scale

PEDESTRIAN AND CYCLIST NETWORK

Figure 19

3.5.5 Cycling and Pedestrian Movement

The Structure Plan delivers a highly permeable road network, creating excellent opportunities for the provision of good pedestrian and cyclist facilities that maximise use of non-motorised transport modes. Figure 19 outlines the proposed pedestrian and cyclist network for the Structure Plan area.

The precise location and alignment of footpaths and shared paths will be determined in consultation with the City of Rockingham as part of detailed civil design following subdivision approval and will generally be provided in accordance with the following principles:

- Paths will generally be provided on at least one side of all roads to a minimum width of 2.0m.
- 2.5m wide paths will be provided in high pedestrian traffic locations such as adjacent the proposed schools.
- There will be paths on both sides on Integrator Arterial and Neighbourhood Connector roads.
- A shared path will be provided within the Tramway Reserve parallel to Baldivis Road, and will connect to the development cells to the north and south.
- Consistent with Liveable Neighbourhoods, there are no formalised on-street cycle lanes within the Structure Plan area. On-street cycle lanes are normally included on Integrator A, Integrator B and Neighbourhood Connector A roads – none of which are proposed as part of this Structure Plan.
- Opportunities to connect with the existing principal shared path along the western side of the Kwinana Freeway will be considered at subdivision stage.

Source: Lloyd George Acoustics

2353-46-01 (26.08.2014), Not to scale

NOISE MITIGATION MEASURES

Figure 20

3.6 Acoustic Considerations

As noted above, the Structure Plan shares a boundary with the Kwinana Freeway to the east which is a Primary Regional Road. The Freeway carries significant levels of traffic and, in accordance with State Planning Policy 5.4, the impacts of traffic noise must be taken into consideration.

A Transportation Noise Assessment has been prepared by Lloyd George Acoustics in support of the Structure Plan, a copy of which is included as Appendix 2. The report concludes that traffic noise is not a constraint to development, subject to the inclusion of some noise mitigation treatments as part of the ongoing development of the Structure Plan area. These noise mitigation measures are depicted at Figure 20 and include:

- Construction of a 2.2m – 3.0m high noise wall along the eastern boundary of the Structure Plan abutting the Kwinana Freeway;
- A statutory provision requiring those lots that are deemed to exceed the 'target' noise level to have a notification placed on title at subdivision stage advising of a noise hazard; and
- A statutory provision requiring dwellings located on those lots exceeding the 'target' noise level to incorporate 'Package A' quiet house design treatments, as set out in Appendix 2.

The Package A quiet house design requirements will be implemented via DAPs as a condition of subdivision.

3.7 Water Management

The Structure Plan provides a comprehensive planning and design response to address all aspects of urban water management. A Local Water Management Strategy (LWMS) has been prepared by RPS and is included as Appendix 4 to the Structure Plan. The LWMS addresses the requirements of the WAPC's Better Urban Water Management Guidelines and is a refinement of the existing regional and district level water strategies for this area.

3.7.1 Existing Water and Drainage Strategies

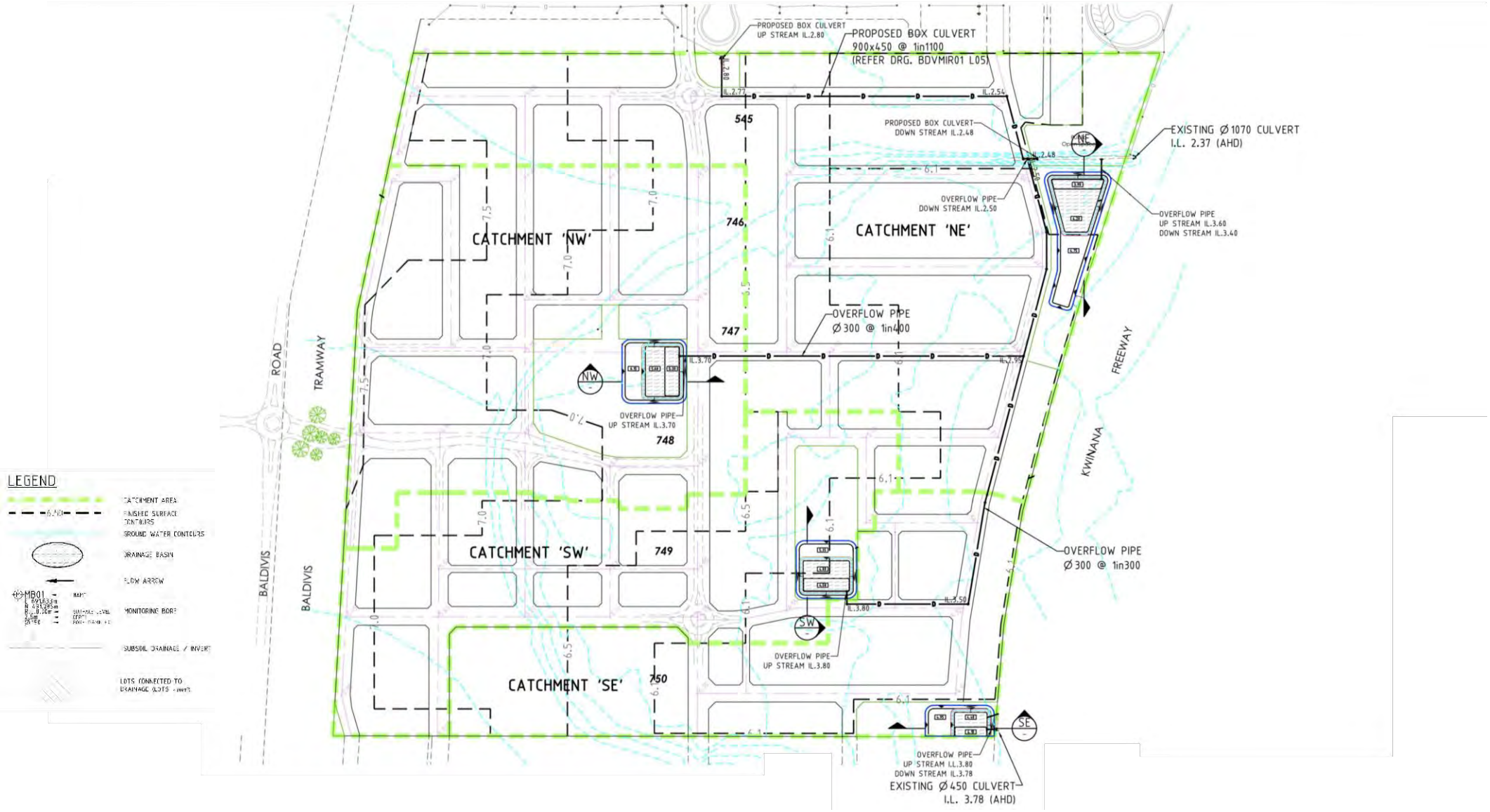
Serpentine River Floodplain Management Strategy (SKM, 2010)

Sinclair Knight Merz was commissioned by Department of Water to develop a floodplain Management Strategy (FMS) for the Serpentine River in the areas of Serpentine, Baldivis, Karnup and Keralup. The LWMS is consistent with the relevant principles of the FMS.

North East Baldivis District Water Management Strategy (Parsons Brinkerhoff, 2007)

The East Baldivis DWMS was prepared in support of the East Baldivis District Structure Plan and has been endorsed by the Department of Water.

The LWMS has been prepared in accordance with the key objectives and principles of the DWMS and refines these principles to a local scale consistent with the WAPC's Better Urban Water Management Guidelines.



Source: Development Engineering Consultants

2353-49A-01 (26.09.2014), Not to scale

LOCAL WATER MANAGEMENT CATCHMENT PLAN

Figure 21

3.7.2 Predevelopment Conditions

The Structure Plan is located within the Peel Estuary–Serpentine River Catchment and Peel Main Drain Sub-Catchment. The Peel Main Drain (PMD) is situated east of the site which drains stormwater run-off from the catchment into the Serpentine River and ultimately the Peel–Harvey Estuary.

The existing topography of the Structure Plan area is generally flat, with elevations between approximately 9.0m AHD adjacent to Baldivis Road and 3.5 m AHD towards the freeway. The site has one main open drain, the Sub F branch drain, traversing the lower lying central and south-eastern sections of the site. Surface water runoff from the majority of the site is captured by this branch drain and flows through one of two culverts under the Kwinana Freeway.

Adjacent to the northern boundary of the Structure Plan area, (within existing Lot 545) contains the Sub H branch drain, which conveys drainage from all the existing rural lots north of the site to Zig Zag Road. The Sub H branch drain flows east through the same 1050 mm diameter culvert under the Kwinana Freeway.

The site is affected by the 1 in 100 year flood levels of the Serpentine River/ Peel Main Drain and as such the finished floor level will be set at a minimum of 500mm above this level. Early advice received from the Department of Water indicated flood levels adjacent to the site could be as high as 5.6m AHD, however recently revised flood modelling has determined more accurate flood levels of around 4.5m AHD in this locality.

3.7.3 Surface Water Management

Surface water management within the Structure Plan area will be consistent with Better Urban Water Management best practice and the City of Rockingham's standards / requirements.

The LWMS proposes to divide the Structure Plan area into a number of internal surface water catchments. Each catchment will maximise opportunities for infiltration where possible with the aim to reduce nutrient export from the site. A street based piped network will convey road generated runoff to POS areas within each internal catchment with the 1 yr ARI events being retained onsite and infiltrated, via bio-retention areas, as close to source as possible. A Local Water Management Catchment Plan is Figure 21.

Events greater than the 1 year ARI will be managed within the greater swales and basins located in each catchment's POS area. Outflow in a major storm event (100yr ARI) via a controlled outlet, will be directed back into the road drainage network before leaving the site by one of two existing culverts that direct water under the freeway and into the Peel Main Drain. One culvert is located in the north eastern corner of the site, where outflows will be firstly directed through a portion of the Sub H drain within the adjacent Lot 545 and the other in the south eastern corner.

3.7.4 Groundwater Management

Annual Average Maximum Groundwater (AAMGL) levels range from between 3.5 to 4.4m AHD accross the site. The LWMS proposes that a subsoil drainage system will be installed within the imported fill to manage any post development rise in groundwater levels. A groundwater model has been undertaken to demonstrate the performance of the proposed subsoil system and to accurately determine a Controlled Groundwater Level for the site. The Groundwater Model Report has been included as part of the LWMS. The subsoil system will have free flowing outlets into the swales and basins located within the POS areas. As well as incorporating water quality treatment through the use of quality fill materials within the subsoil trenches, subsoil outlets will discharge into the bio-retention areas located within the swales and basins.

3.7.5 Monitoring and Implementation

Consistent with best practice, groundwater monitoring will be undertaken monthly for levels and quarterly for quality for a period of three years post development. The same parameters required during pre-development will be analysed and if possible, existing onsite bores will be retained in the same or very similar locations for post-development use.

The post-development surface water monitoring program will include opportunistic sampling and analysis of water quality at the basin and swale locations throughout the development. Additional detail of the post-development monitoring plan will be provided in future UWMPs for the site.

3.7.6 Water Conservation

The State Water Plan (2007) is a strategic policy and planning framework to meet the State's water demands to the year 2030. One of the key targets is to reduce potable water consumption to 40 KL–60 KL per person per year. In order to meet this target, several water saving initiatives to reduce potable water use will be investigated and implemented where practical within the development. Potential options currently being considered include the following:

- the provision of a waterwise landscaping package for buyers encouraging the use of minimal turfed areas and the use of species with low water requirements
- the provision of educational material to buyers regarding appropriate irrigation operation and hydro-zone planting
- installation of AAA water efficient appliances including but not limited to washing machines, toilets and taps.
- Non-potable groundwater will be utilised for construction management purposes and the irrigation of public open space.

PRIMARY SCHOOL CONCEPT

2353-47-01 (26.08.2014), Not to scale

Figure 22

3.8 Education Facilities

The Structure Plan recognises that education facilities form an important part of the community infrastructure provision within the Structure Plan area and provide a focal point for the surrounding residential community.

The EBDSP establishes the number and distribution of primary and secondary schools throughout the DSP area. This distribution has been confirmed in consultation with the Department of Education, with the school sites being centrally located within the surrounding catchment, consistent with Liveable Neighbourhoods.

3.8.1 High Schools

The EBDSP identifies a 9ha public high school site adjacent to Zig Zag Road, approximately 1.5km - 2km north of the Structure Plan area. It is intended that this high school will service the Structure Plan area at ultimate development. In the interim period until this high school is developed, residents of the Structure Plan area have convenient access to the existing public high school to the south of Safety Bay Road within the 'Rivergums' estate.

3.8.2 Primary Schools

The EBDSP identifies three public primary schools within the DSP area, distributed evenly along a north-south axis. A portion of the southernmost primary school site is shown within the Structure Plan area, with the balance of the site shared within the landholding to the south of the Structure Plan.

Consistent with the EBDSP and as agreed with the City of Rockingham and Department of Education, the Structure Plan provides a 2ha portion of the 4ha primary school site, with the balance to be provided by the landowners to the south, refer Figure 22 – Primary School Concept.

3.9 Activity Centres and Employment

The Structure Plan area has excellent access to nearby activity centres and employment opportunities, as recognised by the EBDSP.

The Structure Plan is located approximately 1km from the Baldivis Town Centre – a 'District Centre' as designated via State Planning Policy 4.2 – Activity Centres for Perth and Peel. The Baldivis District Centre will provide for the day to day retail and community needs of future residents of the Structure Plan area, as well as providing employment opportunities for a small proportion of the population. The Rockingham Strategic Metropolitan Centre and Kwinana Secondary Centre are also easily accessible to the Structure Plan area and will provide for a wider range of commercial, community and employment opportunities.

There are a number of major existing employment nodes in the Rockingham and Kwinana areas including the Western Trade Coast, Kwinana Industrial Area, Australian Marine Complex and Jandakot airport. In addition, there are expansive areas of planned industrial development including Latitude 32 industrial area, North-East Baldivis and East Rockingham. Development of the Structure Plan area is a logical solution to increasing the local employment catchment, which is critical to achieving the employment self sufficiency targets set by Directions 2031 and Beyond.

Given the proximity to and accessibility of the Baldivis District Centre, along with the limited residential catchment provided by the Structure Plan, there is little forecast demand for any local retail / commercial facilities within the Structure Plan area. This is recognised in the EBDSP, which does not allow for any local activity centres in the southern portions of the DSP area.

3.10 Infrastructure Coordination, Servicing and Staging

Civil engineering consultants Development Engineering Consultants have prepared a detailed earthworks and servicing strategy (the Strategy) demonstrating the availability of service infrastructure to the Structure Plan area. The strategy is summarised below and is provided in full as Appendix 5. The Strategy demonstrates that essential services are readily available and the provision of services to the Structure Plan area is not a constraint to development.

Further detailed infrastructure planning and design will occur in consultation with appropriate agencies as the planning and development of the land progresses.

3.10.1 Earthworks

Like the rest of the East Baldivis cell, the final earthworks levels for the site are determined via a detailed combination of geotechnical, hydrological, planning, environmental, engineering design and market factors.

The site currently slopes from 9m AHD on the western boundary down to approximately 4m AHD over a transition distance of approximately 150m. The site then levels off with the 4m AHD height continuing to the eastern boundary. It has previously been understood that the Structure Plan area is affected by the 1 in 100 year flood level (5.6m AHD) adjacent the Peel Main Drain. Accordingly it has previously been determined that the site is required to be filled to a level of approximately 6.1m AHD so that development levels are set 500mm above the 1 in 100 year flood level. The Department of Water has recently produced a revised flood study which reduces the 1 in 100 year flood level by approximately 1.1m. Due to the advanced nature of gravity sewer planning and construction in the broader area, it is not feasible to reduce the finished fill levels. The Structure Plan area will therefore continue to be filled to a level of 6.1m AHD at certain points to facilitate drainage requirements and sewer construction. The Structure Plan area will be relatively flat with minor level differences resulting from road, sewer and drainage design.

Given the low-lying nature of certain portions of the Structure Plan area, remedial works are required to be undertaken prior to importing fill onto the site to address the presence of Acid Sulphate Soils (ASS). Importantly, the remediation works proposed are not uncommon and will involve a process of deep dynamic compaction to stabilise the soils which involves minimal disturbance of the soil and remediation of the ASS. The Structure Plan area is expected achieve an 'A' soil classification and the presence of ASS is not an impediment to development.

Market forces also presently dictate the provision of flat building sites with retaining walls to accommodate level differences with low retaining walls to be installed where necessary. Slightly higher retaining walls (up to 1.5m) may be required abutting POS however, where this does occur, DAP's will be implemented to ensure visually permeable fencing on top of the retaining walls and surveillance of the POS.

3.10.2 Electrical Supply

Existing overhead high voltage infrastructure located in Baldivis Road will be utilised to provide a high voltage power supply to the Structure Plan area.

All internal power reticulation lines and transformer installations will be constructed at the cost of the developer. Transformer and switch station sites will be determined at the detailed subdivision design stage to Western Power's satisfaction.

3.10.3 Water Supply

Water supply to the structure plan area will be obtained from an existing 300mm water main that within the Baldivis Road reserve.

Internal reticulation mains will be designed to Water Corporation standards to complete links through the site to the adjoining developments to the north and south.

3.10.4 Wastewater

The Structure Plan area is included within the Water Corporation's current waste water planning for the Baldivis area, with the Water Corporation recently confirming that they are prepared to support urban development within East Baldivis on the understanding that the new Waste Water Treatment Plant (WWTP) in East Rockingham will be operational by the end of 2015, which is commensurate with the timing of development of the Structure Plan area.

The Structure Plan area falls within two sewer catchments, each discharging to a wastewater pump station. The northern half of the site will be serviced by the Baldivis North pump station "I" north of the adjoining Australand development. Arrangements have been made with Australand to extend the sewer to their southern boundary to allow for a connection to Mirvac's land that will service the northern portion of the Structure Plan area. Based on the timing of this connection, the northern portion of the Structure Plan area will be the first stage of development.

The southern portion of the Structure Plan area, which will most likely form the latter stages of development, will be serviced by a pump station located immediately south on the adjoining land, which is currently being developed by Perron Developments Pty Ltd and is subject to a separate structure plan. The pump station on the Perron land will ultimately extend into a 225mm sewer extended north through the Structure Plan area to the Australand site.

3.10.5 Telecommunications

The structure plan area is expected to be serviced by the National Broadband Network for internet and telephone services. Capacity to provide these services exists from Baldivis Road and adjacent development which may require minor extensions to facilitate a connection.

3.10.6 Gas

Gas services are located within the Baldivis Road reserve and the adjacent development will have sufficient capacity to serve the area with minimum augmentation.

Lots 746-750 & 545 Baldivis Road

Structure Plan

Part Three - Technical Appendices

October 2014

LOTS 746 - 750 & 545 BALDIVIS ROAD STRUCTURE PLAN

TECHNICAL APPENDICES

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Project No: 2353Rep16C - Technical Appendices

October 2014

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APPENDIX 1:

Fire Management Plan - Emerge Associates

emerge ASSOCIATES
Integrated Science & Design

Bushfire Safety CONSULTING

FIRE MANAGEMENT PLAN

Local Structure Plan

Lots 746-750 Baldivis Road
Baldivis
City of Rockingham

October 2014
Prepared for Mirvac (WA) Pty Ltd
(Revision B)

This report has been prepared by Bushfire Safety Consulting in collaboration with Emerge Environmental Services Pty Ltd (trading as Emerge Associates).

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Revision: B
October 2014 - updated after comment from client

Prepared for: Mirvac (WA) Pty Ltd

Site: Lots 746-750 Baldivis Road, Baldivis

Front cover photo: Aerial photograph of development site

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EXECUTIVE SUMMARY

This Fire Management Plan (FMP) has been prepared to support the preparation of a Local Structure Plan (LSP) for Lots 746-750 Baldivis Road, Baldivis. This area is herein referred to as "the site" and its location is shown in **Appendix 1**. The site is approximately 30.5 hectares (ha) in size and is located approximately 44 km south of the Perth Central Business District (CBD) within the City of Rockingham. The LSP also includes Lot 545 Baldivis Road (herein referred to as "Lot 545") which is located immediately north of the site, and has been included in this FMP. Lot 545 is approximately 6.5 ha in size.

The site and Lot 545 have historically been cleared for broad scale agricultural purposes and are now largely characterised by extensive coverage of pasture weed species and limited remnant vegetation (as shown in **Appendix 2**). The site is bounded by the City of Rockingham's Tramway Reserve to the west, the Kwinana Freeway to the east, and by land zoned 'Urban' and intended for future urban development to the north and south.

The purpose of the FMP is to outline potential bushfire risk that is likely to apply to the site and determine whether the LSP provides for future development that will support acceptable solutions and responses to the bushfire risk.

The proposed LSP (shown conceptually in **Appendix 3**) provides a guide for residential development within the site and creates a framework for the future urban subdivision of the site into anticipated residential lots, part of a school site and areas of public open space (POS).

There are separate structure planning processes currently underway for landholdings immediately north and south of the site, consistent with the broader East Baldivis District Structure Plan (DSP).

The site is currently zoned "Rural" under the City of Rockingham's Town Planning Scheme No. 2 (TPS No. 2) and "Urban" under the Metropolitan Region Scheme (MRS).

Following development, the site will be completely cleared of vegetation to facilitate development and the majority of remnant vegetation surrounding the site to the east and west will remain and will therefore pose varying bushfire hazards to dwellings within the site. Landholdings to the north and south of the site are intended for future urban development in accordance with the approved East Baldivis DSP and therefore pose only temporary bushfire hazard considerations.

All areas within 100 metres (m) of the site boundary have been assessed for vegetation classification and bushfire hazard rating levels. It has been determined, through an indicative Bushfire Attack Level (BAL) assessment, that all proposed future dwellings arising from the LSP will fall within the acceptable level of risk. Permanent bushfire hazard considerations are posed by the remnant vegetation within the Tramway Reserve adjacent to the western boundary of the site, and by vegetation within the Kwinana Freeway road reserve adjacent to the eastern boundary of the site. It is understood that more detailed plans and implementation budgets are currently being prepared by the City of Rockingham for the entire length of the Tramway Reserve which will outline specific landscaping and vegetation retention outcomes, however the post development hazard assessment in this report has been based on the following scenario: remnant woodland/forest vegetation currently within the reserve is effectively retained/enhanced as per existing site conditions

and all other areas are treated as managed parkland and therefore low threat vegetation types.

Future management of the Tramway Reserve and Kwinana Freeway reserve may alter the hazard ratings associated with these areas of vegetation (should fuel loads be increased or decreased) and mitigation responses may need to be revisited as part of future subdivision applications. Ongoing discussions with the City of Rockingham and Main Roads regarding the management of fuel loads within the Tramway Reserve and Freeway reserve respectively aim to ensure that development within the site is not exposed to any long term preventable risk.

Any new dwellings constructed within 100 m of identified classified vegetation will require consideration of the need for increased construction requirements to address *AS3959 Construction of Buildings in Bushfire Prone Areas*. In order to pre-empt this requirement, a detailed and site specific BAL assessment will be undertaken as part of the subdivision process to confirm the final BAL ratings for each individual new lot created. BAL ratings **should not** be determined for future lots at the LSP stage, as the ultimate lot locations/boundaries will be determined through the subdivision process, and temporary hazards (or even hazards that were expected to be permanent) may not remain at that time, particularly within neighbouring sites currently undergoing separate planning and approvals processes for future urban development as well as within the adjacent Tramway Reserve and Kwinana Freeway reserve. An indicative BAL assessment has been included in this report in order to demonstrate that no areas within the proposed LSP are exposed to an unacceptable level of bushfire risk (i.e. greater than BAL-29).

If subdivision proceeds within those areas of the site designated as Bushfire Prone due to temporary bushfire hazards, prior to the hazards being removed, bushfire hazard management measures (i.e. increased construction standards to meet increased BAL ratings) will be required. Therefore a detailed and specific BAL assessment will be completed at the subdivision approval stage for all lots currently determined to be within “Bushfire Prone Areas” (see **Appendix 10**). The temporary and permanent Building Protection Zones (BPZ) requirements have been assessed and shown in **Appendix 11**. The future BAL assessment will outline specific BAL ratings for site based on the classified vegetation remaining at the time of subdivision, therefore providing a more accurate assessment of the post development hazards posed to future dwellings than can be achieved at this stage of planning.

As part of the subdivision process, any lots deemed to require fire management responses through the detailed BAL assessment, will be subject to a notification pursuant to section 70A of the *Transfer of Land Act 1893* placed on the certificate(s) of title indicating that the lot is subject to the requirements of a Fire Management Plan (i.e. increased construction standards to meet increased BAL ratings).

An acoustic wall is to be constructed at the eastern interface of the site with the Kwinana Freeway reserve, as a response to the acoustic implications of the adjacent freeway. This acoustic wall will also form a barrier between the site and the adjacent hazard, and will provide a shielding effect from the radiant heat flux of a fire within classified vegetation east of the site. Through the subdivision application process, accurate details regarding the height of dwellings in relation to the acoustic wall and management of Freeway vegetation will be produced, allowing for a detailed examination of the vertical shielding provided by

the acoustic wall. This will form part of the detailed and specific BAL assessment undertaken at subdivision stage, and will influence the predicted radiant heat flux exposure of dwellings adjacent to the eastern boundary.

It is expected that the implementation of this FMP will reduce the threat to future residents, visitors and fire fighters in the areas proposed for urban development associated with this FMP.

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1 INTRODUCTION

This Fire Management Plan (FMP) has been prepared for Mirvac (WA) Pty Ltd (Mirvac) to support the preparation of a Local Structure Plan (LSP) for Lots 746-750 Baldivis Road, Baldivis. This area is herein referred to as "the site" and its location is shown in **Appendix 1**. Lot 545, located immediately north of the site, does not form part of the Mirvac landholdings but has been included in the LSP design, and forms part of this assessment. The site is approximately 30.5 hectares (ha) in size and is located approximately 44 km south of the Perth Central Business District (CBD) within the City of Rockingham. Lot 545 is approximately 6.5 ha in size.

The site and Lot 545 have historically been cleared for broad scale agricultural purposes and are now characterised by high coverage of pasture weed species and limited remnant vegetation (as shown in **Appendix 2**). The site is bounded the City of Rockingham's Tramway Reserve to the west, Kwinana Freeway to the east, and by land zoned 'Urban' and intended for future urban development to the north and south.

The site and Lot 545 are currently zoned "Rural" under the City of Rockingham's Town Planning Scheme No. 2 (TPS No. 2) and "Urban" under the Metropolitan Region Scheme (MRS). An amendment of the City of Rockingham's TPS No. 2 is currently underway to rezone the site and Lot 545 (and surrounding areas) from "Rural" to "Development", and imminent formal approval is expected.

Urban zoned land to the north and south of the site are progressing with a separate LSP processes for the residential development of this area in accordance with the East Baldivis DSP.

2 AIM

The aim of this FMP is to reduce the occurrence of and minimise the impact of bushfires within the site, thereby reducing the threat to life, property and the environment.

3 STATUTORY AND POLICY FRAMEWORK

The following key legislation, policies and guidelines are relevant to the preparation of fire management strategies and plans.

3.1 Bush Fires Act 1954

The *Bush Fires Act 1954* sets out provisions 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.

Accordingly, the City of Rockingham publishes annual Firebreak Notices that can be downloaded from: http://www.rockingham.wa.gov.au/Residents/Home-safety-and-security/Fire-safety.aspx.

3.2 State Planning Policy No. 3.4 Natural Hazards and Disasters

The objectives of the *State Planning Policy No. 3.4 Natural Hazards and Disasters 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.
- 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.

3.3 Planning for Bush Fire Protection Guidelines (2010)

The *Planning for Bush Fire Protection Guidelines - Edition 2* was prepared by the Department of Fire and Emergency Services (DFES), the Western Australian Planning Commission (WAPC) and the Department of Planning and Infrastructure. The guidelines are the foundation for fire risk management planning on private land in Western Australia.

The guidelines address important fire risk management and planning issues and set out performance criteria and acceptable solutions to minimise the risk of bushfires in new subdivisions and developments. The guidelines also address management issues including location, design, the development site, setback requirements, Bushfire Attack Level (BAL) ratings, vehicular access and water.

3.4 Draft State Planning Policy 3.7 Planning for Bushfire Risk Management and draft Planning for Bushfire Risk Management Guidelines (2014)

The Department of Planning (DoP) and WAPC have recently released draft *State Planning Policy 3.7 Planning for Bushfire Risk Management* (2014) and the draft *Planning for Bushfire Risk Management Guidelines* (2014). Although currently in draft form, the relevant requirements of these documents have been accommodated within this FMP.

The draft *State Planning Policy 3.7 Planning for Bushfire Risk Management* (2014) is intended to inform and guide decision makers, referral authorities and proponents to achieve acceptable bushfire protection outcomes, including expectations at the different stages of the planning process.

The draft *Planning for Bushfire Risk Management Guidelines* (2014) provides an update on *Planning for Bush Fire Protection Guidelines - Edition 2* (WAPC *et al*, 2010) to ensure necessary bushfire management measures are incorporated into proposed development.

3.5 Lots 746-750 & 545 Baldivis Road, East Baldivis Local Structure Plan (CLE 2014)

This FMP has been prepared to support the Local Structure Plan for Lots 746-750 & 545 Baldivis Road, East Baldivis (CLE 2014), as outlined in Part 1 of the LSP documentation. Part 1 states that any land falling within 100 metres of a 'Moderate' or 'Extreme' bushfire hazard,

as identified in this FMP, is designated as a Bushfire Prone Area for the purpose of the Building Code of Australia.

4 PROPOSAL AND OBJECTIVES

The proposed LSP provides a framework for residential development within the site (see **Appendix 3**).

Community bushfire safety is a shared responsibility between state and local governments, fire agencies, communities and individuals. The planning and building controls outlined in this FMP, when implemented, will reduce the risk to people and property within the site. How future residents interpret the risk, prepare and maintain their properties and buildings and what decisions and actions they take (i.e. evacuate early or stay and defend or other) will greatly influence the consequences of any bushfire.

The objective of this FMP is to address bushfire management issues within the proposed urban residential LSP. If there is a bushfire within or near the site, implementing this FMP will reduce the threat to residents, property and emergency response personnel.

Achievable and measurable goals of this plan include ensuring:

- 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 a bushfire occurs.
- 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.
- The development design will minimise the effects of a bushfire.

This document sets out the roles and responsibilities of the developer (Mirvac), future residents, the City of Rockingham, DFES and Main Roads Western Australia (Main Roads). It is important that the measures and procedures outlined in this FMP are adopted across the various stages of the land use planning and dwelling construction approvals processes.

This FMP 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.
- Maps and plans of fire reduction measures.

A detailed BAL assessment will be undertaken for the site at subdivision stage in order to accurately assess the post development hazards posed to the development, and to determine specific exposure levels for lots within 100m of classified vegetation.

An acoustic wall is to be constructed at the eastern interface of the site with the Kwinana Freeway reserve, as a response to the acoustic implications of the adjacent freeway. This acoustic wall will also form a barrier between the site and the adjacent hazard, and will

provide a shielding effect from the radiant heat flux of a fire within classified vegetation east of the site. Through the subdivision application process, accurate details regarding the height of dwellings in relation to the acoustic wall and management of Freeway vegetation will be produced, allowing for a detailed examination of the vertical shielding provided by the acoustic wall. This will form part of the detailed and specific BAL assessment undertaken at subdivision stage, and will influence the predicted radiant heat flux exposure of dwellings adjacent to the eastern boundary.

5 DESCRIPTION OF THE AREA

5.1 General

The site has historically been subject to systematic and intensive clearing associated with agricultural land uses, and vegetation remaining within the site is in 'Completely Degraded' condition (in accordance with the Bush Forever scale) over the majority of its area. The dominant vegetation of the site and surrounding areas (including Lot 545) was weedy grassland, with planted non-native trees and scattered remnant native *Eucalyptus rudis, Melaleuca preissiana* and *M. rhaphiophylla* trees.

The proposed LSP over the site (as shown conceptually in **Appendix 3**) proposes future residential development and associated uses within the site. The LSP creates a framework for the future subdivision of the site into anticipated residential lots, part of a school site and areas of public open space (POS). There are separate structure planning processes currently underway for landholdings immediately south of the site and north of Lot 545, consistent with the broader East Baldivis District Structure Plan (DSP).

5.2 Climate and Fire Weather

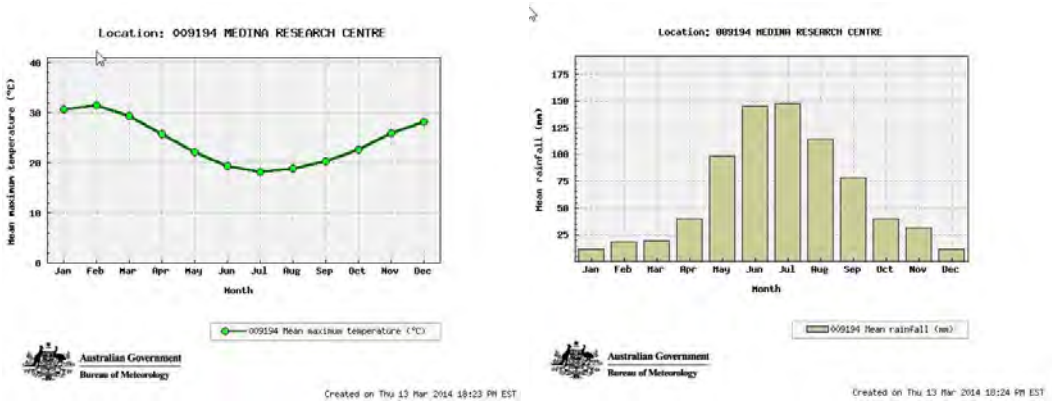
The behaviour of bushfires is significantly affected by weather conditions and they burn more aggressively when high temperatures combine with low humidity and strong winds. In Perth and surrounding coastal areas, the fire risk is greatest from summer through autumn when the moisture content in vegetation 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 (2014) states that extreme fire weather conditions in the Perth region typically occur with strong easterly or north-easterly winds associated with a strong high to the south of the state and a trough offshore. Easterly winds represent approximately 60% of extreme fire weather days (events) compared to fewer than 5% associated with southerly winds. About 15% 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.

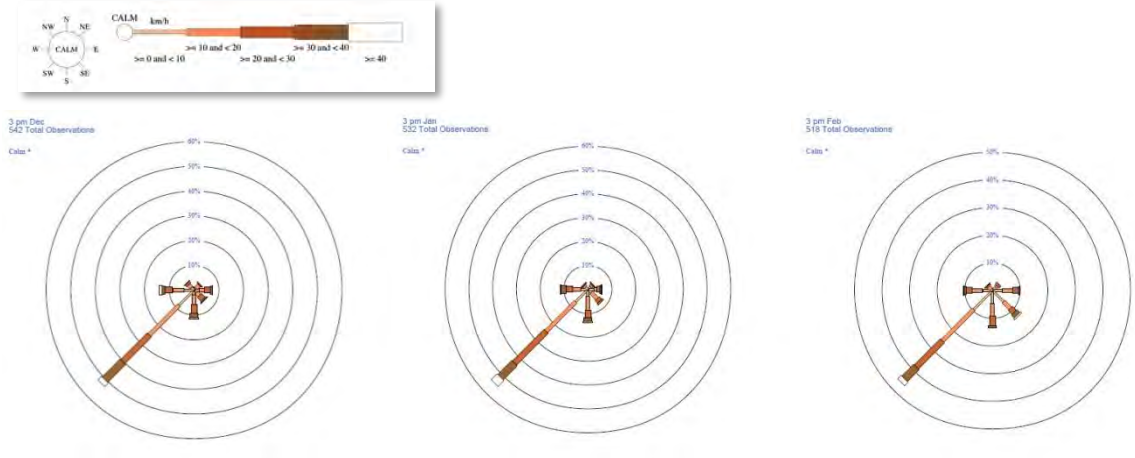
Data from the Medina Research Centre (approximately 10 km northwest of the study site) indicate the area experiences warm dry summers and cool wet winters (**Figure 1**), and is classified as a Mediterranean climate. Mean maximum temperatures vary from 31°C in February to 19°C in July.



Source: Bureau of Meteorology

Figure 1: Mean maximum recorded temperatures and mean rainfall for Medina Research Centre Bureau of Meteorology Station between 1983 and 2014

Data from the weather station indicate that the predominant winds near the study site in the summer months at 3 pm are south-westerly (**Figure 2**). Easterly and south-easterly winds are more common in February. Wind strength, direction and frequency from the west and south-west are dominant and occur 45-50 per cent of the time.



Source: Bureau of Meteorology

Figure 2: Rose of wind direction and wind speed in km/h for December, January and February between 1944 and 2010 at the Medina Research Centre Bureau of Meteorology Station

Interpreting Figure 2 – wind speed vs. direction plot

Wind roses summarise 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/h 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).

5.3 Topography

The landscape is generally flat and low lying across most of the site. Site elevations range from the highest point of 8.5m Australian Height Datum (AHD) in the west of the site to 3.5-4.5m AHD across the remaining area of the site (see in **Appendix 5**). The low point within the site is in the central corridor, generally associated with the agricultural drain that runs through the centre of the site.

Contours within Lot 545 range from 8.5m AHD in the west of the lot to 4.5m AHD in the east. Elevation dips to 3m AHD into the agricultural drain which runs through the centre and south of the lot before cutting through the site. Elevations within Lot 545 are shown in **Appendix 5**.

5.4 Bushfire Fuels

The dominant vegetation within the site and surrounding area is grassland (introduced grassy weed species), with planted non-native trees and scattered remnant native *Eucalyptus rudis, Melaleuca preissiana* and *M. rhaphiophylla* trees. From an intactness point of view, vegetation across the site is in 'Completely Degraded' condition (based on the Bush Forever scale), as the original vegetation structure has been completely altered (i.e. is absent) due to historic clearing and grazing activities associated with agricultural land uses.

There are several areas of vegetation surrounding the site that pose bushfire hazards to the LSP. These areas include remnant 'Forest' and 'Woodland' vegetation within the Tramway Reserve west of the site, 'Forest' vegetation along an open drain line immediately north of the site (within Lot 545), 'Woodland' and grassland vegetation within existing rural lots south of the site (to be developed for urban purposes), and 'Scrub' and 'Shrubland' vegetation within the Kwinana Freeway road reserve east of the site. The implications arising from these areas are discussed further in **Section 6.3.1**.

5.5 Land Use

The site is currently undeveloped, having been historically used for agricultural purposes. Until recently there was one existing residential property located on the western boundary

of the site. Vegetation within the site is in 'Completely Degraded' condition, dominated by grassland (of introduced grassy weed species) with planted non-native trees and scattered remnant native *Eucalyptus rudis, Melaleuca preissiana* and *M. rhaphiophylla* trees.

The site is currently zoned "Rural" under the City of Rockingham's Town Planning Scheme No. 2 (TPS No. 2) and "Urban" under the Metropolitan Region Scheme (MRS). Landholdings immediately north and south of the site are zoned "Urban" under the MRS and are proposed for residential development as per the East Baldivis DSP. Vegetation will likely be removed or significantly modified in these areas as part of this process.

The Tramway Reserve adjacent to the western boundary of the site is zoned "Parks and Recreation" under both the MRS and the City of Rockingham TPS No. 2. Informal discussions with the City of Rockingham regarding the likely future treatments of the Tramway Reserve areas indicate that there is some degree of uncertainty regarding the timing, available budgets and funding mechanisms and ultimate physical treatments for the Tramway Reserve landscape works. It is likely however that the City will seek to retain remnant vegetation and add to this wherever possible through strategic revegetation. Existing remnant vegetation within the Tramway Reserve and any requirements to revegetate areas within the Tramway Reserve is likely to pose differing bushfire hazard considerations to the LSP and to future development within the site.

The Kwinana Freeway reserve is managed by Main Roads and their *Operational Guideline 94 – Roadside Vegetation Management and Fire Hazard Control for Metropolitan Region* (Operational Guideline 94) (see **Attachment 1**) outlines how bushfire hazard and risk is managed within the freeway reserve, including requirements to maintain fuel loads at acceptable levels (i.e. eight tonnes per hectare (8t/ha)), grass/weed control measures, and the construction and maintenance of fire breaks where applicable.

5.6 Assets

In accordance with the proposed LSP the site will support the development of mainly residential lots, a high school and several areas of POS. Once completed, the site will be a residential community.

Dwellings exposed to any bushfire hazard will be those located around the perimeter of the site and within 100 m of classified vegetation that is likely to remain in the medium and long term.

5.7 Access

Informal access into the site is currently available from Baldivis Road across the Tramway Reserve via a driveway to the residence previously located within the site.

The LSP design shows the main point of access into the site from Baldivis Road, and multiple roads extending north and south into adjacent proposed residential developments. Internally, the site has an interconnected road system to ensure all residents and fire fighters have at least two access options at all times. The extensive road system under the proposed LSP design is shown spatially in **Appendix 3**.

If development has not progressed within adjacent areas at the creation of Titles within the site, a second temporary access way will be created in the south-west of the site through a cleared area of the Tramway Reserve to Baldivis Road. This will be undertaken with

extensive consultation with the City of Rockingham, in order to provide an alternative access way for residents and emergency services personnel until such a time as internal roads connect with adjacent developments and to provide two points of access to the site.

5.8 Water Supply

Reticulated water will be provided to the entire development. Fire hydrants will be spaced according to Water Corporation and DFES standards and provide emergency services with access to an adequate water supply.

Public/commercial buildings such as schools will require the proponent to outline the compliance with current standards. The process to determine hydrant coverage and compliance for public/commercial buildings 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.

School buildings are Class 9 buildings in the Building Code of Australia (BCA) and require compliance with the BCA, in particular E1.5 including the Specifications and AS 2118.4 together with 2419.1 – also noting that hydraulic water supplying both systems (hydrant and sprinklers) will need to achieve flow rates simultaneously.

6 FIRE CONSIDERATIONS

6.1 Bushfire History

Fires have been common on the Swan Coastal Plain for thousands of years; the anthropological and historical evidence suggests that Aboriginal people regularly burnt this area (Hallam, 1975; Abbott, 2003).

A recent study has concluded that bushfires may have been in the Australian landscape for 50 million years longer than previously thought. The adaption of eucalypts that allows them to recover from bushfires has been traced back more than 60 million years (Crisp *et al*., 2011), indicating fire has been in the Australian landscape since that time.

Bushfires are common in the City of Rockingham. As land use intensification occurs and urban development replaces rural land and/or areas of native vegetation, bushfire hazards are removed thereby reducing areas that can carry a bushfire. At the same time however, the number of people and assets in the community increases thereby increasing the risk at the bushland interface.

Recent bushfire history includes a bushfire that started near the intersection of Eighty and Fifty Road (approximately 1.5 km north-west of the site) in April 2009, significantly impacting on land west of Baldivis Road. Over 780 ha in total were burnt and numerous public warnings during the event were issued to residents. This area has since been developed for residential purposes; however surrounding woodland vegetation in the district shows extensive signs of this event.

Given that bushfires are common in the City of Rockingham, this FMP plays an important role in ensuring that the development of the land appropriately mitigates the risk and threat posed from bushfire.

6.2 Bushfire Risk

The risk management process described in AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines* is a systematic method for identifying, analysing, evaluating and treating emergency risks.

Bushfire risk is determined by assessing:

- Bushfire hazard (i.e. vegetation).
- Threat level (i.e. proximity of the hazard to assets and people).
- Vulnerability of the asset.
- Consequence rating (i.e. a rating for the potential outcome once the 'incident' has occurred).
- Likelihood rating (i.e. the chance of an event).

It is not necessary to undertake a comprehensive bushfire risk assessment according to AS/NZS ISO 31000:2009 for this FMP, however a comprehensive bushfire hazard assessment that has been undertaken is outlined in **Section 6.3**. The threat level is assessed in later sections by determining the indicative Bushfire Attack Levels (BALs) for exposed areas of the 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.
- Power supply.

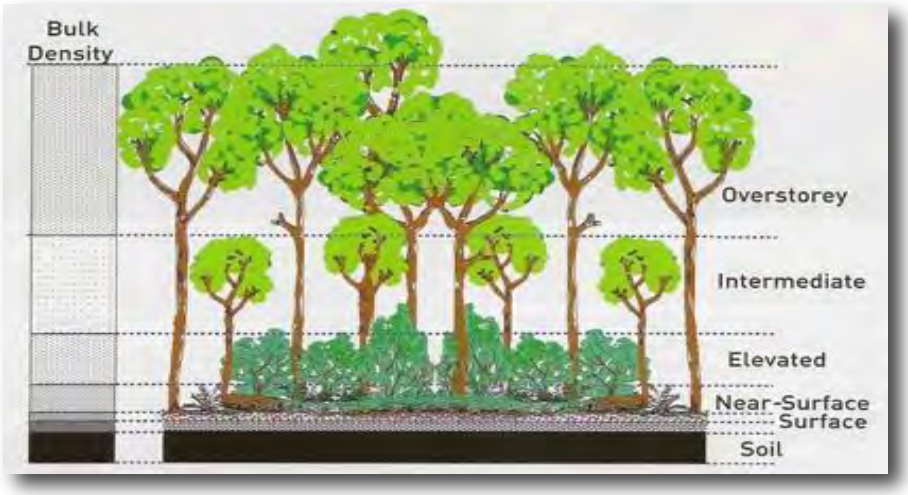
It is likely that buildings are lost because of their vulnerability to the mechanisms of bushfire attack. Buildings constructed to AS 3959 *Construction of buildings in bushfire-prone areas* (Standards Australia 2009), herein referred to as AS 3959, are more likely to survive a bushfire than buildings that do not conform to these construction standards, although building survival is not guaranteed.

The vulnerability of people is determined by several factors, including age, fitness levels, gender, level of preparation, and number of occupants who can actively defend a property.

The development is comprised of residential dwellings, part of a school site and areas of POS, however, there are no other vulnerable assets proposed, such as day care centres or aged care centres. It is expected the school will develop an appropriate Bushfire Risk Management Plan in line with DFES and Department of Education policies and guidelines.

6.3 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 m, as shown in **Appendix 6**. Fuel layers in a typical forest environment can be broken-down into five segments as illustrated in **Figure 3** below. These defined fuel layers are used in the following descriptions regarding vegetation types, fuel structure and bushfire hazard levels.



Source: Gould et al. (2007)
Figure 3: The five fuel layers in a forest environment that could be associated with fire behaviour

6.3.1 Vegetation Type and Structure

Vegetation within the site and Lot 545 has been subject to high levels of historical clearing, stock grazing and weed invasion, and as a result was in 'Completely Degraded' vegetation condition (in accordance with the Bush Forever scale) over the majority of its area.

The dominant vegetation of the site and surrounding areas was grassland (of introduced grassy weed species) (**Figure 4**), with planted non-native trees and scattered remnant native *Eucalyptus rudis, Melaleuca preissiana* and *M. rhaphiophylla* trees (**Figure 5**). The concentration of trees is insignificant to form a distinct vegetation class and is classified according to the understorey vegetation which is grassland at this site.

Figure 4: Grassland vegetation is dominant across the site

Figure 5: Scattered remnant native trees

A small area of marginally more intact vegetation in 'Degraded' condition occurred along the northern edge of the site adjacent to a drainage line outside of the site boundary (within Lot 545). This area contained *Eucalyptus rudis* open forest over weeds (**Figure 6**) which extends through Lot 545 and further landholdings to the north. The strip of open forest is isolated from other areas of classified vegetation and contains minimal intermediate and elevated fuel layers. Landholdings to the north (including Lot 545) and south of the site have been similarly disturbed, and contain little intact remnant vegetation, largely dominated by grasses with planted non-native trees and scattered native trees. The difference in grassland fuel loads between the two areas is directly attributable to the amount of existing grazing pressure. A small patch of *Melaleuca rhaphiophylla* open woodland was however present within 100m to the south of the site.

The adjacent Tramway Reserve to the west of the site contained some intact areas of *Corymbia calophylla*, *Eucalyptus marginata, Eucalyptus gomphocephala* and *Allocasuarina fraseriana* open woodland to open forest over low woodland of *Banksia* spp. over open shrubland of *Acacia pulchella*, *Jacksonia furcellata* and *Macrozamia riedlei* (see **Figure 7**). The southern portions of the Tramway Reserve tended to be in 'Completely Degraded' to 'Degraded' condition, whereas the northern portions were in 'Good' to 'Very Good' condition.

Figure 6: Vegetated drainage line north of the site

Figure 7: Vegetated Tramway Reserve

The eastern Kwinana Freeway interface area was dominated by strips of vegetation between the site boundary and the vegetated area east of the freeway lanes (see **Figure 8**). Within the 100 metre assessment area east of the site, there are a number of sealed vehicle access ways including a bike path and freeway lanes. The vegetation between these access ways is dominated by shrubland and scrub vegetation (see **Figure 9**) which has been planted to revegetate the roadside edges after the construction of the freeway. Planted species include *Eucalyptus rudis, Hakea trifurcata, Melaleuca lanceolata, Jacksonia furcellata* and *Adenanthos cygnorum*. This vegetation is generally in a 'Degraded' condition.

Figure 8: Vegetated Freeway reserve at eastern interface

Figure 9: Vegetated Freeway reserve at eastern interface

6.3.2 Vegetation in Public Open Spaces

There are five areas of POS with within the LSP, as shown in **Appendix 3**. Landscape concept plans are currently being prepared for the POS areas and all POS and drainage areas will be landscaped and designed to a 'Low Threat' standard under AS3959 classifications and therefore pose no hazard to development within the site.

6.3.3 Vegetation in the Tramway Reserve

The Tramway Reserve contains areas of remnant woodland vegetation that may be retained adjacent to the site. It is understood that more detailed plans and implementation budgets are currently being prepared by the City of Rockingham for the entire length of the Tramway Reserve which will outline specific landscaping and vegetation retention outcomes, however the hazard assessment below (**Section 6.3.6**) has been based on the following potential Tramway Reserve treatment scenario: remnant woodland/forest vegetation currently within the reserve is effectively retained/enhanced as per existing site conditions and all other areas are treated as managed parkland and therefore low threat vegetation types.

6.3.4 Vegetation in the Kwinana Freeway reserve

The dominant vegetation type in the reserve is planted scrub and shrubland of *Eucalyptus rudis, Hakea trifurcata, Melaleuca lanceolata, Jacksonia furcellata* and *Adenanthos cygnorum*, with areas of grassland fuels. Although some Eucalypt trees were present, the dominant vegetation and fuel layer existed in the elevated scrub and shrubland vegetation. The management of roadside vegetation and bushfire hazard within the reserve is the responsibility of Main Roads.

At the time of inspection, dead plant material and dry grass fuels were common throughout the reserve. Main Roads' Operational Guideline 94 (see **Attachment 1**) outlines how bushfire hazard and risk is managed within the freeway reserve, including requirements to maintain fuel loads at acceptable levels (i.e. 8t/ha), grass/weed control measures, and the construction and maintenance of fire breaks where applicable.

Mirvac is currently working with Main Roads to ensure implementation of their Operational Guideline 94. In particular, it is expected that for the area of Kwinana Freeway adjacent to the site, bushfire fuels will be maintained at 8t/ha and a firebreak constructed along the length of the interface. This FMP provides solutions to the existing vegetation onsite, but flexibility is provided for the potential treatment of classified vegetation and subsequent reduction and/or removal of bushfire hazard and is expected to be resolved as part of the future detailed BAL assessment to be prepared at subdivision.

6.3.5 Effective Slope

The effective slope under areas of classified vegetation surrounding the site is shown in **Appendix 5**, and is in the range of 0-5 degrees upslope adjacent to the western and eastern boundaries, and effectively flat adjacent to the northern and southern boundaries of the site. The landscape of the site has a westerly aspect, with its highest elevation along the western boundary, sloping down to an effectively flat expanse in the central and eastern portions of the site. There are no effective downslope areas which would influence an approaching bush or grassfire.

The effective slope under areas of classified vegetation north of Lot 545 ranges from downslope 0-5 degrees in the north-west, to effectively flat in the north-east.

6.3.6 Bushfire Hazard Assessment – Existing Site Conditions

The vegetation class map shown in **Appendix 6** outlines the existing vegetation classifications on the study site and in the surrounding 100 m assessment area as identified in AS 3959. Descriptions of the vegetation types, structure and fuel layers are outlined in Section 6.3.1.

The bushfire hazard assessment levels were determined using Appendix 1 of the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al*., 2010).

All areas within the site have a low bushfire hazard rating due to the extensive presence of grassland vegetation. The site and surrounding areas to the north and south have been historically cleared for agricultural purposes and as such, remnant vegetation is scattered with a weedy grassland understorey dominant. Existing hazards surrounding the site can be seen in **Appendix 7**.

6.3.7 Bushfire Hazard Assessment – Post Development Site Conditions

The Post Development Site Conditions vegetation mapping for the site is shown in **Appendix 8**, and outlines the dominant vegetation types that will remain within the site and surrounding area within 100m after development within the site has been completed.

The bushfire hazard assessment levels were determined using Appendix 1 of the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al*. 2010).

The post-development bushfire hazard rating changes substantially compared to the pre-development conditions due to the removal of all vegetation within the site to accommodate the development.

The post development hazard assessment (shown in **Appendix 9**) has been based on the scenario of the forest and woodland vegetation within the adjacent Tramway Reserve to be retained in its current condition/s and all other areas to be maintained as Managed Parkland and therefore 'Low Threat' vegetation. Scrub and shrubland vegetation within the Kwinana Freeway reserve east of the site will be maintained by Main Roads as per their Operational Guideline 94 (attached in **Attachment 1**). Final long term fuel loads within the Freeway reserve and the associated hazard posed to site will be determined as part of the detailed BAL assessment to be undertaken at subdivision. Vegetation surrounding the site to the north and south, and north of Lot 545, will pose only a temporary hazard to the site due to the temporary nature of the vegetation. These areas are subject to future urban development in accordance with the approved East Baldivis DSP, and once vegetation is removed to accommodate development, the hazard will no longer apply.

6.4 Bushfire Threat

Bushfires are common in the City of Rockingham and there is a possibility of a bushfire impacting the site primarily from the Tramway Reserve west of the site and the Freeway reserve east of the site, unless these hazards are managed and/or reduced. Vegetation north and south of the site will also be a potential source of bushfire until such time as the vegetation (and therefore the hazard) is removed as part of future urban development.

The bushfire threat for the LSP is best determined by undertaking an indicative BAL assessment (**Section 7.2.4**) to ensure no areas within the design are exposed to an unacceptable level of bushfire risk (i.e. greater than BAL-29) . The maximum long-term predicted radiant heat flux exposure for a small number of dwellings in this development is BAL-29. The indicative BAL assessment provided in **Section 7.2.4** below does not include consideration of the shielding to be provided by the future acoustic wall to be located along the length of the eastern interface, between the site and Kwinana Freeway. The acoustic wall, in addition to its acoustic shielding, will reduce the effect of radiant heat flux on the site from any fire within the Freeway reserve vegetation. A vertical shielding assessment will be undertaken on the Freeway interface at subdivision stage, allowing for the height of future dwellings to be determined and the predicted exposure to be accurately measured.

6.5 Summary of Bushfire Potential Issues

At the completion of this development and the surrounding urban residential estates to the north and south of the site, the bushfire hazard will be concentrated entirely to the west and east of the site associated with the vegetation in the adjacent Tramway Reserve and Kwinana Freeway. This is shown in **Appendix 9**.

7 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.
- 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.

7.1 Hazard Management

There are some pasture grass hazards presently within the site. Slashing of the grass fuels within 100 m of the internal development stages prior to the bushfire season will ensure any excessive grass fuel loads are maintained and managed to result in low bushfire fuel levels.

The mitigation of hazards within areas proposed as POS will be largely addressed through the detailed design of the landscaping and the selection of suitable species, utilising the DFES species list (DFES, 2011). The City of Rockingham will manage the long term maintenance of the parkland and reserves that fall within POS areas.

7.2 Bushfire Risk Management

It is not necessary to detail a comprehensive bushfire risk assessment as per AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*.

Land use planning bushfire risk mitigation strategies are detailed in the following sections 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 compliant checklist is attached as **Appendix 12**.

7.2.1 Element: Location of the Development

Intent

To ensure that development/intensification of land use is located in areas where bushfire hazard does not present an unreasonable level of risk to life and property.

Acceptable Solution

The majority of the site has a 'Low' bushfire hazard rating due to the expansive areas of grass and weeds. Areas of 'Moderate' and 'Extreme' bushfire hazard located within 100m of the site have an appropriate setback distance applied to them to ensure that the maximum BAL predicted for the site is BAL-29. The majority of proposed dwellings will be rated BAL-LOW, followed by BAL-12.5, BAL-19 and BAL-29. BAL-40 and BAL-FZ ratings are not achieved across the site in any areas.

The exposed dwellings located within 100 m of classified vegetation will have the threat mitigated by ensuring those dwellings are compliant with AS 3959 construction standards and BAL-29 will not be exceeded.

The site will be provided with an adequate water supply and has adequate vehicular access for residents and fire fighters.

7.2.2 Element: Vehicular Access

Intent

To ensure vehicular access serving a subdivision development is safe if a bushfire occurs.

Background

The indicative road network of the proposed LSP is shown spatially in **Appendix 3**. The network integrates with the existing Baldivis Road west of the Tramway Reserve, and with the road networks of proposed future urban developments to the north and south of the site.

Loop roads are common, providing two access routes, and the interconnected roads create a permeable grid-like pattern. The proposed road network also reflects the anticipated traffic volumes.

Acceptable Solution A2.1: Two Access Routes

The interconnected loop road system provides all residents and fire fighters with two road options at all times. The LSP shows one major intersection with Baldivis Road (across the Tramway Reserve), four with proposed future development to the south of the site, and three with proposed future development north of the Lot 545, which will provide alternative routes if one option is threatened by fire.

If development has not progressed within adjacent areas at the creation of Titles within the site, a second temporary access way will be created in the south-west of the site through a cleared area of the Tramway Reserve to Baldivis Road. This will be undertaken in consultation with the City of Rockingham, in order to provide an alternative access way for residents and emergency services personnel until such a time as internal roads connect with adjacent developments.

Acceptable Solution A2.2: Public Roads

Surrounding public roads and all new public roads and laneways 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.
- Minimum inner radius of curves: 12 metres.

7.2.3 Element: Water

Intent

To ensure water is available to the development to enable life and property to be defended from bushfire.

Acceptable Solution A3.1: Reticulated Water

The development is located within an Emergency Services Levy (ESL) Category 3 area. Fire services require ready access to an adequate water supply during fire emergencies.

The area is provided with a reticulated water supply, together with fire hydrants that will meet the specifications of Water Corporation Design Standard DS 63 and DFES. Fire hydrants on land zoned as residential are required to be sited at or within 200 m of residential dwellings (Class 1a).

Public/commercial buildings such as schools will require the proponent at the time of development to outline the compliance with current standards. The process to determine hydrant coverage and compliance for public/commercial buildings 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.

School buildings are Class 9 buildings in the Building Code of Australia (BCA) and require compliance with the BCA, in particular E1.5 including the Specifications and AS 2118.4 together with 2419.1 – also noting that hydraulic water supplying both systems (hydrant and sprinklers) will need to achieve flow rates simultaneously.

The Water Corporation is responsible for all hydrant maintenance and repairs.

7.2.4 Element: Siting of the Development

Intent

To ensure the siting of the development minimises the level of bushfire impact.

Background

The extent of post-development classified vegetation (**Appendix 8**) is restricted to the following main areas:

- Forest and woodland vegetation to the west of the site within the Tramway Reserve. Vegetation within the Tramway Reserve is subject to potential future development for public recreation purposes, and fuel loads may change.
- Shrubland and scrub vegetation within the Kwinana Freeway road reserve east of the site. This vegetation is to be maintained by Main Roads as per their Operational Guideline 94 (see **Attachment 1**).

Classified vegetation north and south of the site, and north of Lot 545, will pose only temporary bushfire hazards to the site. These areas are subject to future urban development

in accordance with the approved East Baldivis DSP, and once vegetation is removed to accommodate development, the hazard will no longer apply.

Vegetation that does not trigger a BAL assessment according to AS 3959 includes the following:

- Vegetation of any type more than 100 m from the site.
- Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
- Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site or each other.
- Strips of vegetation less than 20 m wide (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.
- Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.
- 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.

Building Siting and Predicted Bushfire Attack Levels

AS 3959 has six categories of Bushfire Attack Level, namely BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ. These categories are based on heat flux exposure thresholds.

Methodology and Assumptions

The following indicative BAL assessment has been undertaken to determine the maximum heat flux to which future lots will be exposed once surrounding land has been developed, and has been carried out based on the post development vegetation classification and effective slopes.

The criteria to determine the BAL is outlined as follows:

Designated FDI:	80
Flame Temperature:	1090
Slope:	Flat or upslope
Vegetation Class:	Forest, Woodland, Scrub
Setback distances: (WAPC, 2010).	As per Table 2 in *Planning for Bush Fire Protection - Edition 2*

BAL Outcome

BAL ratings for exposed areas of the development were determined using the methodology in Appendix A of AS 3959. This methodology is also outlined in the *Planning for Bush Fire Protection - Edition 2* (WAPC, 2010).

This BAL assessment is indicative only and does not include consideration of the shielding to be provided by the future acoustic wall to be located along the length of the eastern interface, between the site and Kwinana Freeway. The acoustic wall, in addition to its

acoustic shielding, will reduce the effect of radiant heat flux on the site from any fire within the Freeway reserve vegetation. A vertical shielding assessment will be undertaken on the Freeway interface at subdivision stage, allowing for the height of future dwellings to be determined and the predicted exposure to be accurately measured.

There are no areas in the development exposed to a BAL rating above BAL-29.
An assessment of BAL-29 means there is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat (AS 3959). The risk is considered to be high. It is expected that the construction elements will be exposed to a heat flux not greater than 29 kW/m^2. In this case, the recommended construction sections in AS 3959 are 3 and 7.

An assessment of BAL-19 means the risk is considered to be moderate. It is expected that the construction elements will be exposed to a radiant heat flux not greater than 19 kW/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 (AS 3959). The recommended construction sections in AS 3959 are 3 and 6.

An assessment 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 12.5 kW/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 (AS 3959). The recommended construction sections in AS 3959 are 3 and 5.

Any new dwellings constructed within 100 m of identified classified vegetation will require consideration of the need for increased construction requirements to address *AS3959 Constriction of Buildings in Bushfire Prone Areas*. In order to pre-empt this requirement, a detailed and specific BAL assessment will be undertaken as part of the subdivision process to confirm the BAL ratings for each individual new lot created. BAL ratings **should not** be determined for future lots at the LSP stage, as the ultimate lot locations/boundaries will be determined through the subdivision process, and temporary hazards (or even hazards that were expected to be permanent) may not remain at that time, particularly within neighbouring sites currently undergoing separate planning and approvals processes for future urban development as well as within the adjacent Tramway Reserve and Kwinana Freeway reserve. The indicative BAL assessment included in this report demonstrates that no areas within the proposed LSP are exposed to an unacceptable level of bushfire risk (i.e. greater than BAL-29).

If subdivision proceeds within those areas of the site designated as Bushfire Prone due to temporary bushfire hazards, prior to the hazards being removed, bushfire hazard management measures (i.e. increased construction standards to meet increased BAL ratings) will be required. Therefore a detailed and specific BAL assessment will be completed at the subdivision approval stage for all lots currently determined to be within “Bushfire Prone Areas” (see **Appendix 10**). The future BAL assessment will outline specific BAL ratings for site based on the classified vegetation remaining at the time of subdivision, therefore providing a more accurate assessment of the post development hazards posed to future dwellings than can be achieved at this stage of planning.

As part of the subdivision process, any lots deemed to require fire management responses through the detailed BAL assessment, will be subject to a notification pursuant to section

70A of the *Transfer of Land Act 1893* placed on the certificate(s) of title indicating that the lot is subject to the requirements of a Fire Management Plan (i.e. increased construction standards to meet increased BAL ratings).

An acoustic wall is to be constructed at the eastern interface of the site with the Kwinana Freeway reserve, as a response to the acoustic implications of the adjacent freeway. This acoustic wall will also form a barrier between the site and the adjacent hazard, and will provide a shielding effect from the radiant heat flux of a fire within classified vegetation east of the site. Through the subdivision application process, accurate details regarding the height of dwellings in relation to the acoustic wall and management of Freeway vegetation will be produced, allowing for a detailed examination of the vertical shielding provided by the acoustic wall. This will form part of the detailed and specific BAL assessment undertaken at subdivision stage, and will influence the predicted radiant heat flux exposure of dwellings adjacent to the eastern boundary.

Landscaping Considerations

All plants will burn under the right conditions and plants do not attain a 'fire resistance level' that meets requirements of the Building Code of Australia (BCA). Placing plants too close to a building, under timber decks or next to windows will provide a direct threat to the building. Having a clearance around the building will achieve the desired effect of creating a break between the vegetation and the building. A pathway around buildings may be one way to achieve this requirement. Landscaping can then be established at a suitable distance from the building.

Detailed landscape design is currently underway for the LSP, and will be finalised at subdivision stage.

Acceptable Solution A4.1: Hazard Separation

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 case of subdivision within the site, the provision of a HSZ is not the ideal method to respond to relevant bushfire hazards. The need for a HSZ is avoided through an appropriate increase in construction standards and compliance with AS 3959, and in this regards BAL-29 would not be exceeded within the site.

The above BAL assessment demonstrates that a Building Protection Zone (BPZ, discussed further below) combined with increased dwelling construction standards will achieve acceptable levels of risk for the development.

By taking this approach it will be possible to construct dwellings to an appropriate standard (i.e. BAL-29 or less) under AS 3959.

Acceptable Solution A4.3: Building Protection Zone

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 and roads can form parts of a BPZ.

Recent 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).

This FMP provides for two important BPZ considerations. The first involves the provision of an adequate perimeter BPZ where lots are within close proximity to an external bushfire hazard. Providing for an appropriate perimeter BPZ will ensure vegetation and fuels within close proximity to buildings are able to be managed to reduce radiant heat flux in the case of a bushfire and improve the likelihood of building survival.

The second involves the management of risk at each future stage of development. Each development stage is provided with acceptable setbacks from temporary bushfire hazards to reduce bushfire attack mechanisms impacting on any completed dwellings. Creating a temporary BPZ during each internal stage of the development will ensure dwellings on the perimeter of each stage are not exposed to unnecessary risk from a temporary hazard.

The establishment of the perimeter BPZ areas will ensure the predicted radiant heat flux exposure levels remains at or below BAL-29 for all future 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.
- To reduce ember attack and provide a safer space for people to defend (if required) before, during and after a fire front passes.

Proposed lots within the site that are situated in close proximity to identified bushfire hazards have an internal (within the site) BPZ applied to them as shown in **Appendix 11**. Vegetation currently within the Tramway Reserve triggers BPZ requirements along the western boundary for which the LSP has allowed for a 20-21m BPZ (based on the adjacent classified vegetation, as outlined in **Table 1** below) through the placement of a road reserve and front of lot setbacks, to account for the worst case future hazards associated with the Tramway Reserve. The fuel managed areas of future road and drainage reserves will also become BPZ areas because the City of Rockingham grass slashing program will ensure hazard remains low.

Based on current fuel loads, the eastern interface with the Kwinana Freeway requires only a 13m internal setback in order to achieve an acceptable level of exposure. This setback can be entirely accommodated within lots and enforced at subdivision through the development of a Detailed Area Plan. However, the requirement for a BPZ in this location and the final width of this BPZ is subject to further discussion with Main Roads in regards to future fuel loads within the freeway reserve and the placement of a firebreak along the length of the interface with the site (as per Operational Guideline 94). The placement of a firebreak within the Freeway reserve at the interface with the site will contribute to a reduction in the predicted radiant heat flux to which adjacent dwellings are exposed, therefore the width of the BPZ may be reduced to reflect the reduced threat. This will be addressed and finalised through further site specific assessment and modelling to be undertaken as part of the future detailed BAL assessment at subdivision.

The BPZ must be established and maintained to the following standards:

- Width: as identified in **Appendix 11** and **Table 1** below.
- 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 (including existing trees and shrubs and new plantings) is to be within 2 metres of any building.
- All fences are constructed of non-combustible materials (i.e. Brick or limestone).
- All sheds are constructed of non-combustible materials (i.e. Brick or limestone) and, if located within 6m of the main residence, are subject to increased AS 3959 construction standards.
- All shrubs to contain no dead material within the plant.
- No tall shrubs are to be in clumps within 3 metres of any building.
- No trees are to contain dead material in the crown or on the bole.

It is the responsibility of the developer to ensure the BPZ is created by appropriate design, and that construction of buildings is restricted within the identified zone.

Table 1: Minimum building protection zone widths

Area of classified vegetation	Vegetation Class	BPZ width	Effective Slope
Western interface	Forest	21 metres	Flat or upslope
	Woodland	20 metres	Flat or Upslope
Eastern interface	Scrub	13 metres	Upslope
Northern interface	Forest	21 metres	Flat or upslope
	Woodland	20 metres	Flat or upslope

7.2.5 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 A5.2: Performance Criterion P5 Compliance

The development complies with AS 3959 and BAL-29 is not exceeded for any dwelling.

7.3 Future Development

This FMP is expected to inform the detailed BAL assessment that will be prepared and implemented as part of the future subdivision approval stage. The post-development Bushfire Prone Areas map (**Appendix 10**) will be used to guide the requirement for further BAL assessment.

7.4 Access and Fire Breaks

Compliance with the City of Rockingham Firebreak Notice is required across the entire site and public road access must provide two access options at all stages of development.

7.5 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. *Prepare. Act. Survive.* (DFES, 2012) provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures are available from http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/publications.aspx.

The City of Rockingham provides bushfire safety advice to residents available from their website http://www.rockingham.wa.gov.au/Residents/Home-safety-and-security/Fire-safety.aspx. It also provides details on how to become a volunteer at either of the local volunteer Bush Fire Brigades. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high risk areas.

7.6 Fire Safer Areas

There are no designated Community Fire Refuges in the City of Rockingham, However, at the time of an emergency, the relevant authorities can select an evacuation centre and DFES, the City of Rockingham 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 that 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 this site and within the City of Rockingham that are not bushfire-prone, including landscaped open spaces and urban areas, but they have not been declared. Obviously a non-bushfire-prone area can provide a safe location for people during a bushfire, but there are 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 that when

household bushfire survival plans have failed, residents should go to a safer place such as a local open space or building to seek shelter from a bushfire (DFES, 2012).

7.7 Assessment of Fire Management Strategies

The bushfire hazard that could threaten this development is concentrated in the forest and woodland vegetation located within the Tramway Reserve west of the site, and the scrub and shrubland vegetation within the Kwinana Freeway road reserve east of the site.

Vegetation in the Kwinana Freeway reserve will be actively managed by Main Roads as per their Operational Guideline 94 (see **Attachment 1**) and hazard levels may alter depending on the implementation of this guideline. Final hazard implications will be determined as part of the detailed BAL assessment to be undertaken at subdivision.

Vegetation surrounding the site to the north and south is subject to clearing associated with proposed future urban development and therefore will not pose long term considerations.

Grasslands fuels in the public roadside reserves west of the Tramway Reserve (Baldivis Road) will be managed through City of Rockingham's roadside slashing program. Fuels in POS and drainage areas will be managed at a low threat level.

Fire response operations will utilise the reticulated water supply and the extensive loop road network to defend property and life.

7.8 Implementing the Fire Management Plan

7.8.1 Developer's Responsibilities

To achieve an acceptable level of risk from bushfire, the developer's responsibilities arising from this FMP are to:

- As part of the subdivision approval or Detailed Area Plan preparation process (whichever comes first) undertake a specific BAL assessment for any proposed lots that fall partly or entirely within Bushfire Prone Areas as shown on the structure plan and/or on **Appendix 10**, with assessment recommendations to be submitted to the City of Rockingham and accommodated in the lot clearances and/or Detailed Area Plan outcomes.
- For each new lot created within Bushfire Prone Areas exposed to a BAL rating exceeding BAL-LOW, lodge a Section 70A Notification on the Certificate of Title in order to alert purchasers and successors in title of the existence of the overarching FMP and specifically the requirements associated with meeting the AS 3959 construction standards.
- Install the public roads to standards outlined in **Section 7.2.2**.
- On all vacant land, comply with the City of Rockingham Firebreak Notices as published.
- Install reticulated water supply and hydrants to Water Corporation, DFES and the City of Rockingham standards.
- Design and landscape all managed POS areas with DFES-approved species to create a low threat environment.

- Establish and maintain the BPZs within the site to standards as specified in this document, and liaise with the City of Rockingham regarding the management of fuel loads within the adjacent Tramway Reserve.
- Ensure 100 m of vegetation is managed from the perimeter of each construction stage within the overall development site to ensure temporary hazard does not threaten any subdivision stage. Liaise with surrounding landowners and the City of Rockingham to ensure the management of vegetation within surrounding sites and the adjacent Tramway Reserve to ensure these hazards do not threaten any subdivision stage.
- At subdivision approval stage, the developer is to provide detailed hydrant plans to the City of Rockingham and DFES local fire station for monitoring.
- Make a copy of this FMP available to each lot owner subject to AS 3959 construction standards, along with the *Homeowners Bush Fire Survival Manual, Prepare, Act, Survive* (or similar suitable documentation) and the City of Rockingham's Firebreak Notice.

7.8.2 Property Owner/Occupier's Responsibilities

The owners/occupiers of future individual residential lots within this site, as created by the subdivision process, 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. Property owners and occupiers will be responsible for:

- Ensuring that all lots comply with the City of Rockingham Firebreak Notices as published.
- Maintaining each property in good order to minimise bushfire fuels, and maintaining BPZ areas (where applicable) in accordance with the requirements outlined in this FMP.
- Ensuring that where hydrants are located, they are not obstructed and remain visible at all times.
- Ensuring construction of dwellings complies with AS 3959, if required.
- If dwellings are subject to additional construction in the future, such as renovations, AS 3959 compliance is required.

7.8.3 City of Rockingham'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 Rockingham.

The City of Rockingham shall be responsible for:

- Providing fire prevention and preparedness advice to landowners upon request, including the *Homeowners Bush Fire Survival Manual, Prepare, Act, Survive* (or similar suitable documentation) and the City of Rockingham's Firebreak Notice.
- Ensuring bushfire hazard remains low in the internal POS areas and roadside grassland vegetation is slashed in the annual roadside slashing program.
- Monitoring bush fuel loads in road reserve sites and liaising with relevant stakeholders to maintain fuel loads at safe levels.

- Monitoring and maintaining bush fuel loads in the Tramway Reserve to a "Low Threat" level.
- Maintaining public roads to appropriate standards and ensuring compliance with the City of Rockingham Firebreak Notices.

7.8.4 Main Roads' Responsibilities

Main Roads is responsible for the management of vegetation and bushfire fuels in the Kwinana Freeway reserve. Their Operational Guideline 94 (see **Attachment 1**) outlines how bushfire hazard and risk is managed within the freeway reserve, including requirements to maintain fuel loads at acceptable levels (i.e. 8t/ha), grass/weed control measures, and the construction and maintenance of fire breaks where applicable.

7.8.5 Water Corporation's Responsibilities

The Water Corporation is responsible for the repair of water hydrants, as needed.

8 CONCLUSIONS

This FMP 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), and is expected to inform the BAL assessment that will be prepared and implemented as part of the future subdivision approval stage.

Dwellings located in the bushfire prone area (i.e. within 100 m of classified vegetation) will have the risk mitigated via compliance with AS 3959 standards. The indicative BAL assessment included in this report demonstrates that BAL-29 is not exceeded and a BPZ is incorporated into the entire western boundary to allow for hazards posed by unknown development within the adjacent Tramway Reserve, the main source of long term hazard for the site. Vegetation management and hazard mitigation within the Kwinana Freeway reserve will be undertaken by Main Roads in accordance with their Operational Guideline 94. Loop roads and reticulated water supply and hydrants are provided. The proposed development will fall within the acceptable level of risk.

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10 GLOSSARY

AS	Australian Standard
AHD	Australian Height Datum
BAL	Bushfire Attack Level
BCA	Building Code of Australia
BOM	Bureau of Meteorology
BPZ	Building Protection Zone
DFES	Department of Fire and Emergency Services (was FESA)
ESL	Emergency Services Levy
FESA	Fire and Emergency Services (now DFES)
FMP	Fire Management Plan
HSZ	Hazard Separation Zone
LPS17	Local Planning Scheme No. 17
LSP	Local Structure Plan
POS	Public Open Space
TPS	Town Planning Scheme
VBRC	Victorian Bushfires Royal Commission
WAPC	Western Australian Planning Commission

APPENDICES

Appendix 1: Location Plan
Appendix 2: Site Plan
Appendix 3: Proposed LSP
Appendix 4: Local Context and Surrounding Land Uses
Appendix 5: Site Topography and Effective Slope
Appendix 6: Existing Site Conditions - AS3959 Vegetation Classification
Appendix 7: Existing Site Conditions - Bushfire Hazard Assessment
Appendix 8: Post Development Site Conditions – AS3959 Vegetation Classification
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Appendix 10: Post Development Site Conditions – Bushfire Prone Areas
Appendix 11: Post Development Site Conditions – Building Protection Zone Requirements
Appendix 12: Compliance Checklist

Appendix 1:	**Location Plan**	**Plan Number: EP14-011(01)--AP03a**	
Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis	Drawn: GRO Date: 30/09/14 Approved: CKK Date: 30/09/14 Checked: VMK Scale: 1:7,000@A4	
Client:	Mirvac (WA) Pty Ltd	0 50 100 200 Metres	

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Appendix 2:	**Site Plan**
Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP04a

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

0 50 100 200 Metres

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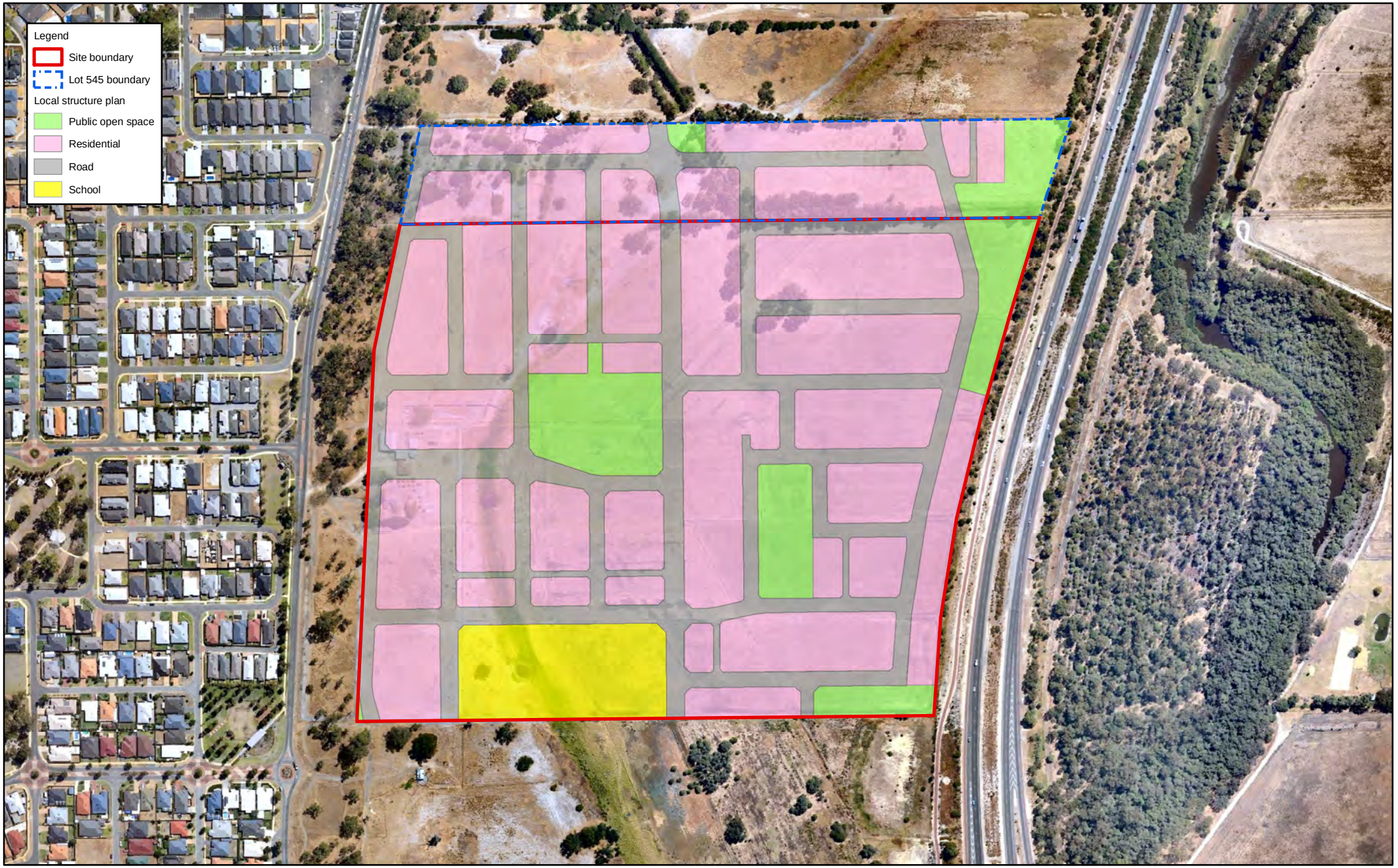

Appendix 3:	**Proposed LSP**
Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP05b			
Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

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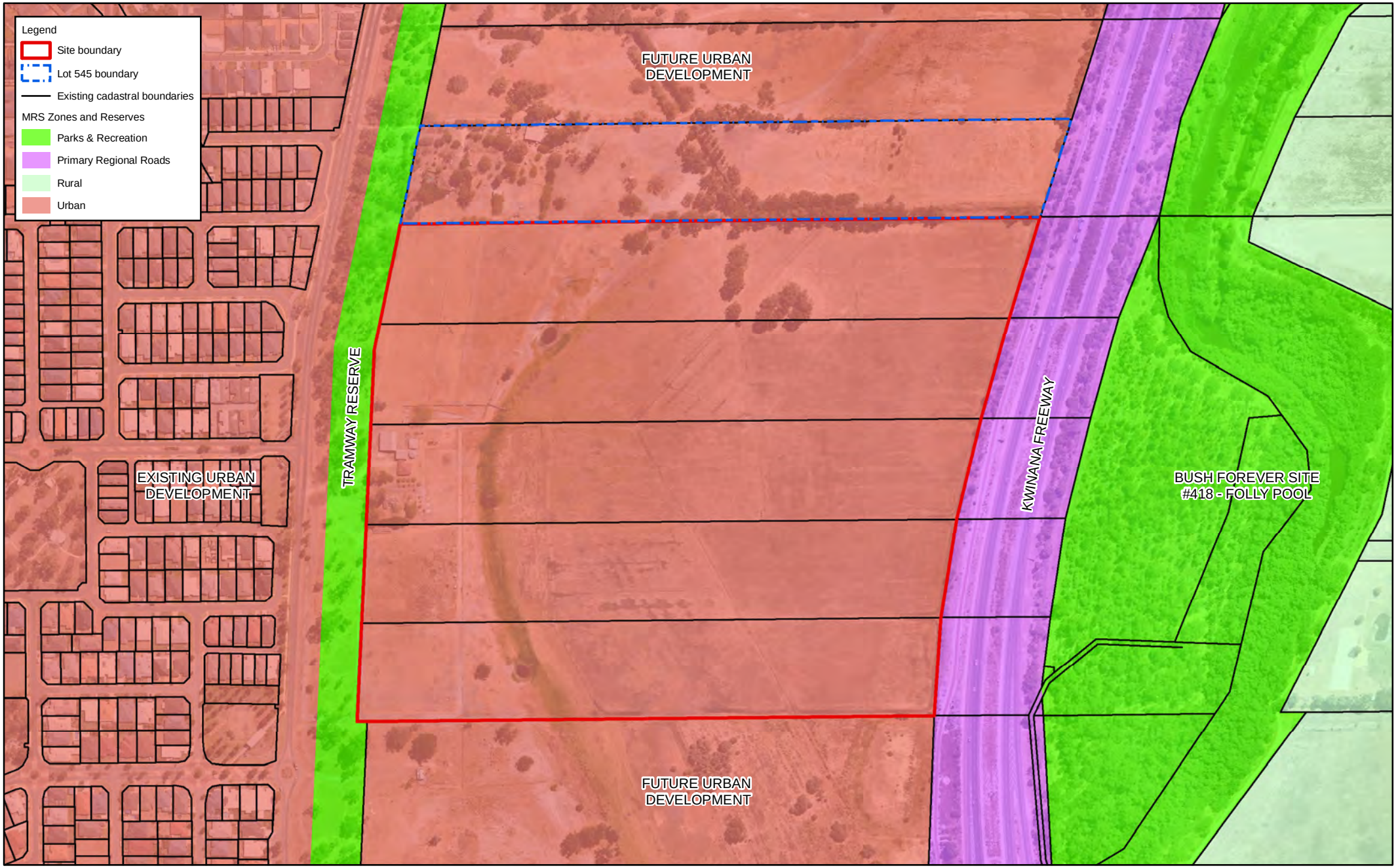

Appendix 4: Local Context and Surrounding Land Uses

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP06a

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
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Sources: The following datasets were used in the production of this map: MRS Zones and Reserves - DoP (2013)

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Appendix 5:	**Site Topography and Slope**
Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP07a

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
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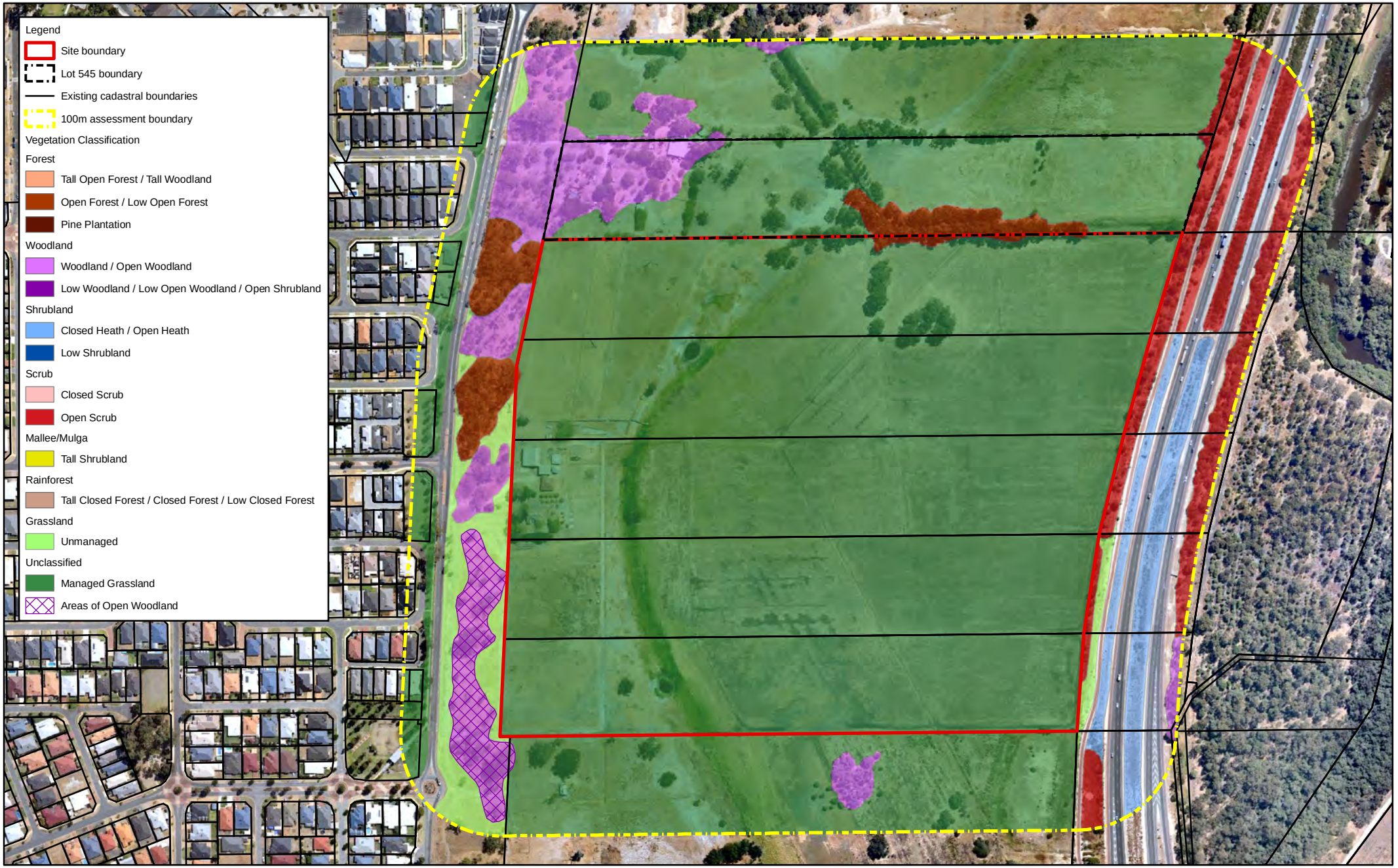

Appendix 6: Existing Site Conditions - AS3959 Vegetation Classifications

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP02a

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

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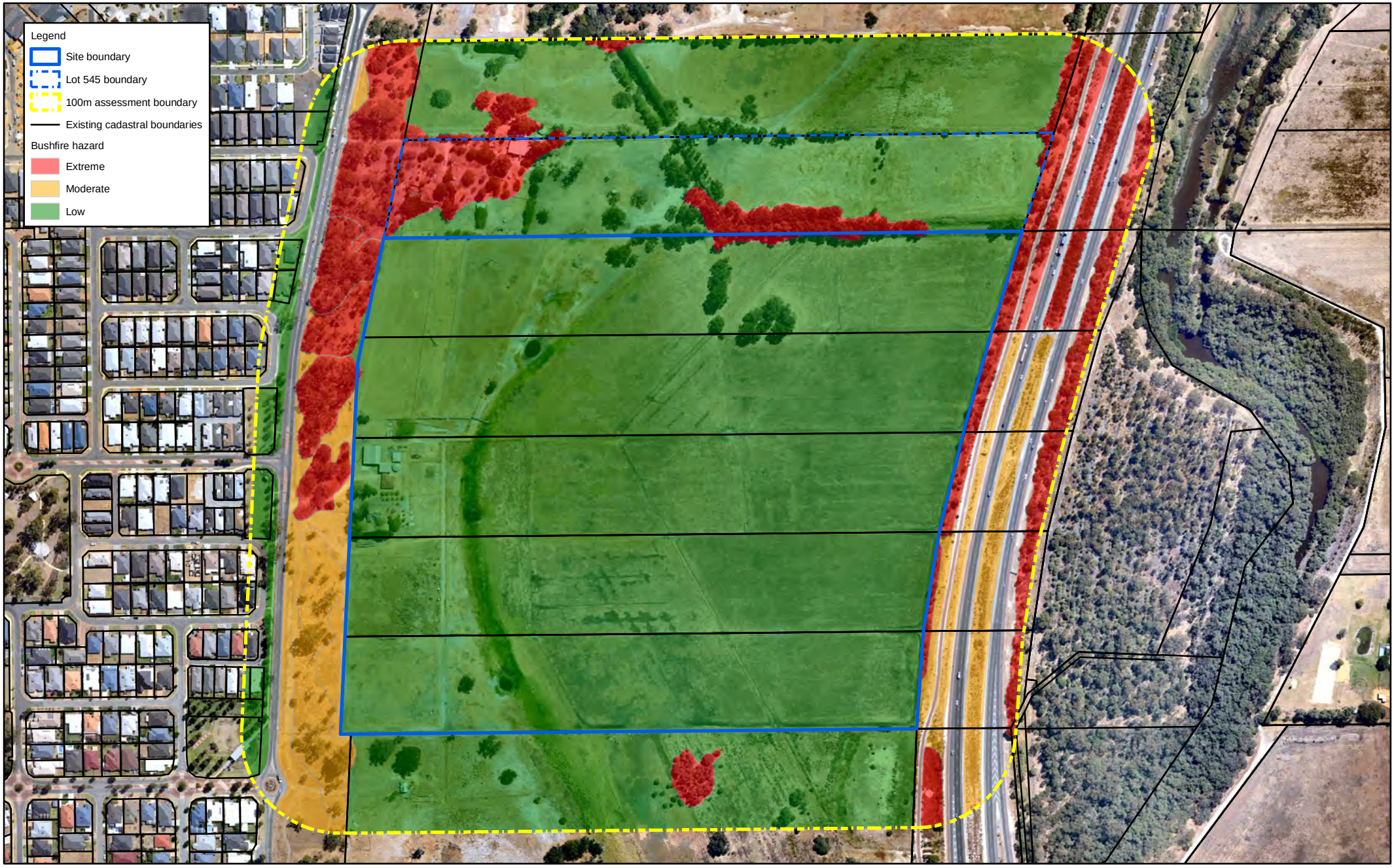

Appendix 7: Existing Site Conditions - Bushfire Hazard Assessment

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP08b

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

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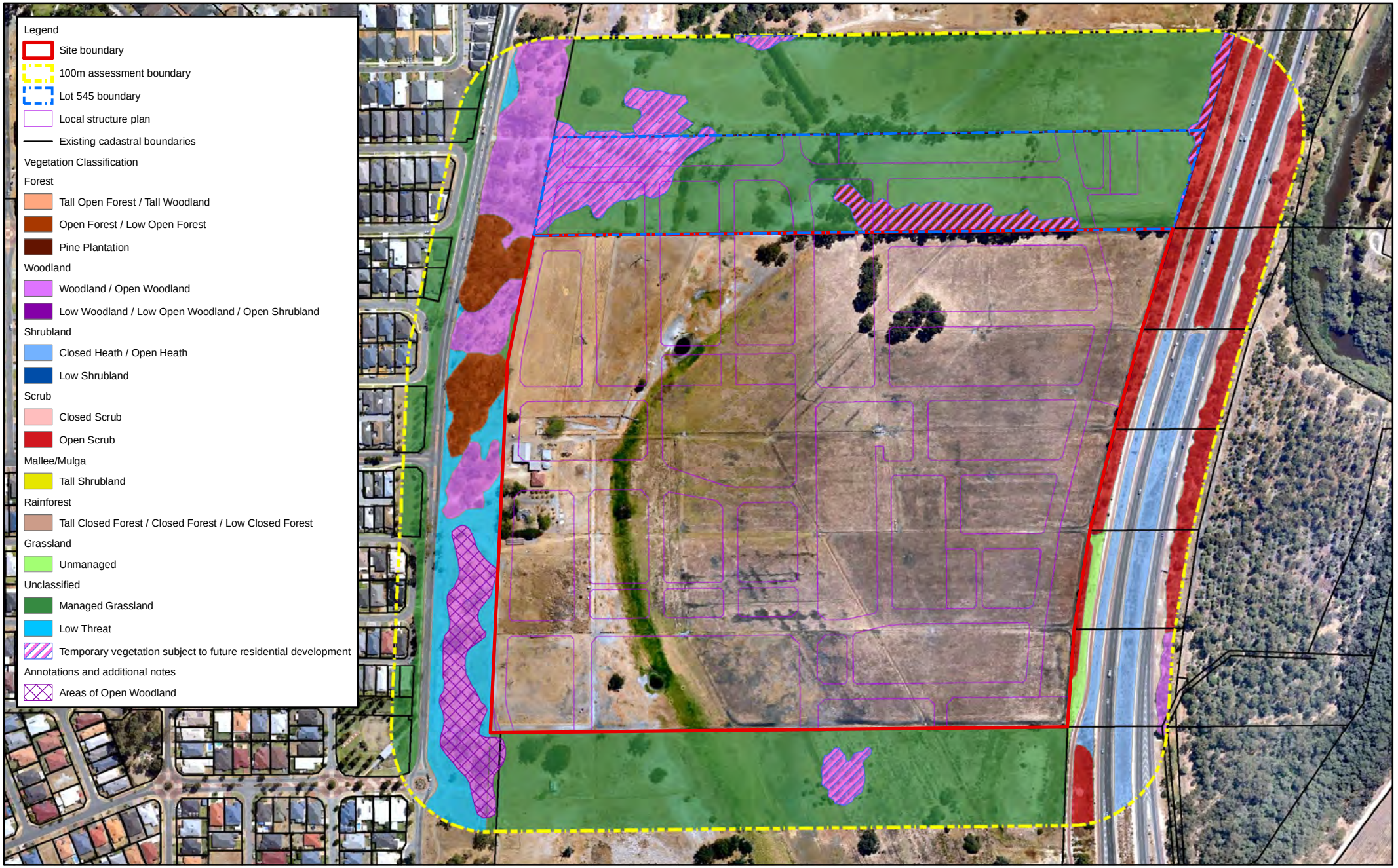

Appendix 8: Post Development - AS3959 Vegetation Classifications

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP09b

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
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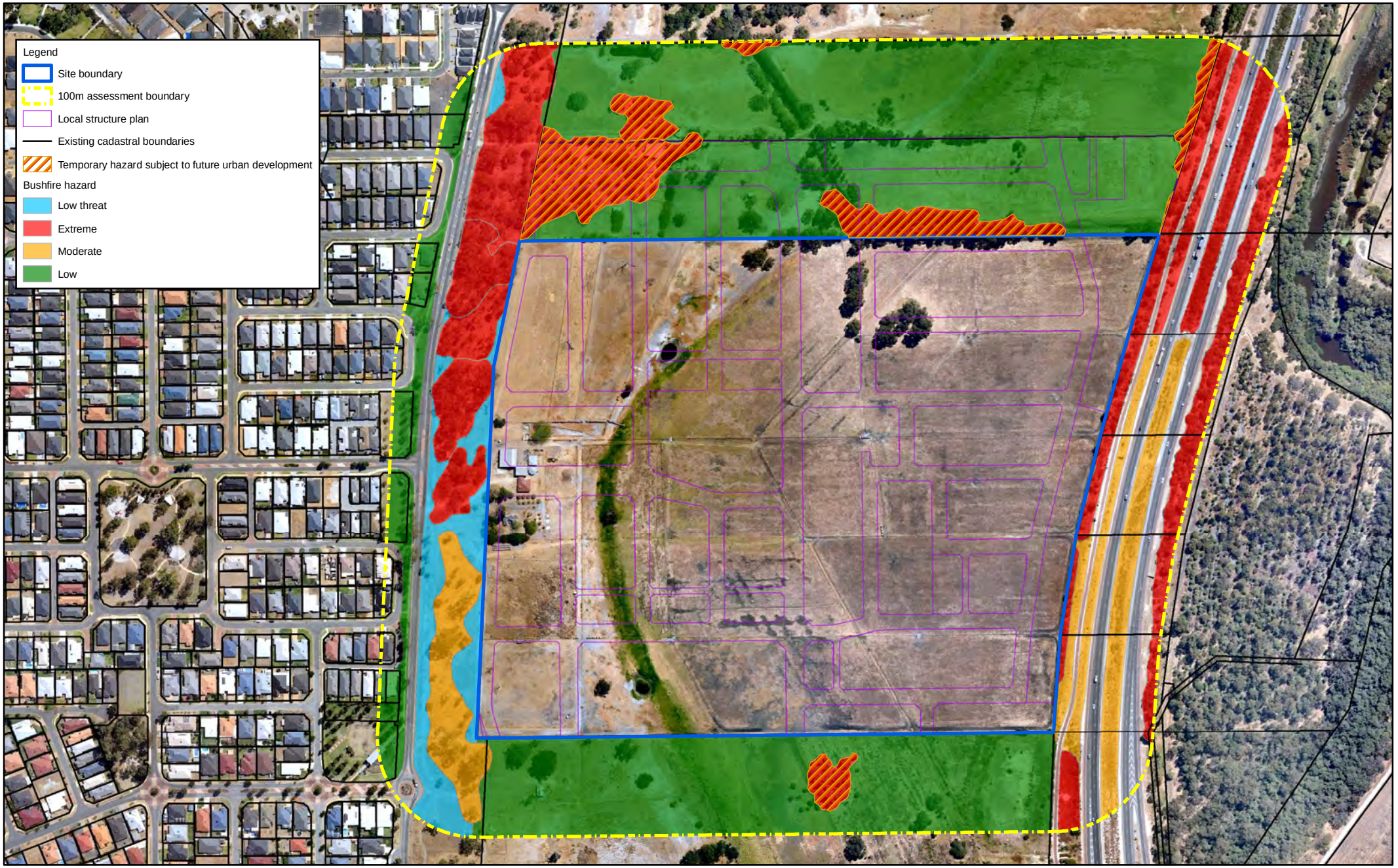

Appendix 9: Post Development - Bushfire Hazard Assessment

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP10b

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
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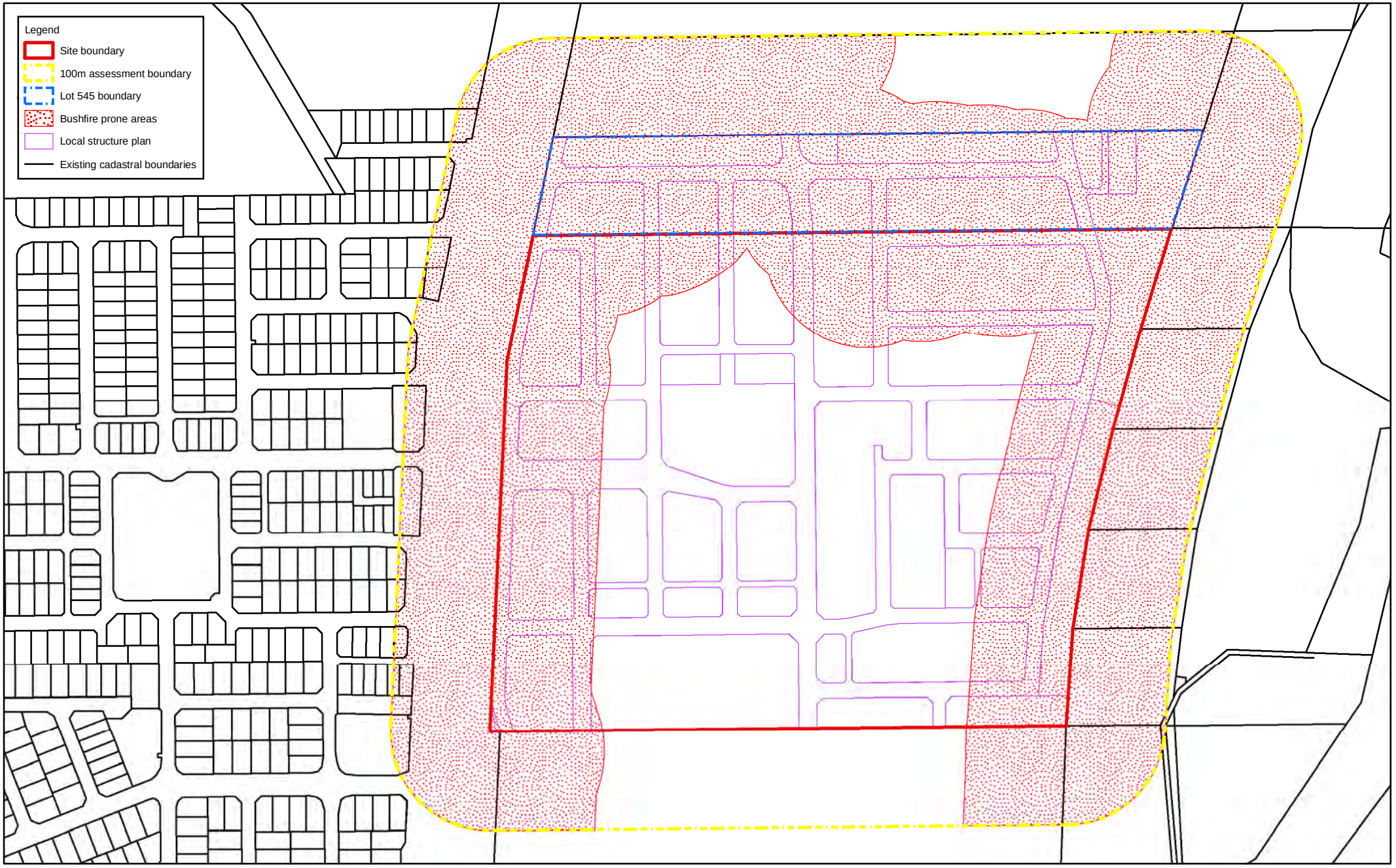

Appendix 10: Post Development Site Conditions - Busfire Prone Areas

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP11c

Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

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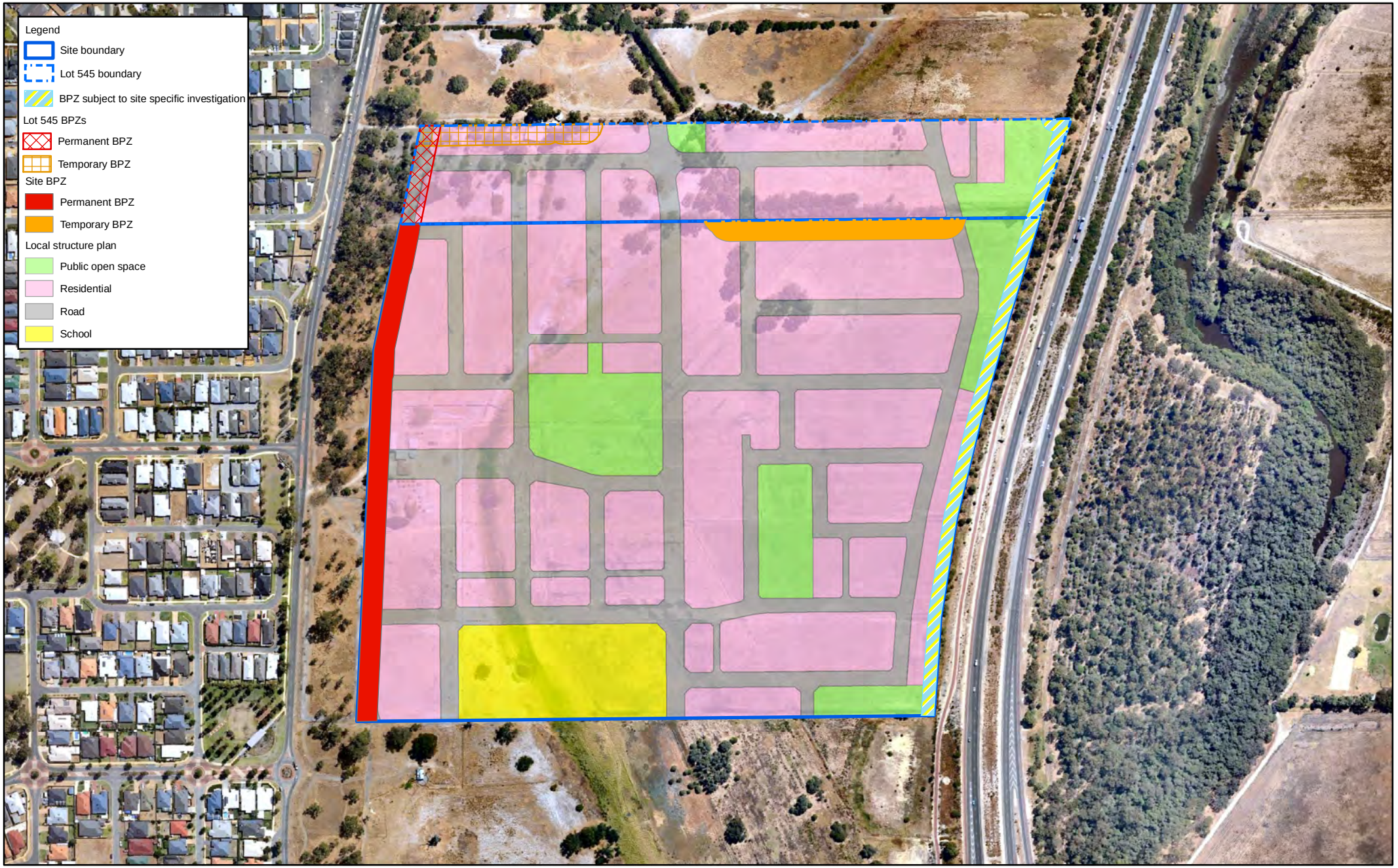

Appendix 11: Building Protection Zone Requirements

Project:	Fire Management Plan Lots 746-50 Baldivis Road, Baldivis
Client:	Mirvac (WA) Pty Ltd

Plan Number: EP14-011(01)--AP12c			
Drawn:	GRO	Date:	30/09/14
Approved:	CKK	Date:	30/09/14
Checked:	VMK	Scale:	1:5,000@A4

0 50 100 200 Metres

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Appendix 12: Compliance Checklist

Element/Question	Response
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?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.4?	Not applicable.
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.
4: Siting of the Development	
Does the proposal comply with the performance criteria by applying acceptable solution A4.1?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A4.2?	No. However, the grassland vegetation is classed as low hazard and is expected to be slashed prior to the fire season each year to maintain a low hazard in perpetuity.

Element/Question	Response
Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	No. However, the proposal does comply with the performance criterion P4, because building construction standards will be increased to comply with the reduced BPZ consistent with AS 3959. BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A4.4?	No. However, the performance criteria P4 is achieved, because all dwellings within 100 m of classified vegetation will comply with AS 3959, and BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A4.5?	Not applicable.
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 to offset the requirement for a HSZ. BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A5.2?	Yes.

Applicant Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:

Name: Rohan Carboon

Date: 01/10/2014

ATTACHMENTS

Attachment 1: Operational Guideline 94: Roadside Vegetation Management & Fire Hazard Control for Metropolitan Region (Main Roads Western Australia 2014)

Operational Guideline 94

ROADSIDE VEGETATION MANAGEMENT & FIRE HAZARD CONTROL FOR METROPOLITAN REGION

This Policy is owned and controlled by the Executive Director Regional Services. Please submit all comments and requests for changes to the delegated custodian - Director Regional Operations.

Authorisation

This document is authorised for use.

EXECUTIVE DIRECTOR REGIONAL SERVICES

Date: 6/3/2014

ISSUE 1 REVISION 4

The Controlled Copy of this document is contained on the MAIN ROADS WA Internal Home Page: iRoads > Online Documents

Hard copies are not controlled and might not be the latest revision.

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1. GENERAL

1.1 Guideline Scope

Roadside vegetation in the road reserve is controlled by Main Roads. This includes routine maintenance, periodic maintenance, rehabilitation activities and vegetation improvement works.

Routine maintenance of vegetation is usually reactive and occurs in response to incidents such as storms, drought, bushfire, vandalism, accidents, pests, and unpredicted plant mortality. It is carried out for safety, the protection of assets, maintenance of a suitable roadside appearance and maintenance of environmental values. Routine maintenance usually involves localised day-to-day activities such as weed control, pest control, pruning and the removal of dead or fallen branches.

Periodic maintenance is planned vegetation protection and control undertaken to maintain a safe road environment, for screening, soil holding, fire risk mitigation and aesthetic functions, and to conserve and enhance environmental value. Periodic maintenance includes programmed activities such as pruning to maintain roadside clearances and sightlines, mowing, slashing, herbicide spraying, mulching and the replacement of dead or damaged plants.

Rehabilitation is substantially restoring a vegetated area to its original Roadside Condition Rating status. Rehabilitation can involve soil preparation and revegetation of degraded and denuded areas.

Vegetation improvement is undertaken by regions to improve vegetation environments, vegetation screening, weed inhibition, soil holding, aesthetics or to meet environmental standards. Vegetation improvement may involve seeding or planting, preferably with native vegetation indigenous to the area but sometimes with exotic vegetation if considered appropriate.

Some routine and periodic vegetation maintenance activities may be suspended at sites of vegetation rehabilitation and improvement until new vegetation is established.

For Main Roads' statewide guidelines on roadside vegetation management and fire hazard management see Corporate Procedure 6707/045, Vegetation Control and Operational Guideline 93, Burning and Firebreak Construction on Roadsides.

1.2 Guideline Review

Operational Guideline 94 is to be reviewed annually and updated when necessary to ensure relevance, achievability and continual improvement in roadside vegetation management. This will incorporate up-to-date advice from relevant authorities and experts including the Department of Parks and Wildlife (DPAW), the Department of Agriculture and Food, the Department of Fire and Emergency Services (DFES) and the Office of Bushfire Risk Management.

2. CLEARING REGULATIONS FOR NATIVE VEGETATION

2.1 General

Areas of remnant native vegetation and vegetation within the road reserve that has been planted or seeded in accordance with a statutory condition or commitment are controlled by the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and associated amendments to the *Environmental Protection Act 1986* (EP Act). The clearing

regulations, which are wide ranging apply to the removal of all types of living or dead native terrestrial and aquatic vegetation, including all native grasses, shrubs and trees.

2.2 Clearing Exemptions

Exemptions for certain routine land management practices are contained in the clearing regulations. Details of these and requirements for clearing are provided in Main Roads' environmental guideline Document No. 6707/034 "Native Vegetation Clearing Regulations and Permits". Those exemptions that apply to Main Roads activities include:

- Clearing maintenance zones within existing transport corridors to the width and height previously cleared within the last 10 years:
    - To maintain and protect infrastructure and public roadside facilities.
    - To maintain sight lines.
    - To the extent necessary to maintain the efficiency and safety of the infrastructure and to provide access to maintain it.
- Clearing within 1.5 m from the fence line on crown land/road reserve (subject to Main Roads' approval), unless in an Environmentally Sensitive Area (ESA).
- Clearing to maintain an existing area along a fence line to provide access to construct or maintain the fence where the vegetation was lawfully cleared within the last ten years, unless in an ESA.
- Clearing for fire hazard reduction, unless in an ESA.
- Clearing as a result of an accident where the clearing was not caused by the negligence of the person clearing or the person who authorised the clearing unless in an ESA.
- Clearing for a temporary road that is necessary to bypass a stretch of road that is impassable due to unforseen damage, unless in an ESA.
- Clearing for the purpose of preventing imminent danger to human life or health or irreversible danger to a significant portion of the environment, unless in an ESA.

The approval of the Asset Manager must be given prior to clearing.

2.3 Environmentally Sensitive Areas

The above exemptions under the Act do not apply within ESAs, where clearing permits are required for vegetation control activities.

ESAs include:

- World heritage sites.
- Areas listed on the Register of the National Estate.
- Wetlands or the area within 50 m of the wetland.
- Declared Rare Flora or the area within 50 m of Declared Rare Flora.
- Threatened ecological communities.
- Bush Forever sites (except where the site may be cleared under a decision by the Western Australian Planning Commission).
- Areas covered by environmental protection policies. These policies include *Environmental Protection (Gnangara Mound Crown Land) Policy 1992; Environmental Protection (Western Swamp Tortoise) Policy 2002; Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* and *Environmental Protection Policy (Swan and Canning Rivers) Policy 1998*.

ESA locations can found on the Department of Environment and Conservation website: https://secure.dec.wa.gov.au/idelve/nv

2.4 Clearing Permits

Where clearing of native vegetation is required and exemptions do not apply, a permit to clear native vegetation must be obtained.

3. VEGETATION CLEARANCES

3.1 Underpasses, Large Culverts and Bridges

The following vegetation clearing requirements must be maintained for large culverts, underpasses and bridges:

- A zone clear of trees and shrubs extending 10 m around the structure is to be maintained, with woody plant regrowth such as suckers and seedlings removed from the clearance envelope, as shown in **Attachment 4**.
- Plant material must be removed from floodways and upstream of structures as specified in the RMIP under “Floodways: Silted; scour; excessive weed and vegetation growth” and “Waterways: Blocked or Silted; flotsam; erosion; scour; excessive weed and vegetation growth”.

Notwithstanding the requirements of **Attachment 4**, vegetation within the clearance area shown in **Attachment 4** that does not pose a fire hazard, does not have the potential to fall onto or damage the structure, does not affect the free flow of water under the structure, is of value as erosion protection or is otherwise considered to be of special significance or of special aesthetic value may be retained where approved by Asset Manager Structures. These locations are to be recorded in the Maintenance Delivery Strategy developed by Main Roads’ Metropolitan Region to detail the processes of assessing the road reserve and the infrastructure it contains, and the specific actions taken and proposed to comply with Operational Guideline 94.

This approval to retain vegetation deemed to be of minimal fire risk will be made in line with guidance from the DFES. The “Building Protection Zone Standards”, “Building Protection Zone Information Note” and “Government Building Bushfire Survivability Assessment” published by the DFES http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/Pages/BushfireProtectionZones.aspx are considered by the DFES to apply to structures (TRIM documents D12#379206, D12#379211 and D12#379213). In summary, the requirements are:

- DFES recognises a need to conserve the community, habitat, stabilisation and other values of trees. Trees are acceptable within 10 m of a bridge if the canopies and adjacent fuels are limited:
    - Tree canopies should not overhang and should be pruned to be 2 m clear of structures to unlimited height.
    - Maintain a 3 m separation between the crowns of trees within 10 m of a bridge, considering tree structural integrity, growth form and fauna habitat.
    - Prune lower branches of trees to a height of 2 m.
    - Remove all limbs that are dead or likely to drop from trees and any flood-caused debris within 10 m of a bridge, and remove dry logs within 5 m of a bridge.
    - For a tree within a few metres of a structure, fire can be excluded from travelling up the tree to the canopy by the use of a 1 m wide “mineral earth” break around the tree i.e. bare soil.
    - Remove hollow-butted trees within 10 m of a bridge or specifically authorise for retention.
- Shrub foliage should be 2 m clear of structures.
- Maintain grass to < 100 mm height and ground fuels (litter, trash, scrub) to < 2 t/ha within 10 m of a bridge between October and May.

3.2 Boundary Fence Line Vegetation Clearances

Fire-fighting resources are usually readily available in urban areas and because road reserves are generally narrow and fires can be easily accessed from the road, access tracks for fire-fighting vehicles are rarely required. However, where verges are wider than 15 m, access tracks may be required depending on adjacent land use, and these must be accessible, driveable and well maintained i.e. sufficient width, no major depressions, free of rubbish and debris:

- A minimum vegetation clearance envelope 3 m wide and of sufficient height to allow access for fire-fighting vehicles must be maintained along fence lines in "high" and "medium" priority areas as specified in Section 8.1.
- Where significant trees are located within 3 m of a fence-line, the access track may curve around the tree(s) to allow their retention.
- Principal Shared Paths (PSPs) or other maintained paths or tracks that are at least 3 m wide can serve as fire-fighting access, therefore not requiring the creation of an additional 3 m-wide track unless the vegetation between the path and fence is wider than 15 m.

For areas where there is little bushfire threat, a minimum vegetation clearance of 1 m must be maintained along fence lines that abut urban property to prevent fence damage from trees and shrubbery and to facilitate fence inspection and maintenance.

The establishment of new developments adjacent to the road reserve will normally require the establishment of appropriate clearances along the fence line.

Overhanging branches that present a danger or major maintenance issue to structures or people beyond the road reserve must be pruned to ensure there is a vertical vegetation clearance extending 1 m inside the fence line. Main Roads also has a duty of care to trim branches from trees outside the road reserve that overhang the fence line and are hazardous to people or property within the road reserve.

Ongoing mowing, slashing or herbicide treatment is required to reduce flammable materials within boundary fence line clearances as specified in the RMIP under "Fire Hazard". Care should be taken to minimise bare and compacted areas so that soil erosion, scour and degradation of abutting vegetation is avoided.

3.3 Drainage

Clear access must be maintained to drainage structures and waterways, and unless otherwise specified, grass, shrub and tree regrowth must be controlled to maintain a minimum 500 mm clearance around all drainage structures.

Grass, shrub and tree regrowth must also be controlled within table drains, catch drains, basins, and around culvert inlet and outlet drains to maintain functional capacity, in accordance with the RMIP under "Vegetation Affecting Road Pavement". To avoid erosion, clearing roadside drains and basins using earthmoving equipment must be avoided where mowing or slashing is suitable.

3.4 Areas with Indigenous Native Vegetation

The requirements include maintaining existing clearings, weed and pest control, removal of hazardous vegetation such as overhanging branches or unstable trees, fire hazard management and mowing or slashing of cleared areas within indigenous native vegetation areas.

Native vegetation, which includes remnant vegetation and native species planted as a statutory or ministerial requirement for the purpose of conservation, is subject to the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. These provide for the following exemptions from the requirement for a clearing permit:

- Clearing, pruning, mowing and slashing within areas cleared in the last 10 years to the width and height previously cleared.
- Removal of hazardous vegetation such as overhanging branches or unstable trees as long as it isn't within an ESA.
- Fire hazard management as long as it isn't within an ESA.

Non-clearing maintenance activities within ESAs, such as weed control, do not require a permit if the maintenance is not likely to impact on the native vegetation.

For further information on ESAs, refer to Sections 2.2 & 2.3.

3.5 Non-statutory Revegetation and Exotic Vegetation Landscapes

3.5.1 General

In addition to maintaining existing clearings, selective weed control, the removal of hazardous vegetation growth such as overhanging branches or unstable trees, fire hazard management and mowing or slashing of cleared areas, vegetation maintenance requirement for all non-statutory native and exotic vegetation areas in transition zones includes the removal of all dead, dying or damaged trees, tree branches, shrubs and ground covers and their replacement with plants of similar species.

3.5.2 Wood Chipped and Mulched Areas

The DFES advises that straw mulch and fine aerated mulch (as produced by recycling plants) should not be used on road verges as they are highly susceptible to accidental ignition from discarded cigarettes, faulty exhausts and maintenance plant. Therefore, only mulch that is coarse and dense may be used to hold the soil together and suppress weeds within cleared areas along road verges and medians.

Temporary mulch stockpiles must not exceed 750 mm in height due to the risk of self-ignition.

Brush thatching may be used on steep slopes.

In landscaped areas where wood chip or pine bark mulch has been specified as an ongoing requirement, the chips or bark must be continuously maintained by topping-up with like material and spread to an even thickness of 75 mm (min) between plants, tapering down to zero thickness 100 mm from plant stems.

Weeds in wood chip or pine bark mulched areas reduce visual amenity and therefore regular weed control is a high priority.

4. VEGETATION CONTROL PRACTICES

4.1 Mowing or Slashing

4.1.1 General

The control of grass and weeds is important to maintain sightlines, visual amenity, environmental value and to reduce the likelihood and consequence of fire. A combination of mowing, slashing and herbicide treatment is used to control grass and weeds.

Mowing and slashing activities must meet the following general requirements:

- All surface obstructions must be marked and rubbish removed from the work site prior to mowing or slashing operations.
- Where practical, mowing/slashing of weeds should be carried out prior to flowering.
- Care must be exercised to avoid unnecessary destruction of native flora.
- Areas of grass within the road reserve that cannot be accessed by mechanical plant must be cut manually or controlled by herbicide.
- Cuttings must be evenly dispersed, must not be left where they can wash into storm water drains or waterways or spread into native vegetation.
- The direction of travel of slashing/mowing shall generally be such that any side discharge is directed away from the shoulder or road.
- Projectile damage to passing traffic must be avoided; but rectified if it occurs.

Mechanical mowing and slashing exclusions include:

- Areas already treated with herbicide. However mowing and slashing is required where late spraying has occurred and the height of the dead material exceeds maximum intervention level.
- Revegetated areas where plants are below lawn/grass height.
- Steep or un-trafficable batters.
- Wet boggy areas during winter.

4.1.2 Mowing (Urban Areas)

Mowing is required to control grass and weeds on freeways, major highways built to freeway standards and other highways and main roads within urban areas, in accordance with the RMIP under “Excessive Roadside Vegetation”. Appropriate heights after mowing are between 10 mm and 30 mm.

Mowing on medians and verges must extend from the shoulder or kerb:

- To the natural line of vegetation, where one exists (i.e. where plants are generally less than 5 m apart).
- Between plants, if they are more than 5 m apart.
- To as near as possible to road furniture or trees by machine and then any remaining grass must be cut using a brush cutter.
- Where the existing vegetation comprises shrubs or bushes, machine mowing must be to the “drip-line” or to a limit such that no damage is caused to the shrub or bush. Brush cutting must then take place to 500 mm inside the “drip-line”.
- Grass is to be mown along the fenceline to a distance of 3 m from the fenceline.

4.1.3 Slashing (Rural Areas)

Slashing, in lieu of mowing, is required to control grass and weeds on rural highways and main roads within the Metropolitan Region in accordance with the RMIP under "Excessive Roadside Vegetation", with a height of less than 100 mm appropriate after slashing.

Slashing on medians and verges must extend from the shoulder or kerb:

- To the natural line of vegetation, where one exists (i.e. where plants are generally less than 5 m apart).
- Between plants, if they are more than 5 m apart.
- To as near as possible to road furniture, trees, shrubs or ground cover without causing damage or, to the limit of any herbicide treatment around the object.
- Brush cutter work is not required where herbicide treatment has been undertaken around plants and road furniture.
- Grass is to be slashed along the fenceline to a distance of 3 m from the fenceline.

4.2 Management of Declared and Invasive Plant Species

4.2.1 Declared Plants

Main Roads is legally required under the *Biosecurity and Agriculture Management Act 2007* to control or eradicate plant species found on land vested with Main Roads that are nominated as "declared" pests. One of the key objectives of the Act is to address "biosecurity", or the "protection from the adverse effects an organism may have on the environment".

The Western Australian Organism List has been created to assist with the identification of an organism's declared status, with all declared pests placed in one of three categories: C1 (exclusion), C2 (eradication) or C3 (management). This list may be found at the Department of Agriculture and Food website http://www.biosecurity.wa.gov.au.

Each Region is responsible for ensuring that the Act is complied with and operational staff and contractors are familiar with declared plants that occur or could occur in their area.

4.2.2 Weed Control Strategy

4.2.2.1 General

Good weed management is about making the landscape resistant to invasion by weeds and thus preventing weeds from establishing.

Eradication of every weed species is not possible and therefore the Region makes best use of available resources by firstly following a weed control strategy that:

- Inhibits growth, reduces populations and prevents the spread of all weed species.
- Targets specific high risk weed species at sites where their potential impact is greatest.

All weeds should be controlled at optimum weed stage development (i.e. before seeding and flowering) and at the optimum season to allow for high control effectiveness. An alternative control method to herbicide within sensitive areas (i.e. ESAs, Public Drinking Water Source Areas and vineyards) shall be used.

4.2.2.2 Inhibiting Weed Growth on Road Shoulders and Formations

Weeds are most likely to establish on the road shoulders and formations and spread to the transition zone. Therefore:

- Herbicide should be used to keep road shoulders and formations constructed with material resistant to erosion weed free.
- Seeding with low growing native vegetation that if fire resistant, non-invasive and easy to maintain is the preferred option for inhibiting weeds on road shoulders and formations constructed in sandy soils.
- The secondary option for inhibiting weeds in sandy soil is coarse dense mulch.

Where invasive grasses and weeds are already growing on sandy road shoulders and formations, and seeding with native ground cover or spreading mulch is not an option available at the time, it is essential, particularly during dry, hot and windy periods to inhibit weed growth and the ignition and spread of bushfires by ensuring that invasive grasses are controlled by ongoing mowing or slashing; preferably prior to flowering.

4.2.2.3 Inhibiting Weed Growth within the Transition Zone

Inhibiting weed growth within the transition zone is achieved by promoting dense, intact or complete indigenous native vegetation. This involves protecting existing native herbs, ground covers, shrubs and trees; revegetation to substantially restore areas of degraded or denuded vegetation to a quality condition; and vegetation improvement involving seeding or planting native vegetation within sites that have been cleared for construction purposes.

Native ground cover should be used to inhibit weed growth in areas cleared specifically for sight lines, services, structures, furniture, fences, drains, etc. Weed control by ongoing mowing, slashing, herbicide, mulching or manual means must be used in cleared areas and bare soil areas that are still to undergo revegetation.

4.3 Tree and Shrub Pruning

Tree and shrub pruning or lopping must be carried out in accordance with AS 4373, “Pruning of Amenity Trees” and undertaken by certified operators in tree surgery or arboriculture. Tree lopping cut sequences must be in accordance with Main Roads’ Standard Drawing No 9531-0329. (**Attachment 14**)

4.4 Use and Disposal of Cut Vegetation

On the day that it is removed, vegetation cut for the purposes of sightline or clear zone establishment/maintenance should be chipped and respread on site as a soil surface protection measure and a surface mulch to suppress weeds. Care must be taken to ensure that plant and soil material within dieback-infested or dieback-uninterpretable areas are not spread or exported outside of the clearing site. Ideally, placement of chipped material will be done just before rain so that fine particles can be washed out. Material that is predominantly fine or material removed to reduce fire hazards as described in Section 8 are not suitable for re-use. Material with a high weed content or comprising environmental or declared weeds are not to be spread.

Cut material not suitable for re-use must not be stockpiled on site within the Metropolitan Region and must be disposed of at a recognised and authorised disposal site approved for handling the type of material to be deposited.

5. FIRE HAZARD CONTROL

5.1 General

The benefits we receive from roadside vegetation do not come without risks and these must be managed. Fire within roadside vegetation is a risk that requires mitigating to a level that is affordable, has minimal environmental impact and the community is willing to accept.

The DFES regularly updates its Bushfire Threat Analysis Mapping, which indicates the spatial distribution of predicted behaviour, threat, values, suppression response, likelihood and consequences of fire, and this mapping should be consulted. The DFES also publishes on its website recommended building protection zones that should be consulted regularly to help keep the advice that Main Roads follows up-to-date.

A fire threat rating system has been developed by the DFES to assist local authorities throughout south-west Western Australia to determine fire risks on various tenures and take appropriate action to mitigate these risks. It is based on AS 3959 – 2009 but has an additional component incorporating Fire Threat Levels: Low, Medium, High and Very High. To attempt to ensure uniformity of approach, these will be adopted and used in the risk assessment procedure described below in Section 8.6.

Main Roads' Metropolitan Region will in a timely manner consider and directly respond to any notifications from the DFES, the DPAW or local government authorities of potential bushfire risk. This will contribute to informed decisions being made regarding management of the road reserve, with attendant safety benefits for the public and protection of infrastructure, property and the environment. It will also provide accountability for the Region to demonstrate that it conducts appropriate actions where it has been made aware of a potential bushfire risk.

Managing fire risk within ESAs requires Environmental Impact Assessment and a clearing permit obtained from the DPAW, refer to Section 4.2. These requirements apply to the removal of both live and dead, intact plants, and consider the greater intensity and detail of fuel reduction practices necessary to protect rare flora specimens, fauna habitat, threatened ecological communities and wetland/watercourse environments. The Metropolitan Region maintains records of areas of road reserve and structures that occur within ESAs (TRIM file 12/6067) and applies for clearing permits as required by the DPAW.

Main Roads' Metropolitan Region follows a maintenance program and Maintenance Delivery Strategy specifically relating to fire hazard management. This Strategy details the processes of assessing the road reserve and the infrastructure it contains, the methods and timing of assessing fuel loads and fire risk, and the specific actions taken and proposed to comply with this Guideline.

5.2 Maintaining Safe Vegetation Clearance Zones to Property and Infrastructure

The DFES document "Rural Urban Bushfire Threat Analysis" (RUBTA) provides a pictorial key describing a fire risk assessment for structures at various distances from various types of vegetation. It indicates that distance from the predominant vegetation is a key factor for protecting structures from bushfires. Risk factors considered when determining appropriate clearance zones include:

- the need to maintain essential screening, soil-holding, aesthetic and environmental functions of existing roadside vegetation
- steepness of slopes
- strength of prevailing wind

- vegetation landscape:
    - vegetation type
    - height and density of upper stratum foliage
    - density of under-storey
    - type and density of fuel load on ground
- accessibility to fire-fighting resources

The large vegetation offsets recommended within the RUBTA document have been calculated to protect urban settlements or structures within rural areas surrounded by extensive bushland and should not be applied to narrow road corridors passing through urban areas as it would result in most roadside vegetation being cleared. Factors that must be considered when determining appropriate vegetation offsets include:

- Fire in narrow roadside vegetation would not build to the intensity of fire in extensive bushland. This is defined as < 15 m verge width.
- Structures requiring protection are usually set back an additional distance beyond the road reserve boundary.
- Narrow roadside vegetation is easily accessed by fire-fighting resources.
- The road itself acts as a firebreak.

Reduced vegetation setback distances places extra importance on the following:

- Isolating fire ignition sources from flammable vegetation (Section 8.3)
- Maintaining fuel loads at acceptable limits (Section 8.4)
- Maintaining access for fire-fighting resources (Sections 3.4 and 8.5)

5.3 Isolating Fire Ignition Sources from Flammable Vegetation

The source of most bushfires within the road reserve is close to the road. Discarded cigarettes, lightning, spread from adjacent properties, vehicles with defective parts (exhausts) and sparks from maintenance plant (slasher blades striking rocks) are thought to be primary causes of ignition. PSPs and other paths or tracks within the road reserve also provide access for ignition sources. An important function of the roadside vegetation clearance envelopes established throughout the Region is to provide a low fuel buffer between the primary ignition source (road shoulder) and flammable vegetation landscapes within the road reserve.

It is not necessary to clear all grass and vegetation fuels from fenceline to road edge – what is required is to disrupt the continuity of fuels in a targeted manner. For example, cut-off drains can break up fuel continuity on slopes. Wind direction, wind breaks and wind funnelling may be considered by roadside maintenance officers to determine the likely direction of fire spread and where fuels particularly should be reduced.

Low native ground cover and coarse dense mulch (not fibrous bark or the fine aerated mulch produced by recycling plants) are more resistant to fire ignition, require less maintenance than grass and are the preferred options for roadside vegetation envelopes.

However, where grass or weeds are already growing within roadside clearance envelopes, it is essential, particularly during dry, hot and windy periods to inhibit ignition and spread of bushfires by ensuring grass is kept below maintenance intervention levels. Priority areas for this control of grass are roads with speed limits less than 75 km/h, as Commonwealth Scientific and Industrial Research Organisation (CSIRO) tests have shown that cigarettes disposed from vehicles at higher speeds are less likely to cause ignition.

Roadside maintenance plant such as mowers and slashers must be well maintained, have spark arresters fitted to exhausts, carry fire extinguishers and (in accordance with the *Bush Fires Act 1954*) must not operate when harvesting bans are in place. Operators of slashers and mowers must have the means to contact fire and emergency services if required.

5.4 Maintaining Fuel Load in Transition Zone at Acceptable Limits

5.4.1 General

The height and density of dry, dead material should be limited to reduce fire risk. The amount and density of fuel available is directly related to fire intensity, and height affects the rate of fire spread particularly to elevated canopies that in turn increases the risk of spotting. Therefore, fuel loads should be maintained at acceptable levels to reduce the intensity of bushfires within the road reserve and contribute significantly to the success of fire-fighting efforts. Acceptable fuel levels are generally considered by the DFES to be less than 8 t/ha, assessed for material < 6 mm diameter.

The preferred management option is to apply fuel reduction practices such as controlling grass and weed growth and removing dead branches, shrubs and trees. Some large "stags" and logs should be left intact on-site as fauna habitat – this is acceptable in terms of overall reductions in fuel and the priority of removing finer material.

5.4.2 Prescribed Burning

Where prescribed burning in the road reserve is recommended by the DFES or the DPAW, and consultation with the relevant Main Roads manager and local government has been carried out, Main Roads accepts the recommendation and action of the DFES or the DPAW subject to any traffic, safety or environmental conditions Main Roads may set. Any other proposed burning not recommended by the DFES or the DPAW must be approved by the Director Metropolitan Operations or person delegated by him, and done under the guidance of or advice from the DPAW, the DFES, local Bushfire Brigades or other relevant authority. Local government must also be consulted. Also, because fire can promote the growth of many weed species and not destroy weed seed in soil, immediate follow-up weed assessment needs to be done with appropriate controls where required.

5.4.3 Fuel Reduction in Grass and Weed Infestations

Infestations of annual and perennial grasses and weeds within the transition zone must be controlled as they contribute significantly to fuel load, are a primary source of ignition and facilitate the spread of fire between stands of vegetation.

Grass and weeds can be controlled by herbicide – this reduces the propagation of weeds, allows weed material to decompose and reduces the standing height of weeds. This treatment is a particular priority where the overall fuel load is greater than the 8 t/ha referred to in section 8.4.1 and in high priority areas as specified in Section 8.6.

Although fire spreads at the same rate for slashed grass and standing grass, flame height in slashed grass is approximately halved, lowering the risk of fire reaching upper-storey vegetation. Therefore, grass height anywhere within the transition zone must be maintained below the maintenance intervention level.

Where the vegetation is particularly sensitive, such as threatened ecological communities or declared rare flora locations, the removal of mown or slashed material from site should be considered. This could involve hand-removal, raking by hand or machine, or using mowing equipment with a catcher.

5.4.4 Reducing Fuel Build-up in Native Vegetation

Regular inspections of the road reserve by a suitably qualified fire risk assessor as approved by the DFES must be conducted to identify when fuel loads are excessive. It takes approximately 5 years for fuel loads to build to unacceptable levels within native trees, shrubs and ground covers – this should be considered to ensure timely coverage of assessment and treatment of all land for which Main Roads is responsible. The DFES publishes guides for rapidly assessing fuel load visually: "Visual Fuel Load Guide" for the scrub vegetation of the Swan Coastal Plain, including Geraldton Sandplains and Leeuwin Ridge Regions of Western Australia", and " Grass Curing Visual Guide for Western Australia".

Following identification of high fuel loads and entry of this information in Main Roads' Maintenance Management Information System, the Region's Environmental Officer is responsible for assessing the site to ensure that native vegetation clearing regulations are adhered to and fauna habitats and the regeneration of native plant species are not impacted by the over-clearing of dead plants and branches. The Region's Asset Manager is responsible for approving the type and extent of material to be removed.

Examples of appropriate practices that are targeted rather than extensive include:

- Burn or trim the "skirts" underneath grass trees – their fuel density can be a very high 20 t/ha. Burning by applying a match to the skirts can be done safely in winter, with the rest of the grass tree not burning, provided adequate precautions are taken to protect surrounding vegetation and fuels from fire.
- Reduce material at wetlands, as described at Sections 8.4.1 and 8.4.2, only if excessively dense and dry. This reduces the risk of long-burning sub-surface fires that move through the high soil organic material found there. Such fires are difficult to extinguish and, because the fire aerates the sub-surface material, can generate actual (as opposed to potential) acid sulphate soil.
- Prune tree canopies that are closer than 15 m to reduce risk of spread and reduce the amount of elevated material from which the wind can transport embers more easily than from shrubs and groundcovers. This would not be done everywhere – only in specific areas where there are significant properties or fuels that may be susceptible to embers, and as instructed by the Region's Asset Manager.

5.5 Maintaining Access for Fire-Fighting Resources

To provide access for fire-fighters, slashed or mown Fire Access Ways (FAWs) should be positioned and maintained along fence lines (refer to Section 3.4) where the adjacent land use represents a significant risk (refer to Section 8.6), and also established at 250 - 500 m intervals along road corridors, perpendicular to the road, where the verge is over 30 m wide. Such breaks should use existing cleared areas, be 3 m wide with 5 m vertical clearance, and link to fenceline FAWs. Do not install locked gates, bollards or any barrier on any FAW.

Existing FAWs on the reserve boundary need to be maintained, but no new ones created unless requested by the local authority or the DFES and authorised by Main Roads on a case-by-case basis, or where a residential area abuts the road reserve. Existing firebreaks on adjacent tenure may be adequate for protecting the road reserve and adjacent assets. Principal Shared Paths are of sufficient width and condition to serve as FAWs, and therefore negate the need to create a separate boundary FAW. Main Roads is currently exempt from requiring FAWs or firebreaks at this time.

5.6 Fire Risk Management Procedure

The following risk assessment procedure has been developed for fire management and should be undertaken by a person with suitable fire management experience, skills or training:

ESTABLISH THE CONTEXT

1. Identify adjacent tenure ownership or management from Landgate and other sources to confirm Main Roads' responsibility areas.

2. Identify assets in various fire risk classes:

   The Metropolitan Region has established the following fire hazard risk hierarchy based on land use adjacent to roads to ensure the mitigation effort is proportional to the level of risk:

Table 1 – Metropolitan Region Asset Classification

ASSET CLASS	DESCRIPTION
High	• Hospitals, schools and aged care homes. • Public buildings and residential subdivisions where escape routes are limited and access for fire-fighting equipment poor. • Essential utilities, including electrical substations. • Vehicle bridges/culverts that are the responsibility of Main Roads. • Large industrial facilities.
Medium	• Residential subdivisions and public and private buildings with multiple access and escape routes. • Environmentally Sensitive Areas (ESAs). • Small or scattered industrial facilities.
Low	• Buildings that are (i) more than 30 m from the road AND (ii) have intervening local roads, cleared parkland or < 2 t/ha fuel. • Little or no vegetation between the road and adjacent buildings or utilities.

GATHER INFORMATION AND IDENTIFY FIRE RISKS

Areas that do not require further assessment include those that are:

- adjacent to a “Low” asset class as defined in Table 1 above
- adjacent to assets < $500 000 in value
- dominated by grasses and herbs
- < 1 ha
- < 500 m in length along the road
- < 10 m wide from the mowed roadside edge to the nearest track or cleared access
- not owned or managed by Main Roads, even if they combine with Main Roads’ vegetation to otherwise qualify for assessment. Such areas need to be jointly assessed and managed by Main Roads and the relevant land owner/manager.

3. Use attached Bushfire Threat, Risk, and Consequences Assessment form (Attachment 16) to record onsite detail and later determine threats risks and consequences.
   a. Access past fire history and record (years since last burnt). Sources may include Main Roads’ records, Main Roads’ staff, regional fire services, the DFES, the DPAW or Police Arson. It is unlikely that records will be highly detailed, instead indicating only the location and size of the fire.
   b. Assess and record fuel age and quantity using DPAW “Red Book” or DFES “Visual Fuel Load Guide”. Record Line 4.
   c. Use AS 3959 – 2009 Figure 2.3 (Attachment 17) to determine vegetation structure and classification.
   d. Note whether the vegetation is primarily upslope or downslope of the dwelling/building/asset/value.
   e. Use inclinometer to measure, and record average slope.
   f. Measure and record distance from the classifiable vegetation to the building/asset. Record Line 7.

ASSESS THE RISK

   g. Determine and record the Bushfire Attack Level (BAL) with AS 3959 Table 2.4.3 (Attachment 18).
   h. Determine Threat rating – Very High, High, Medium, or Low (Attachment 18).
   i. Use Fire Risk Assessment Matrix to determine fire Likelihood based on fire frequency, Consequence and Risk Ranking (Attachment 19).
   j. Record any recommendations or actions in Comments.
   k. Identify location of any Fire Access Ways required and record same.

4. Take photographs of typical vegetation and assets at risk.

5. Customer and Stakeholder Engagement – contact and consult with key stakeholders and interest groups including local authorities, the DPAW, the DFES and ratepayer representatives.

TREAT RISKS

6. Appropriate actions depend on the Risk Ranking determined by the Bushfire Threat, Risk, and Consequences Assessment and defined in Attachment 19, and the area in which the road reserve occurs as shown in Attachment 20 and defined by the following:

   "Area A" – Outer Metropolitan Forest: sections of the heavy traffic roads Albany Highway, Brookton Highway and Great Eastern Highway comprising largely jarrah and marri forest with associated understorey species, adjacent to DPAW-managed land, where larger contiguous areas of vegetation occur, no separation of MRWA reserves to other tenures exist, established bush fire brigades exist, and the threat of bushfires is greater.

   "Area B" – Outer Metropolitan Rural: non-forest areas, urban-rural interfaces, small pockets of trees such as sandplain banksia, sheoak, peppermint, with a significant percentage of understory scrub, and wetlands (riparian zones, including paperbark swamps). Adjacent tenures would include farms, orchards, small 'lifestyle' lots, parks and various conservation/recreation reserves. Roads would include Toodyay Road, Indian Ocean Drive and South Western Highway.

   "Area C" – Inner Metropolitan: high population, high density commercial, residential and services areas, very heavy traffic flows

   Where specific actions should be undertaken is outlined in Table 2 below.

7. Present completed Bushfire Threat, Risk, and Consequences Assessment forms to the Region's Asset Manager, Maintenance Delivery Manager and Manager Metropolitan Road Program to determine actions that can be funded and undertaken and to obtain necessary approvals.

8. File reports with action and management outcomes, with bring-up date for action items.

Table 2 – Treatments or Hazard Mitigation Options

ACTION	WHERE TO USE
No action	Areas with "Low" Risk Ranking as defined in Attachment 19 Moist, green or growing vegetation Except near timber bridges, logs can be retained as their heat during burning is limited in area and easy to target by fire-fighters
Physical inspections or detailed onsite survey, done annually by 15th August to allow time to plan and undertake herbicide treatments by 15th October with a follow-up inspection by 15th November and remedial action where necessary	Areas with "Moderate" or higher Risk Ranking as defined in Attachment 19 Existing fire access ways
Occasional prescribed burning by DPAW for hazard reduction, biodiversity protection or enhancement purposes*	Areas within "Area A" with "Very High" Risk Ranking as defined in Attachment 19 Must be done by a qualified practitioner with appropriate equipment, and only where no other form of hazard mitigation is effective or appropriate. The period between burns needs to be the longest interval at which reproduction occurs for all species in order to produce sufficient seed for regeneration after fire. Grass needs to be managed such that burning achieves low flame heights that minimise damage to over-storey. Burning is risky especially with high fuel loadings in some areas (eucalyptus litter, sheoak needles, grass tree skirts), highly volatile vegetation, close proximity of traffic, lack of fire access ways, high value assets adjacent, wind direction changes, and lack of suitable burn preparation in adjacent properties, traffic management and signage.
Herbicide spraying	"Area A", "Area B" and "Area C" The method of application must be targeted to avoid native plants and overspray
Slashing vegetation, grass, litter and scrub	"Area A", "Area B" and "Area C" Weed-infested areas Areas immediately adjacent to ignition sources e.g. roads, PSPs
Heavy slashing*	Low-conservation areas
Raking – mechanical or by hand Removal of ground fuels is to be completed by 1 Oct annually and maintained until 1 May. Inspections every two months required and additional material to be removed where necessary.	"Area C" Areas with "High" or "Very High" Risk Ranking as defined in Attachment 19, where fuels are significantly higher than 8 t/ha and where practicable and resources permit.

ACTION	WHERE TO USE
Fire Access Ways	"Area B" and "Area C" Where deemed necessary in accordance with Section 8.6 Step 3 of this Guideline
Mechanical grading as a means of weed control*	Disturbed, already cleared locations Where land gradient is a relatively high in terms of fire spread
Modifying vegetation structure, such as brushcutting and parkland thinning Mulching standing dead material	Most areas for pruning Low-conservation areas for more destructive activities
Removal of hazardous trees*	Only where the safety of people is directly and imminently threatened
Mulching understorey vegetation and vegetative litter	Low-conservation areas

* These treatments are recommended but require consideration of soil erodibility and the time taken for viable seeds or other propagules of native vegetation to mature. A treatment that is too frequent or too high-intensity may allow for erosion and the colonisation of introduced grass species. Introduced grasses may alter the ecology and environmental values, fire threat status and fire behaviour in these areas.

MONITOR AND REVIEW RISKS

9. Annual evaluation of fuels by suitably-trained roadside maintenance officers.

10. Record fire occurrences on MRWA reserves in a spreadsheet in TRIM file 12/6067 – date, time, cause, vegetation classes, impact on vegetation, values damaged or destroyed, replacement cost. Determine if a standard recording sheet or system is available from and or compatible with DFES.

11. Review these Guidelines annually, especially if changes are made to the *Bush Fires Act 1954* that may alter the legal responsibilities and obligations to MRWA.

6. RESTRICTED AREAS AND PRACTICES

6.1 Declared Rare Flora and Priority Flora Sites

These must be protected from the impacts of weed and fuel control, and therefore require more intensive management including:

- awareness and avoidance of rare flora – recorded in Main Roads' Integrated Road Information System (IRIS), indicated by on-ground markers, and advised through environmental reports, management plans, inductions and pre-start meetings.
- avoidance of traffic, spraying, slashing, grading, burning or any impacts within the designated Declared Rare Flora (DRF) buffer, generally extending 50 m either side of the extent of the population.
- application of herbicides using backpacks, wands and painting to ensure DRF plants are avoided, not using herbicides when orchids are visible above ground, and using selective herbicides under advisement by the DPAW.
- the direct protection of plants from herbicide overspray using some form of plant guard during spraying e.g. plastic bag, bucket, bin.
- hand pulling
- brush-cutting

6.2 Aboriginal and Other Heritage Sites

Main Roads is legally obligated under the *Aboriginal Heritage Act 1972, Environmental Protection and Biodiversity Conservation Act 1999* and *Heritage of Western Australia Act 1990* to protect aboriginal and other heritage sites within lands vested under its control.

Main Roads approach to protecting these sites is not only to comply with the Acts but to avoid disturbing sites where possible. Therefore, before maintenance work is undertaken within an aboriginal or other heritage site, the respective requirements of either Main Roads' corporate environmental procedures No 6707/006 "Aboriginal Heritage" or No 6707/009 "Heritage" must be met.

Aboriginal heritage sites can be found on Western Australian Government website http://maps.dia.wa.gov.au/AHIS2/default.aspx

Other heritage sites can be found on Western Australian Government website http://inherit.stateheritage.wa.gov.au/public

6.3 Watercourses

A permit is required from the Swan River Trust for works along the Swan and Canning Rivers, and a Bed and Banks permit is required from the Department of Water for any works associated with watercourses in declared Proclaimed Surface Water Areas. These authorities should be consulted for maintenance works, though the requirement for a permit may be avoided provided impacts are not significant e.g no stump removal, no erosion associated with dragging cleared vegetation.

7. REHABILITATION

7.1 Revegetation

Revegetation must be conducted using species endemic to the local area and in accordance with Main Roads' Corporate Procedure No 6707/022 "Vegetation Placement within the Road Reserve" and Main Roads' Specification 304 Revegetation and Landscaping. In addition to these, guidelines published by the DFES should be consulted to provide appropriate spacings between different species to reduce fuel continuity – "Plant Guide within the Building Protection Zone for the Swan Coastal Plain of Western Australia" (2011) – and to provide choices of species that are relatively less flammable – "Fire Retardant Plants".

Special emphasis must be placed on revegetating areas within the road reserve that abut good quality native vegetation and on revegetating the following high risk locations where degraded or denuded vegetation may result in erosion or scour that could compromise the structural integrity of an asset or an elevated fire hazard:

- Sumps.
- Bridge substructures and culverts.
- Floodways.
- Waterways.
- Revetment, stone pitching and rock protection.
- Banks and levies.
- Batters and embankments.
- Road shoulders.
- Wide verges.

7.2 Maintenance of Recently Revegetated Areas

Regular inspection must be carried out to monitor the success of the revegetation and assess the need for weed and pest control and follow up revegetation work. No more than 10% of the planted area may be covered in weeds.

Blanket herbicide spraying is not permitted. Mechanical mowing or slashing is not permitted in revegetated areas where plants are below grass level or close together. Hand weeding, spot herbicide treatment or the use of hand held brush cutters is required.

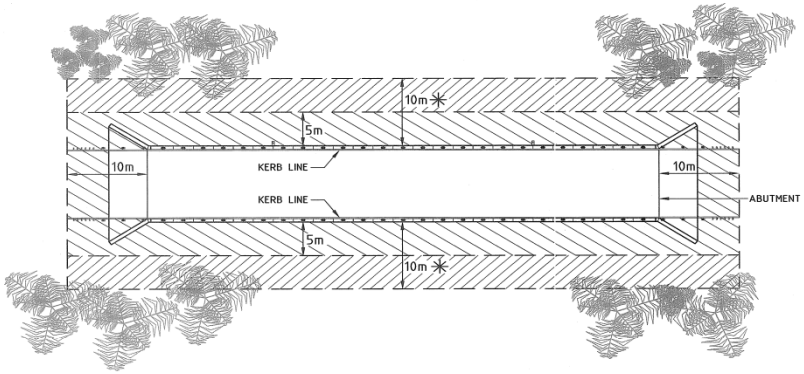
Pest infestations i.e. snails must be controlled by applying suitable pesticides treatment according to the label instructions.

Replacement and infill vegetation work is required for any bare soil areas resulting from unsuccessful revegetation.

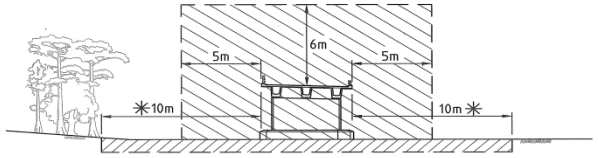
8. LIST OF ATTACHMENTS

Attachment 4 Vegetation clearance for bridges
Attachment 14 Tree pruning
Attachment 16 Fire field assessment form
Attachment 17 Vegetation classifications
Attachment 18 Bushfire Attack Level Table and Fire Threat Levels
Attachment 19 Fire Risk Assessment Matrix
Attachment 20 Metropolitan Region Land Use Areas

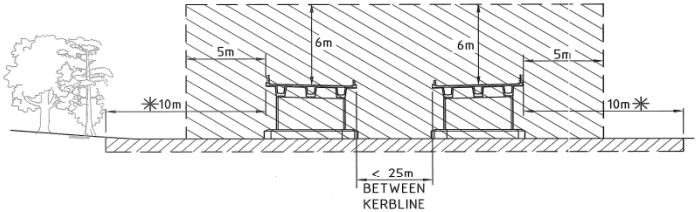
Attachment 4



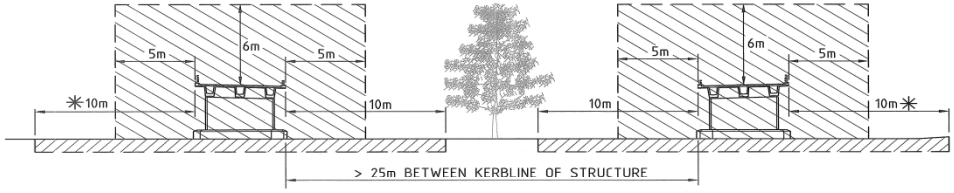
GENERAL PLAN VIEW FOR CLEARING AROUND STRUCTURES



ELEVATION – SINGLE STRUCTURE



ELEVATION – DUAL STRUCTURE



ELEVATION – SPLIT STRUCTURE

LEGEND:
NO TRUNKS > Φ100mm MAINTAIN TO 100mm HEIGHT
NO OVERHANGING BRANCHES FOR 6m ABOVE DECK SURFACE

NOTE:
WHERE THERE IS LESS THAN 10m TO ROAD RESERVE BOUNDARY, CLEARING SHALL BE TO BOUNDARY ONLY

SCALE A2

No.	DATE	DESCRIPTION	AUTHORISED

AMENDMENTS

PLANNING AND TECHNICAL SERVICES DIRECTORATE
STRUCTURES ENGINEERING
Don Aitken Centre
Waterloo Crescent, East Perth WA 6004
Telephone (08) 9323 4111 Fax (08) 9323 4136

DESIGNED		
VERIFIED		18/6/12
DRAWN	M. GUEVARRA	JUNE 2012
CHECKED		
DATUM		
APPROVED		18/6/12
FILE N°		

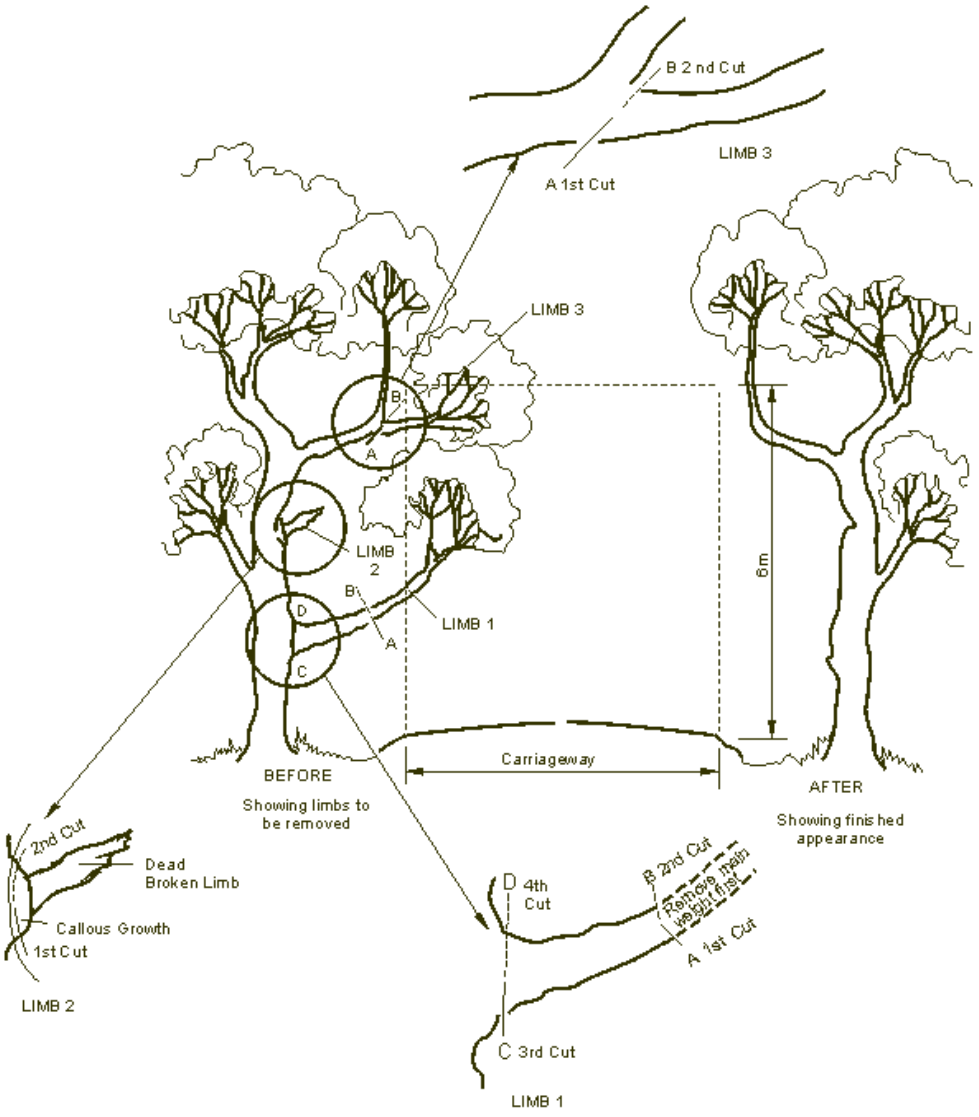
VEGETATION CLEARANCE ENVELOPES FOR BRIDGES

Government of Western Australia
mainroads WESTERN AUSTRALIA

DRAWING NUMBER 1230-1666 AMEND.

ATTACHMENT 14

TREE PRUNING



All cuts to be close tree trunk or remaining limb. This retains natural appearance and allow wound to heal neatly.

NOTE
Belly cut to be ⅓ - ½ the thickness of the limb.

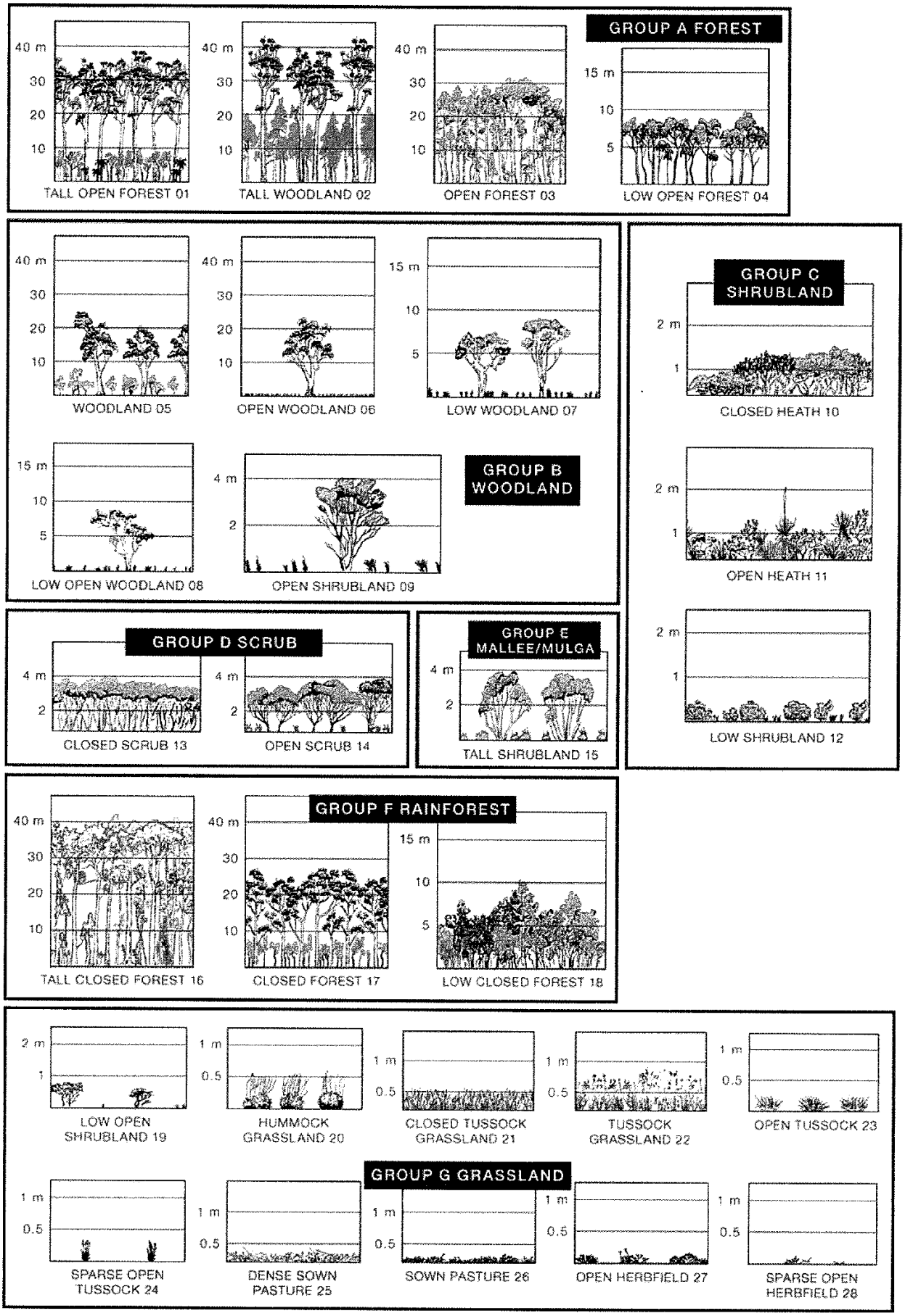
14.cdr

Attachment 16

Bushfire Threat, Risk and Consequence Assessment Form	
1. Reserve name and location. Attach aerial and ground images to separate sheet	
2. Adjacent property or values at risk	
3. Years since last burnt	
4. Total fuel (t/ha)	
5. Vegetation class and type	
6. Slope degrees	
7. Distance to structure (m)	
8. BAL rating	
9. Threat rating	
10. Likelihood of fire	
11. Frequency of fire – years	
12. Consequences to assets	
13. Risk ranking	
14. Comments, recommendations, actions.	

Attachment 17

VEGETATION CLASSIFICATION



Attachment 18

DETERMINATION OF BUSHFIRE ATTACK LEVEL (BAL)—FDI 80 (1090 K)

Vegetation classification	Bushfire Attack Levels (BALs)				
	BAL—FZ	BAL—40	BAL—29	BAL—19	BAL—12.5
	Distance (m) of the site from the predominant vegetation class				
	All upslopes and flat land (0 degrees)				
A. Forest	<16	16–<21	21–<31	31–<42	42–<100
B. Woodland	<10	10–<14	14–<20	20–<29	29–<100
C. Shrubland	<7	7–<9	9–<13	13–<19	19–<100
D. Scrub	<10	10–<13	13–<19	19–<27	27–<100
E. Mallee/Mulga	<6	6–<8	8–<12	12–<17	17–<100
F. Rainforest	<6	6–<9	9–<13	13–<19	19–<100
G. Grassland	<6	6–<8	8–<12	12–<17	17–<50
	Downslope >0 to 5 degrees				
A. Forest	<20	20–<27	27–<37	37–<50	50–<100
B. Woodland	<13	13–<17	17–<25	25–<35	35–<100
C. Shrubland	<7	7–<10	10–<15	15–<22	22–<100
D. Scrub	<11	11–<15	15–<22	22–<31	31–<100
E. Mallee/Mulga	<7	7–<9	9–<13	13–<20	20–<100
F. Rainforest	<8	8–<11	11–<17	17–<24	24–<100
G. Grassland	<7	7–<9	9–<14	14–<20	20–<50
	Downslope >5 to 10 degrees				
A. Forest	<26	26–<33	33–<46	46–<61	61–<100
B. Woodland	<16	16–<22	22–<31	31–<43	43–<100
C. Shrubland	<8	8–<11	11–<17	17–<25	25–<100
D. Scrub	<12	12–<17	17–<24	24–<35	35–<100
E. Mallee/Mulga	<7	7–<10	10–<15	15–<23	23–<100
F. Rainforest	<11	11–<15	15–<22	22–<31	31–<100
G. Grassland	<8	8–<10	10–<16	16–<23	23–<50
	Downslope >10 to 15 degrees				
A. Forest	<33	33–<42	42–<56	56–<73	73–<100
B. Woodland	<21	21–<28	28–<39	39–<53	53–<100
C. Shrubland	<9	9–<13	13–<19	19–<28	28–<100
D. Scrub	<14	14–<19	19–<28	28–<39	39–<100
E. Mallee/Mulga	<8	8–<11	11–<18	18–<26	26–<100
F. Rainforest	<14	14–<19	19–<28	28–<39	39–<100
G. Grassland	<9	9–<12	12–<18	18–<26	26–<50
	Downslope >15 to 20 degrees				
A. Forest	<42	42–<52	52–<68	68–<87	87–<100
B. Woodland	<27	27–<35	35–<48	48–<64	64–<100
C. Shrubland	<10	10–<15	15–<22	22–<31	31–<100
D. Scrub	<15	15–<21	21–<31	31–<43	43–<100
E. Mallee/Mulga	<9	9–<13	13–<20	20–<29	29–<100
F. Rainforest	<18	18–<25	25–<36	36–<48	48–<100
G. Grassland	<10	10–<14	14–<21	21–<30	30–<50

Fire Threat Level – Very High

Fire Threat Level – High

Fire Threat Level – Medium

Fire Threat Level – Low

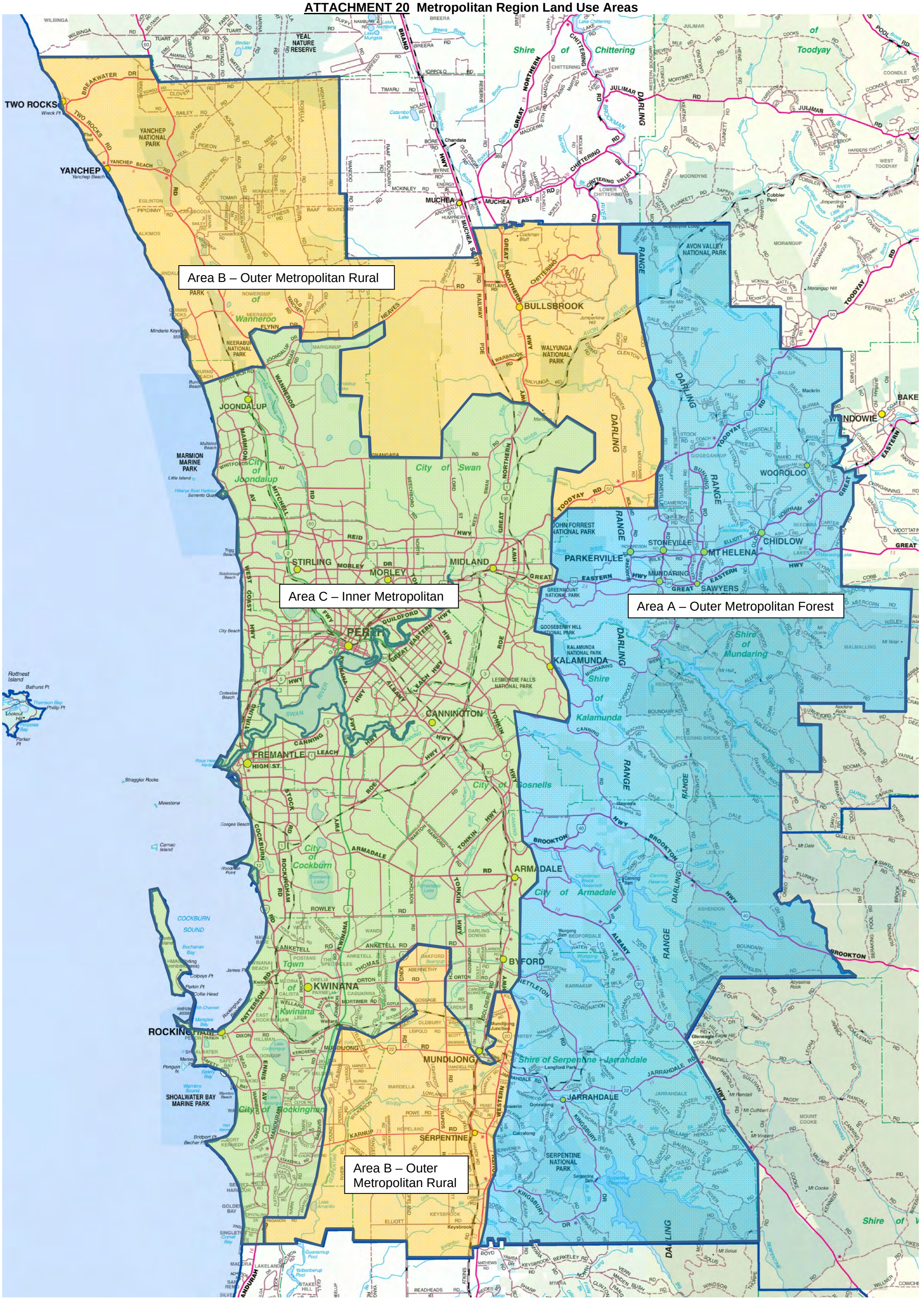
Attachment 19

CONSEQUENCE	LIKELIHOOD				
	1 Rare	2 Unlikely	3 Possible	4 Likely	5 Almost Certain
5 Catastrophic:	H	H	H	VH	VH
4 Major:	M	H	H	H	VH
3 Moderate:	M	M	M	H	H
2 Minor:	L	L	M	H	H
1 Insignificant:	L	L	L	M	M

Definitions of Fire Occurrence and Consequence						
Likelihood of fire occurring		**Consequence** of fire damage				
Descriptor	Frequency	Descriptor	Health and safety	Asset loss	Financial loss	Environmental loss
Rare	Less than once in 20 years	Insignificant	No medical treatment required	Single dwelling or building	Less than $100,000	Minor damage to native vegetation
Unlikely	At least once in 10 years	Minor	First aid treatment	Single dwelling or building	$100,000 to $500,000	Significant damage to native vegetation: > 1 ha
Possible	At least once in 3 years	Moderate	Medical treatment required	Multiple dwellings or buildings	$500,000 to $5 million	Loss of listed vulnerable flora or ecological community
Likely	At least once per year	Major	Extensive injuries	Multiple dwellings or buildings	$5 million to $20 miliion	Loss of endangered listed flora or ecological community
Almost Certain	More than once per year	Catastrophic	Death or severe permanent disablement	Substantial or high value larger buildings	More than $20 million	Loss of critically endangered listed flora or ecological community

Risk Rankings	
VH	Very High – Unacceptable
H	High – Urgent Action
M	Moderate – Management Controls)
L	Low (Specify Actions & Monitor)

ATTACHMENT 20 Metropolitan Region Land Use Areas



APPENDIX 2:

Transportation Noise Assessment - Lloyd George Acoustics

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Transportation Noise Assessment

Lots 746-750 & 545 Baldivis Road, East Baldivis

Reference: 14072844-01a.docx

Prepared for:
CLE & Mirvac

Member Firm of Association of Australian Acoustical Consultants

Report: 14072844-01a.docx

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This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd George Acoustics Pty Ltd 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 George Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Prepared By:	Terry George
Position:	Project Director
Date:	20 August 2014

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A Deemed-to-Satisfy Construction Standards

B Terminology

1 INTRODUCTION

Mirvac are proposing to subdivide Lots 746-750 Baldivis Road (refer *Figure 1-1*) located to the west of the Kwinana Freeway, north of Safety Bay Road and east of Baldivis Road. Whilst Mirvac do not own Lot 545, consideration has also been given to noise mitigation to this area.

As the subject site is to be residential and is in close proximity to the Kwinana Freeway, being a major road, it is a requirement to undertake an acoustic assessment in order to assess the potential noise impacts and possible mitigation/management options.

Figure 1-1 Subject Site Locality (Source: CL Site Plan No. 2304-03A-01E)

Figure 1-2 provides the proposed concept for the subdivision with that shown on Lot 545 also considered within this report.

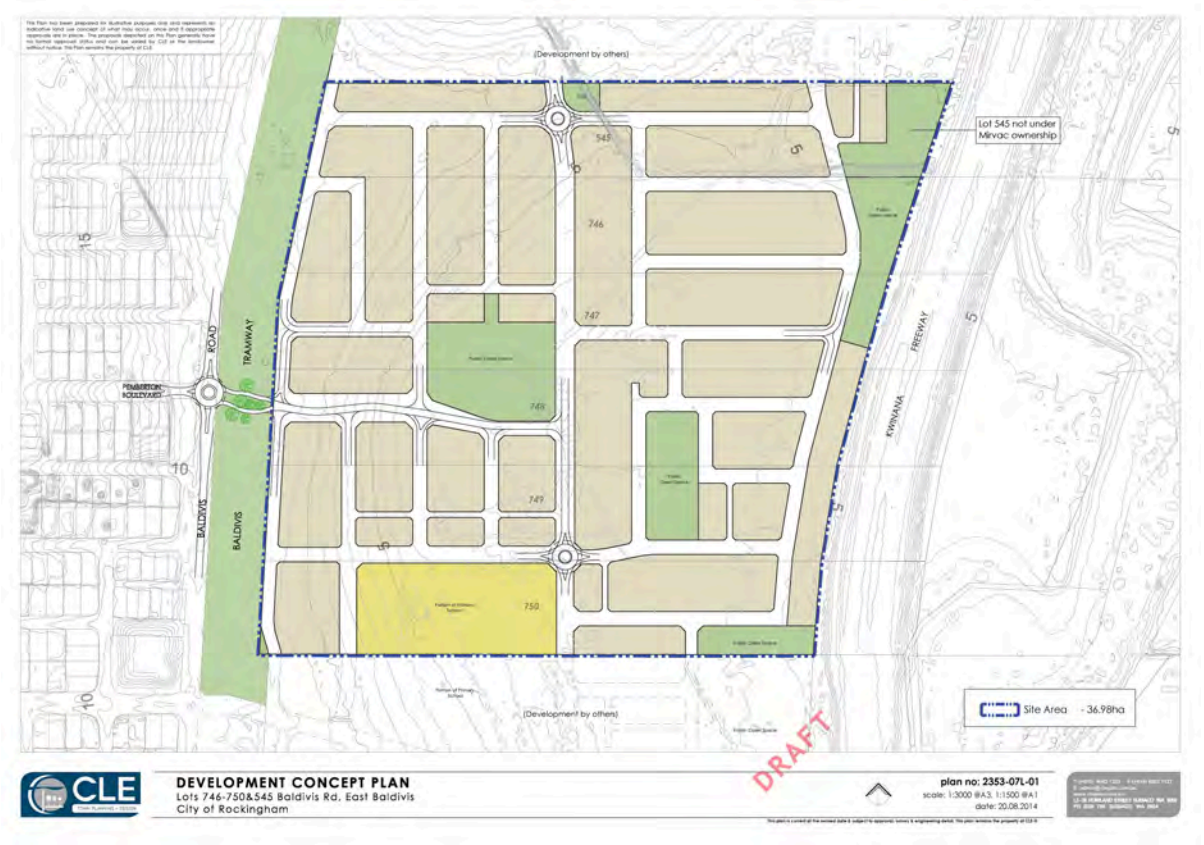


Figure 1-2 Proposed Subdivision Concept (Source: CLE Plan No. 2353-07K-01)

Appendix B contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this policy.

In areas where the *target* is exceeded, a detailed noise assessment is to be undertaken. Customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

3 METHODOLOGY

Noise measurements and modelling have been undertaken in accordance with the requirements of the Policy as described below in *Sections 3.1 and 3.2*.

3.1 Site Measurements

Noise monitoring was undertaken at two (2) locations in order to:

- Quantify the existing noise levels;
- Determine the differences between different acoustic parameters ($L_{A10,18hour}$, $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$); and
- Calibrate the noise model for existing conditions.

The instruments used were ARL Type 316 noise data loggers with the microphone 1.4 metres above ground level in free-field conditions – refer *Figures 3-1 to 3-2*. The loggers were located on and near the subject site, as shown on *Figure 3-3*. Each logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. This instrument complies with the requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The loggers were field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

Figure 3-1 Logger Near Kwinana Fwy South

Figure 3-2 Logger Near Safety Bay Road

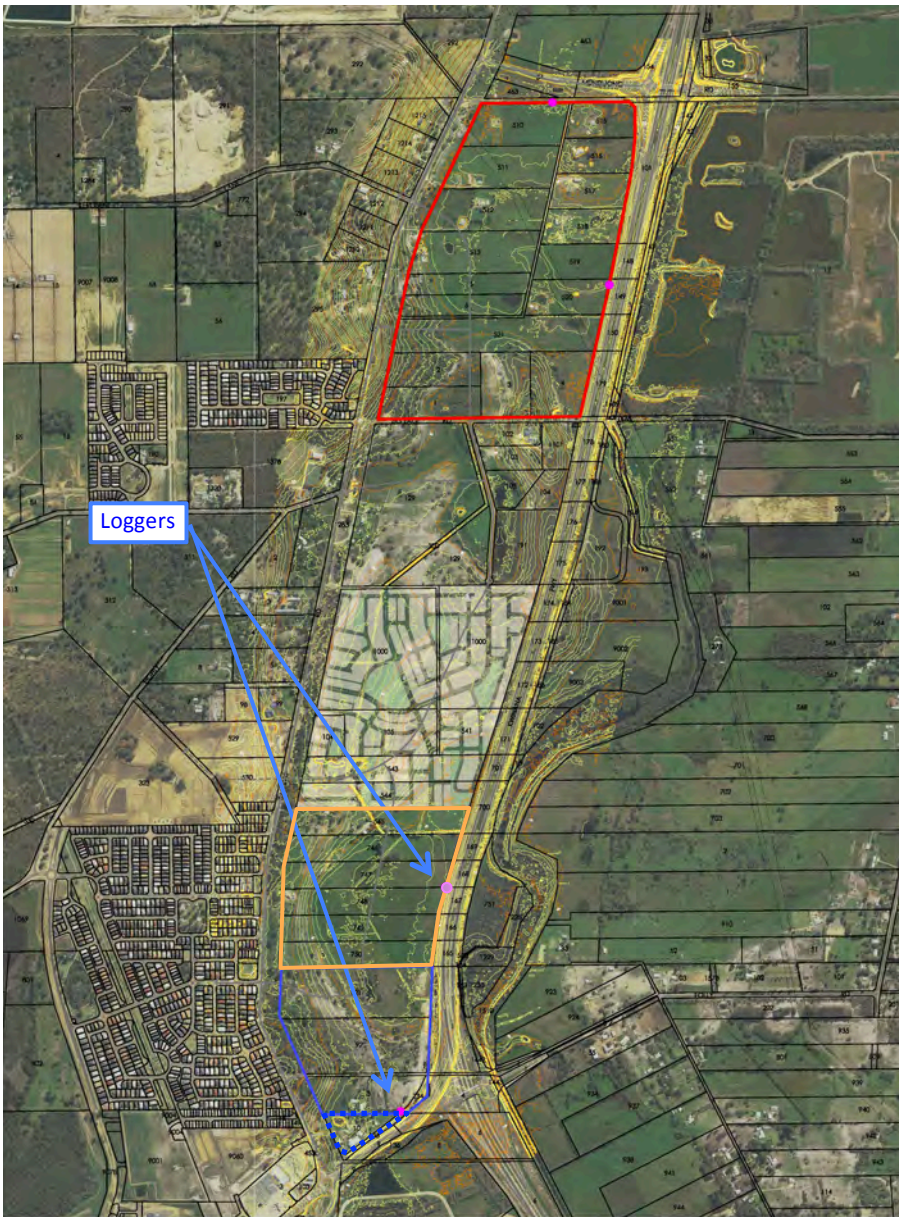


Figure 3-3 Logger Localities

3.2 Noise Modelling

The computer programme *SoundPLAN 7.2* 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. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered. 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, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- 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.

Predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from an assumed building façade (resulting in a + 2.5 dB correction due to reflected noise).

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed below.

3.2.1 Ground Topography, Road Design & Cadastral Data

Topographical data was mostly based on that provided by CLE, which is a combination of site survey and Landgate data. In addition, this data was combined with other already on file, particularly in relation to the Perth Bunbury Highway project.

Future buildings have been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All single storey buildings are assumed to have a height of 3.5 metres.

Detailed design levels for the subdivision were unavailable, however indicative levels were provided, with those closed to the Freeway at 6.1m relative level.

3.2.2 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown below in *Table 3-1*.

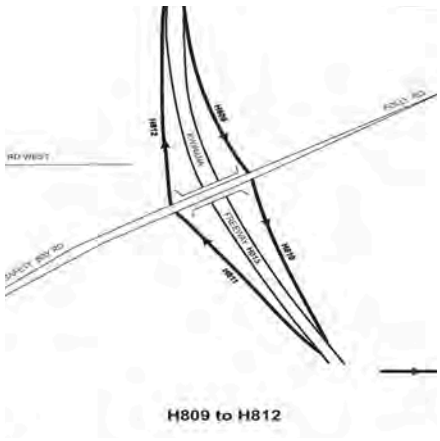
Table 3-1 Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

Kwinana Freeway has an open graded asphalt road surface and this is expected to also exist in the future.

Freeway on/off ramps generally consist of both dense and open graded asphalt with *Table 3-2* providing the information obtained from MRWA.

Table 3-2 Road Surfaces for On/Off Ramps

	**H809** DGA for all 390m **H810** DGA for all 390m **H811** DGA for all 410m **H812** DGA for all 370m

- Vehicle Speed

  Kwinana Freeway has a posted speed of 100km/hr.

  The posted speeds change on the on ramps from 70km/hr to 100km/hr at approximately 250 metres from Safety Bay Road and similarly on the off ramp from 100km/hr to 70km/hr.

- Traffic Volumes –

  The most recent short term traffic counts were obtained from MRWA being from 2012/13. The existing traffic volume information is summarised on *Figure 3-4*.

  The forecast 2031 traffic volumes were requested and obtained from MRWA. This has again been summarised in the same format as the existing traffic volumes in *Figure 3-5*.

It should be noted that only the 24-hour future volumes are provided by MRWA. It is considered that with the increase in traffic volumes, the percentage within an 18-hour period will increase over time so this has been estimated by adopting a 95% minimum relationship between the 18-hour and 24-hour volumes. Where the existing traffic volumes had a higher percentage relationship, the existing has been used.

3.2.3 Ground Attenuation

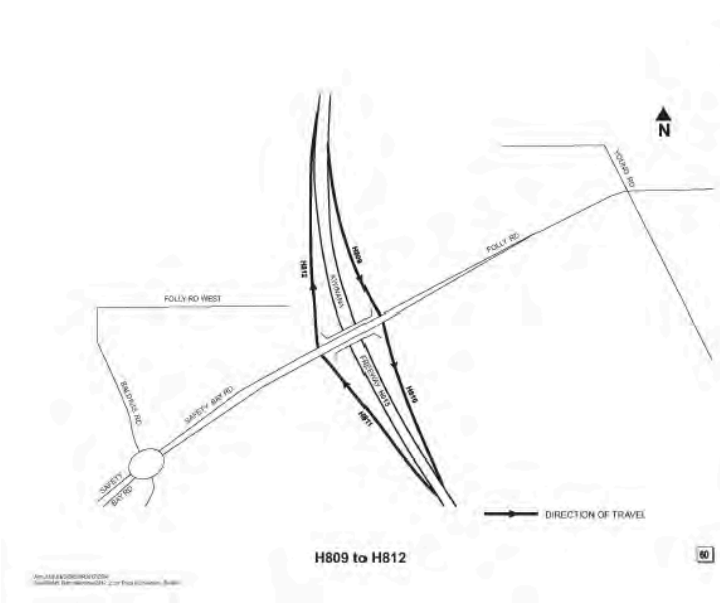
The ground attenuation has been assumed to be 0.2 (20%) within the road reserves, 0.5 (50%) throughout the future subdivision, except for the public open space that were set to 1.00 (100%). Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.2.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. The WAPC Policy however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles).

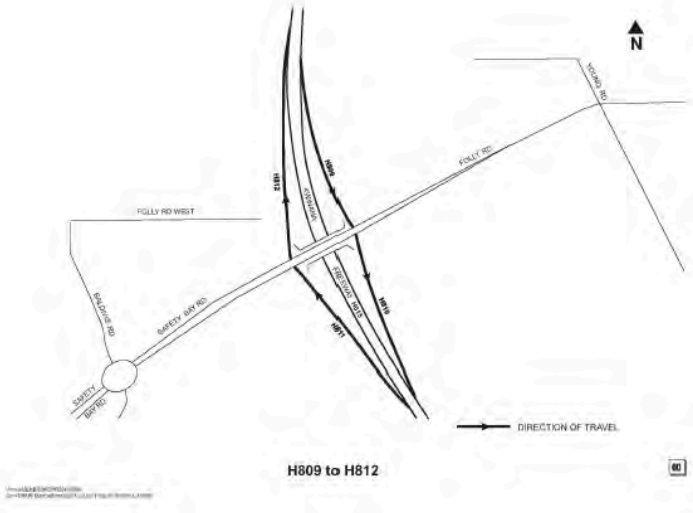
To calibrate the noise model, the conversion between parameters is based on the relationship obtained from the noise monitoring.

For future traffic with the increase in traffic volumes, it is expected the $L_{Aeq(Day)}$ will only be 1.5 dB less than the $L_{A10,18hour}$, however the difference between the $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ will increase to at least 5 dB so that the $L_{Aeq(Day)}$ value in the future will be the critical parameter in terms of noise compliance.



Road Name	Section	Direction	24hr Volume	% Heavy	% 18hr	18hr Cars	18hr Trucks
Kwinana Fwy	N of Ramp H713	Northbound	30083	10.8	88.1	23641	2862
Kwinana Fwy	Under Mundijong Road	Northbound	27902	9.9	87.9	22098	2428
Kwinana Fwy	N of Ramp H812	Northbound	28002	9.9	86.1	21723	2387
Kwinana Fwy	Under Safety Bay Road	Northbound	20784	10.5	88.6	16481	1934
Kwinana Fwy	S of Ramp H811	Northbound	20741	11	90.3	16669	2060
Kwinana Fwy	Off Ramp H809	Southbound	9811	8.3	86.4	7773	704
Kwinana Fwy	On Ramp H810	Southbound	338	9	97	298	30
Kwinana Fwy	Off Ramp H811	Northbound	43	8.3	86.4	34	3
Kwinana Fwy	On Ramp H812	Northbound	7218	9	97	6371	630
Folly Road	E of Kwinana Fwy	Eastbound	100	3	96	93	3
Folly Road	E of Kwinana Fwy	Westbound	100	3	96	93	3
Safety Bay Road	W of Kwinana Fwy	Eastbound	13036	9	97	11507	1138
Safety Bay Road	W of Kwinana Fwy	Westbound	12626	8.3	86.4	10003	905

Figure 3-4 Existing Traffic Volumes



Road Name	Section	Direction	24hr Volume	% Heavy	% 18hr	18hr Cars	18hr Trucks
Kwinana Fwy	N of Ramp H713	Northbound	51400	5	95	46389	2442
Kwinana Fwy	Under Mundijong Road	Northbound	45500	5	95	41064	2161
Kwinana Fwy	N of Ramp H812	Northbound	50100	5	95	45215	2380
Kwinana Fwy	Under Safety Bay Road	Northbound	35000	6	95	31255	1995
Kwinana Fwy	S of Ramp H811	Northbound	36700	6	95	32773	2092
Kwinana Fwy	Off Ramp H809	Southbound	13700	3	95	12625	390
Kwinana Fwy	On Ramp H810	Southbound	1700	5	97	1567	82
Kwinana Fwy	Off Ramp H811	Northbound	1700	5	95	1534	81
Kwinana Fwy	On Ramp H812	Northbound	15000	3	97	14114	437
Folly Road	E of Kwinana Fwy	Eastbound	200	3	96	186	6
Folly Road	E of Kwinana Fwy	Westbound	200	3	96	186	6
Safety Bay Road	W of Kwinana Fwy	Eastbound	16700	3	97	15713	486
Safety Bay Road	W of Kwinana Fwy	Westbound	15400	3	95	14191	439

Figure 3-5 Future Traffic Volumes

4 RESULTS

4.1 Noise Monitoring

The results of the noise monitoring are summarised below in *Tables 4-1 to 4-2* and shown graphically in *Figures 4-1 to 4-2*.

Table 4-1 Measured Average Noise Levels – Logger Adjacent Kwinana Freeway (South)

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Wednesday 19 June 2013	67.1	64.5	65.1	61.6
Thursday 20 June 2013	66.9	64.3	64.9	61.2
Friday 21 June 2013	67.6	64.7	65.4	61.3
Saturday 22 June 2013	65.0	62.5	63.2	58.3
Sunday 23 June 2013	65.9	63.7	64.8	55.6
Weekday Average	**67.2**	**64.5**	**65.1**	**61.4**

Table 4-2 Measured Average Noise Levels – Logger Adjacent Safety Bay Road

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Wednesday 19 June 2013	58.5	55.9	56.6	52.4
Thursday 20 June 2013	57.9	55.5	56.1	52.3
Friday 21 June 2013	58.3	55.8	56.4	53.0
Saturday 22 June 2013	55.7	53.7	54.4	50.2
Sunday 23 June 2013	55.4	53.3	54.4	46.2
Monday 24 June 2013	56.9	55.1	55.8	51.8
Tuesday 25 June 2013	57.8	55.9	56.6	52.1
Weekday Average	**57.9**	**55.6**	**56.3**	**52.3**

Figure 4-1: Background Noise Monitoring Adjacent Kwinana Freeway (Lot 748)

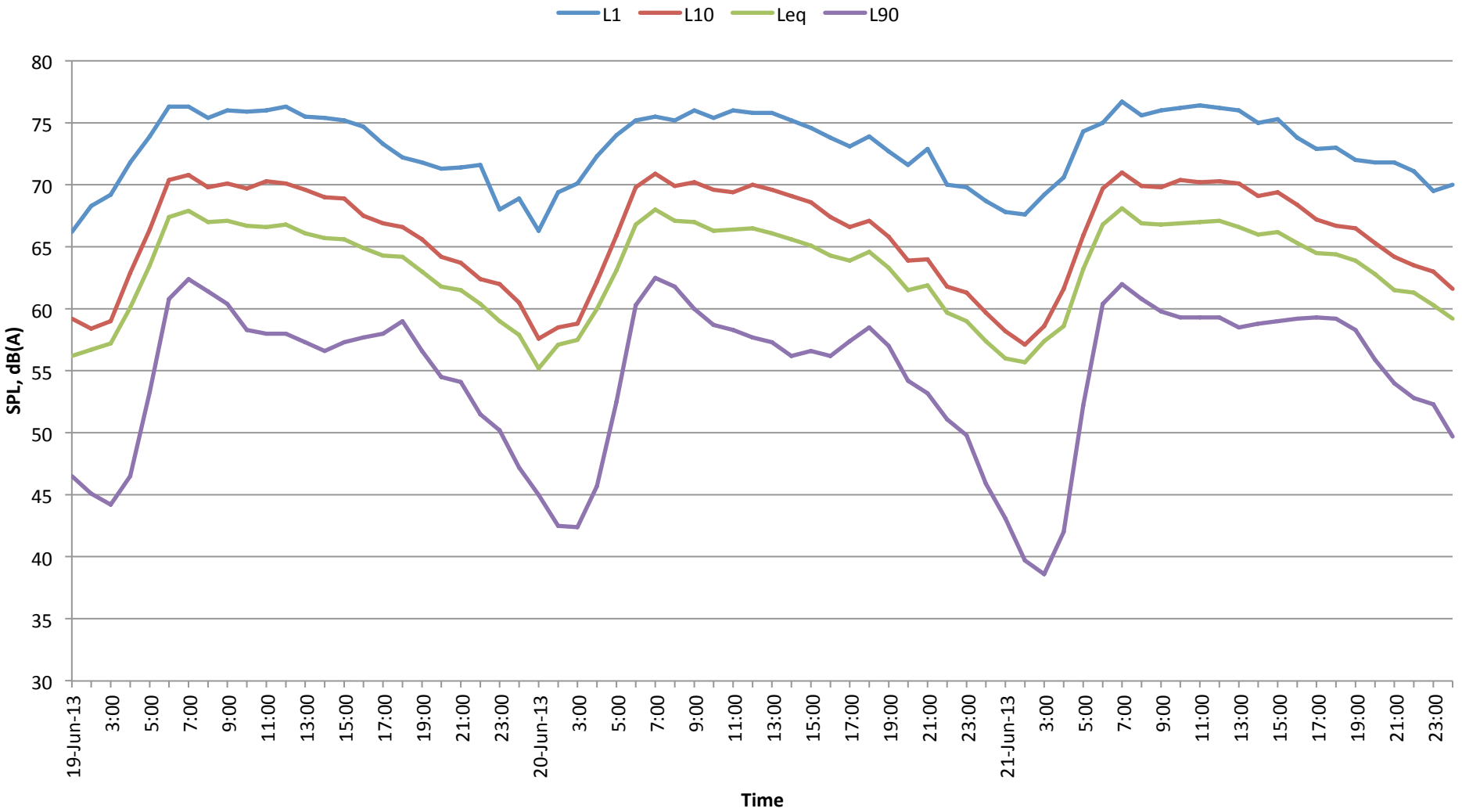
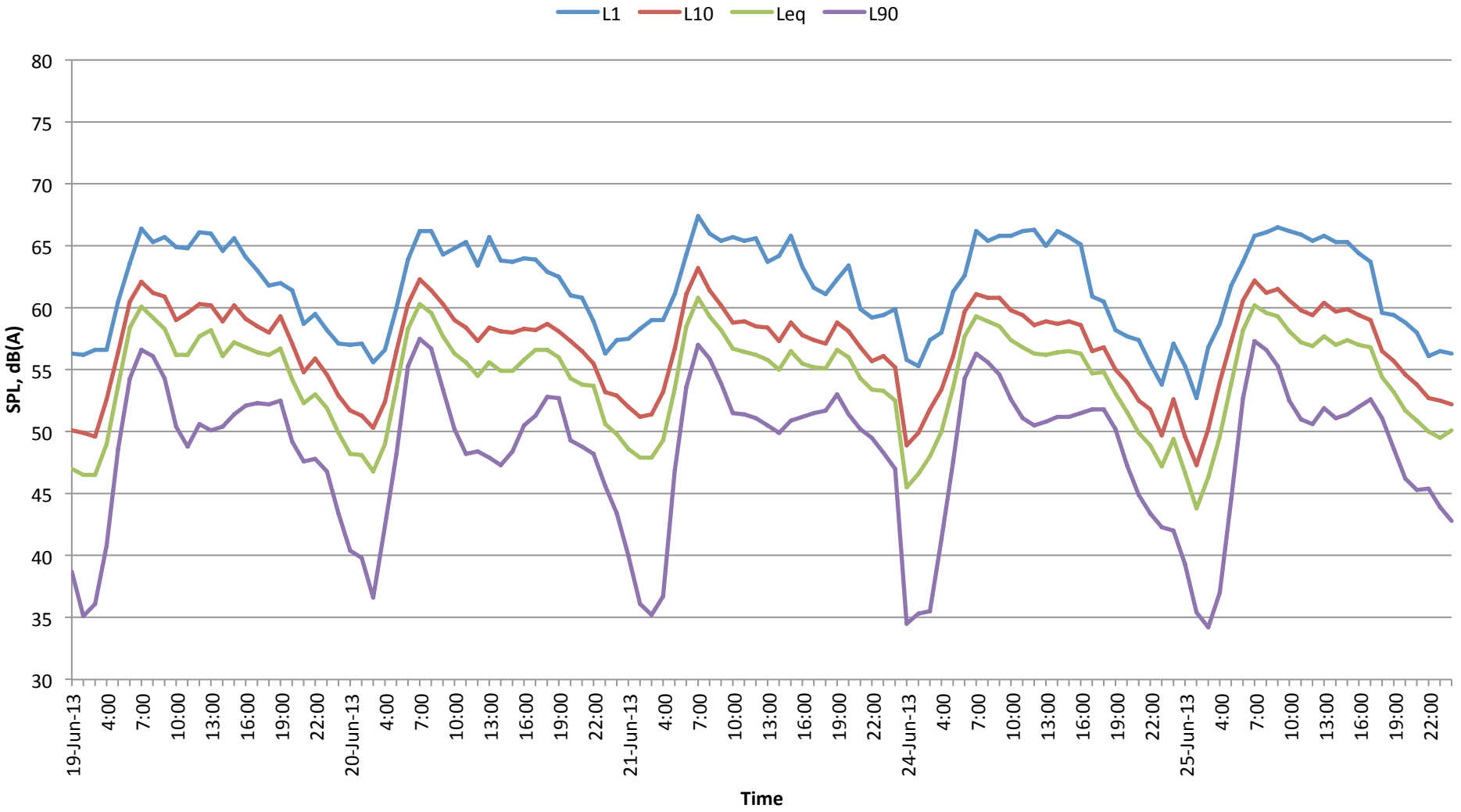


Figure 4-2: Background Noise Monitoring Adjacent Safety Bay Road



The average differences between selected parameters are shown below in *Table 4-3*.

Table 4-3 Differences Between Parameters

Location	Average Weekday Noise Level, dB	
	$L_{A10,18hour} - L_{Aeq(Day)}$	$L_{Aeq\ (Day)} - L_{Aeq(Night)}$
Mundijong Road	1.4	2.5
Kwinana Freeway North	2.1	3.2
Kwinana Freeway South	2.1	3.7
Safety Bay Road	1.6	3.9

4.2 Noise Modelling

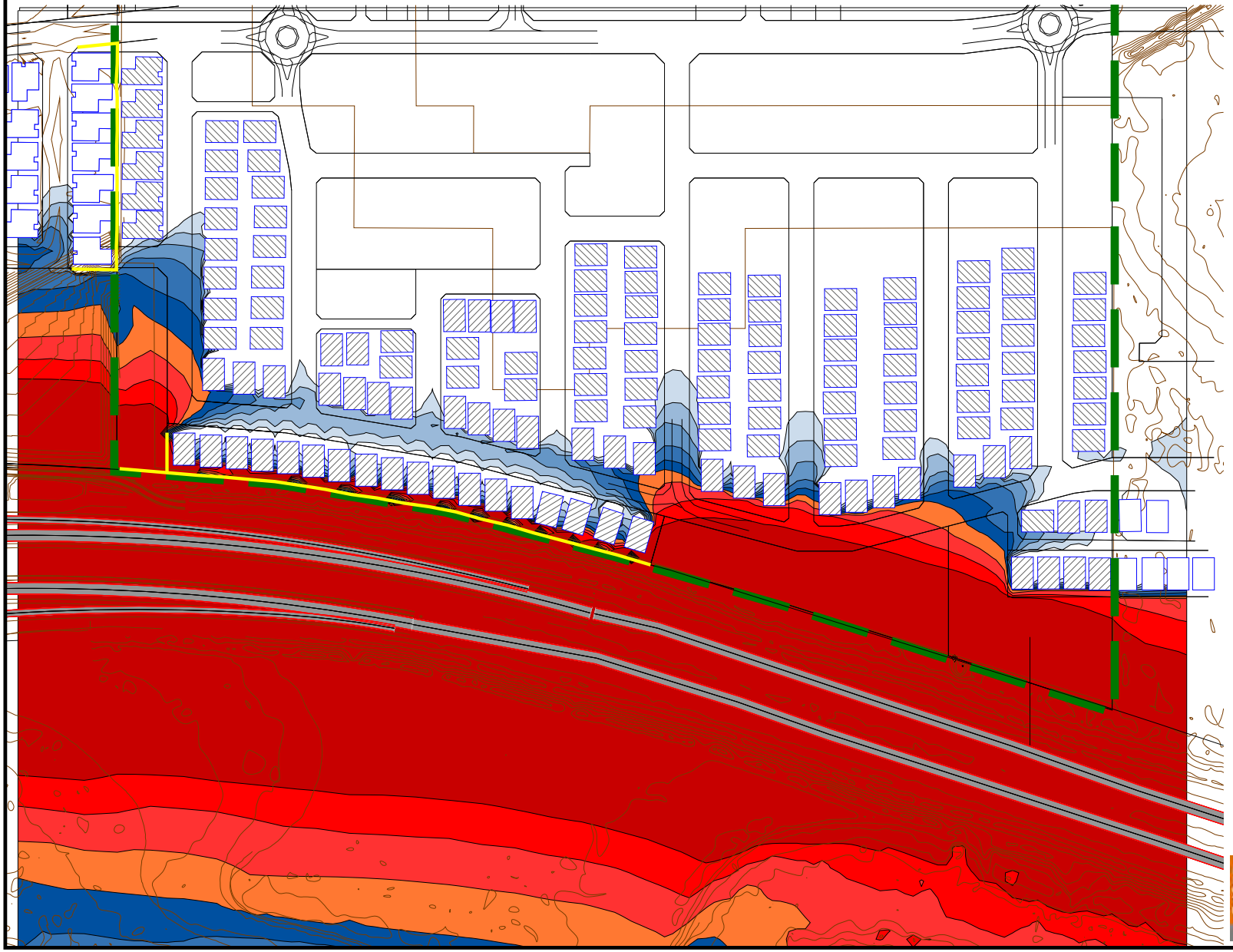
The noise modelling for future conditions is provided in *Figure 4-3* as an $L_{Aeq(Day)}$ noise level contour plot. These contours include the influence of future buildings and assume a standard 1.8 metre high property fence for residences backing onto the Freeway.

It can be seen that predicted noise levels at the nearest houses will be above the ***target*** and therefore noise control is to be considered. *Figure 4-4* provides a noise wall design option as well as identifying areas where Package A treatments (refer *Appendix A*) are required based on the noise contours provided in *Figure 4-5*.

Figure 4-3

Mirvac Land Residential Subdivision

LAeq(Day) Noise Level Contours - Future Scenario: No Mitigation (Houses & 1.8m High Fences)
Includes Indicative Design Levels for Mirvac Land and Land to the South



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Building
- Study Area
- Elevation line
- 1.8m High Fence
- Future Building

16 August 2014

Length Scale 1:3500

0 20 40 80 120 160 m

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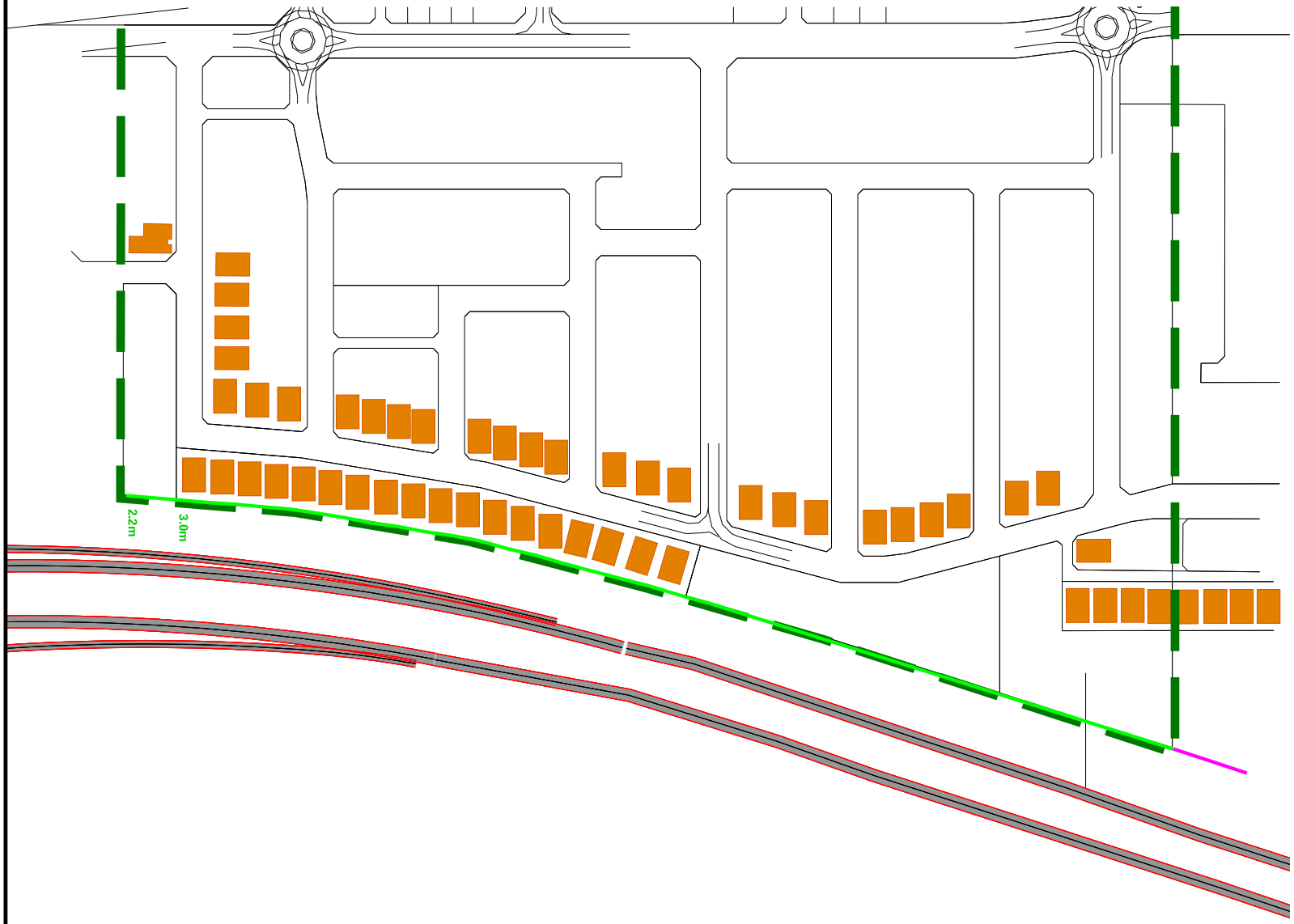
Figure 4-4

Mirvac Land Residential Subdivision

LAeq(Day) Noise Level Contours - Future Scenario: With Mitigation (Wall Height Above RL 6.1m)
Includes Indicative Design Levels for Mirvac Land and Land to the South



Signs and symbols

- Road Surface
- Package A
- Study Area
- Designed Noise Wall
- Future Noise Wall

20 August 2014

Length Scale 1:3500

0 20 40 80 120 160 m

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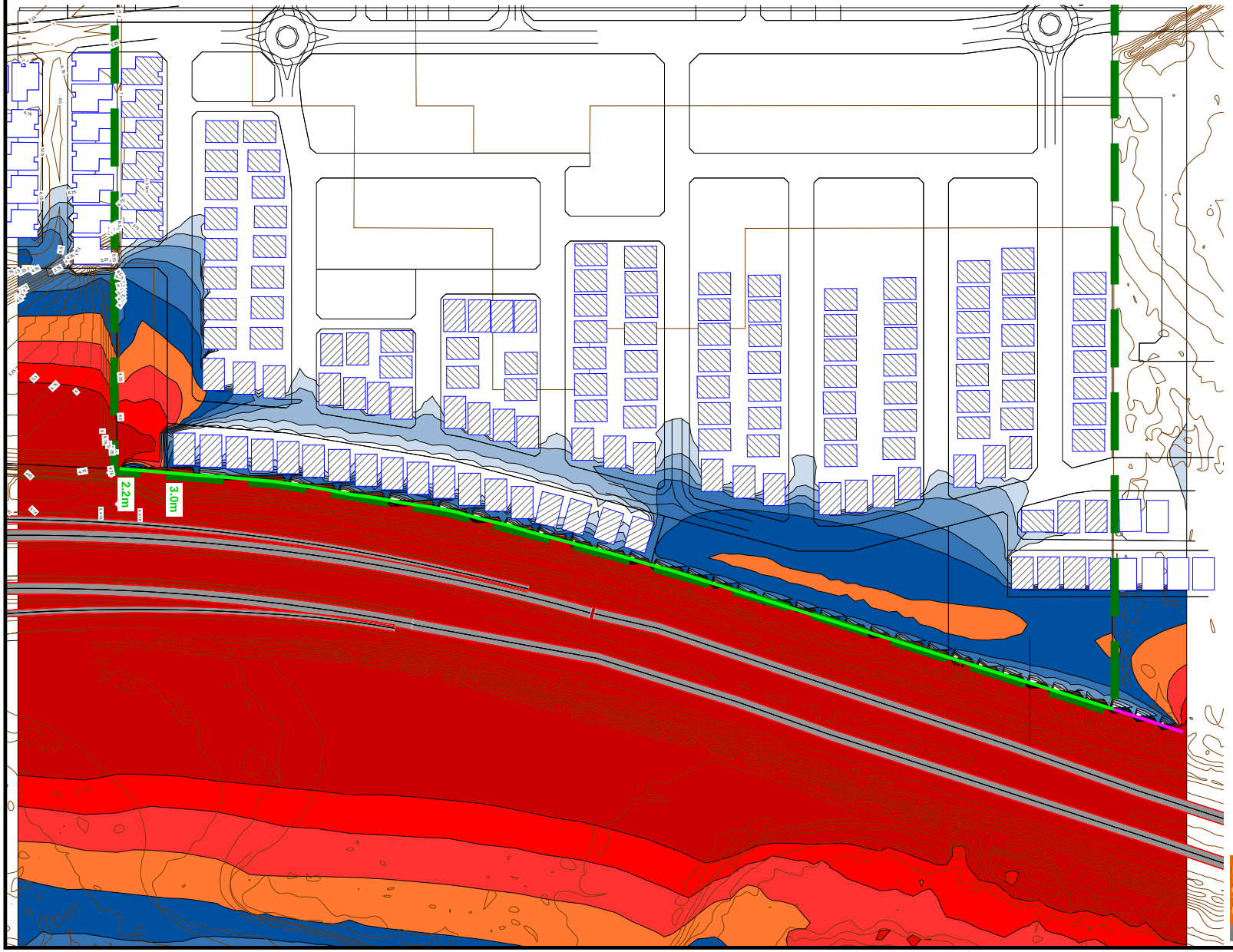
Figure 4-5

Mirvac Land Residential Subdivision

LAeq(Day) Noise Level Contours - Future Scenario: With Mitigation (Wall Height Above RL 6.1m)
Includes Indicative Design Levels for Mirvac Land and Land to the South



Noise levels
LAeq,Day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

N

Signs and symbols

- Road Surface
- Building
- Study Area
- Elevation line
- Future Building
- Designed Noise Wall
- Future Noise Wall

20 August 2014

Length Scale 1:3500

0 20 40 80 120 160 m

Lloyd George Acoustics
by Terry George
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5 ASSESSMENT & CONCLUSION

The objectives of the criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Where the *target* is achieved, no further controls are required. Where the *limit* is achieved or noise levels are within the *margin* (between the *limit* and *target*), further controls are necessary.

With no noise control, road traffic noise levels for future dwellings will be above the *target* at some parts of the development. To comply with the Policy, the following is recommended:

- Construct a noise wall along the boundary of the subdivision as shown on *Figure 4-4*. Noise wall is to be of solid construction, free of gaps and have a surface mass of minimum 12kg/m^2.
- Incorporate notifications on titles and dwellings to incorporate Package A treatments for lots above the *target* as shown on *Figure 4-4*.

Should any of the 'affected' dwellings be proposed as double storey, they will require a specific assessment once the house plans are available. The reason for this is that the upper floor will not receive the same amount of barrier attenuation as the ground floor. Such an assessment is to be undertaken by a suitably qualified acoustical consultant being a member firm of the Association of Australian Acoustical Consultants (AAAC).

Similarly, the Package A treatment is a default deemed to satisfy construction sufficient of providing an acceptable internal amenity, where external noise levels are up to the *limit* (e.g. 60 dB $L_{Aeq(Day)}$). This means that where external noise levels are less than the *limit*, there may be scope to reduce the deemed to satisfy provisions. Should a home owner wish to deviate from the default Package A standard, this is to be supported by an assessment undertaken by a suitably qualified acoustical consultant based on the proposed building plans.

Appendix A

DEEMED TO SATIFY CONSTRUCTION STANDARDS

Package A: Noise levels within the *margin*

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the noise *target* but are within the *limit*.

Area type	Orientation	Package A measures
Indoors		
Bedrooms	Facing road/rail corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[1]
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Living and work areas[2]	Facing corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 35mm (minimum) solid core external doors with acoustic seals[3] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Other indoor areas	Any	No requirements

[1] See section on Mechanical ventilation/airconditioning for further details and requirements.
[2] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[3] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Mechanical ventilation/airconditioning

Where outdoor noise levels are above the "target", both Packages A and B require mechanical ventilation or airconditioning to ensure that windows can remain closed in order to achieve the indoor noise standards.

In implementing Packages A and B, the following need to be observed:

- Evaporative airconditioning systems will not meet the requirements for Packages A and B because windows need to remain open;
- Refrigerative airconditioning systems need to be designed to achieve fresh air ventilation requirements;
- air inlets need to be positioned facing away from the transport corridor where practicable;
- ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from road and rail corridors can be effective in warning people of the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need and opportunities to reduce the impact of noise through sensitive design and construction of buildings and the location and/or screening of outdoor living areas.

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise-sensitive development or planning approval involving noise-sensitive development, where external noise levels are forecast or estimated to exceed the "target" criteria as defined by the Policy. In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under section 12A of the Town Planning and Development Act and section 70A of the Transfer of Land Act. An example of a suitable notice is given below.

Notice: This property is situated in the vicinity of a transport corridor, and is currently affected, or may in the future be affected, by transport noise. Further information about transport noise, including development restrictions and noise insulation requirements for noise-affected property, are available on request from the relevant local government offices.

Appendix B

Terminology

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

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

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 level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

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

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

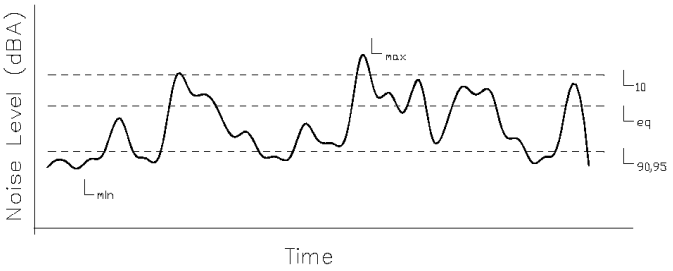
$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ 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 typically 1-3 dB less than the $L_{A10,18hour}$.

Satisfactory Design Sound Level
The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level
The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Austroads Vehicle Class

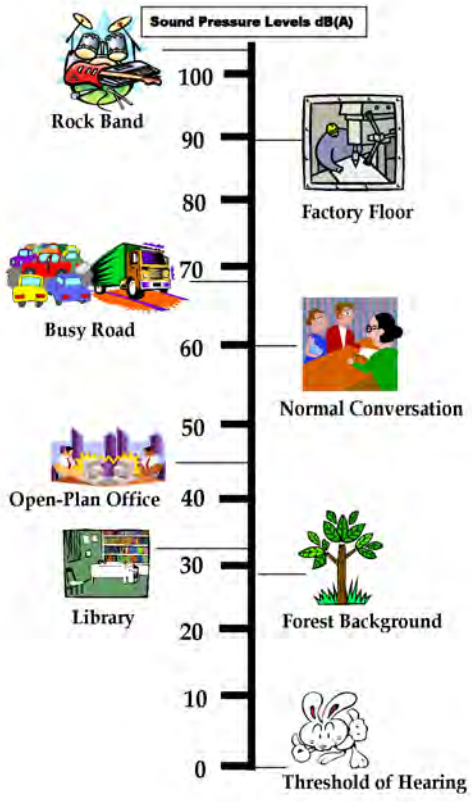
AUSTROADS Vehicle Classification System

Level 1 Length (indicative) Type	Level 2 Axles and Axle Groups Axles	Groups	Level 3 Vehicle Type Typical Description	AUSTROADS Classification Class	Parameters	Typical Configuration
			LIGHT VEHICLES			
Short up to 5.5m		1 or 2	**Short** Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
Medium 5.5m to 14.5m	3, 4 or 5	3	**Short - Towing** Trailer, Caravan, Boat, etc	2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
			HEAVY VEHICLES			
	2	2	**Two Axle Truck or Bus**	3	d(1) > 3.2m and axles = 2	
	3	2	**Three Axle Truck or Bus**	4	axles = 3 and groups = 2	
	> 3	2	**Four Axle Truck**	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	**Three Axle Articulated** Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	**Four Axle Articulated** Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	**Five Axle Articulated** Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	**Six Axle Articulated** Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles > 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	**B Double** B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	**Double Road Train** Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	**Triple Road Train** Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart; Groups: Number of axle groups; Axles: Number of axles (maximum axle spacing of 10.0m)

d(1): Distance between first and second axle
d(2): Distance between second and third axle

Typical Noise Levels



APPENDIX 3:

Environmental Assessment Report - RPS

ENVIRONMENTAL ASSESSMENT REPORT

Lots 746 – 750 and 545 Baldivis Road, Baldivis

ENVIRONMENTAL ASSESSMENT REPORT

Lots 746 – 750 and 545 Baldivis Road, Baldivis

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Report No: L1404001
Version/Date: Rev 0, July 2014

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	Draft for Client Review	GilGla	JohHal	19.07.14	DC 21.07.14		
Rev 0	Final for Issue	JohHal	KatCho	29.07.14	DC 30.07.14	S. Rolls	30.07.14

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SUMMARY

Introduction

The Mirvac Local Structure Plan (LSP) (the site) includes Lots 746, 747,748,749, 750 and the neighbouring Lot 545. The site is bound by Kwinana Freeway to the east, Baldivis Road to the west and is located approximately 42 kilometres (km) south of the Perth Central Business District (Figure 1). The site extends over an area of approximately 37 hectares (ha) which is inclusive of Lot 545 (Figure 2).

Historically, the site has been extensively cleared for agricultural purposes; it therefore consists largely of grassed paddocks. Horses are currently being kept on the site.

Historical Planning and Environmental Assessment Context

State Approval Background

In 2009, a Metropolitan Region Scheme (MRS) Amendment rezoned approximately 383 ha in Baldivis (including the site) from "Rural" to "Urban Deferred". This rezoning was endorsed by the Western Australian Planning Commission (WAPC) and subsequently promulgated by parliament.

The Environmental Protection Authority (EPA) assessed the MRS Amendment in 2006. The EPA advised that the appropriate level of assessment was "Scheme Not Assessed – Advice Given". The EPA in its assessment did provide advice in relation to wetlands.

East Baldivis District Structure Plan

A District Structure Plan (DSP) for the 383 ha area was prepared to provide further definition of the intended land uses, urban design and environmental management against the zonings set out in the MRS (Figure 3).

A District Water Management Strategy (DWMS) (Parsons Brinckerhoff 2007) was prepared in October 2007 in support of the DSP. The DWMS defined the water management objectives at the district level for the East Baldivis DSP. The DWMS was approved by the Department of Water (DoW) in November 2007. The management objectives from the DWMS have been incorporated into the site specific Local Water Management Strategy (LWMS) supporting the LSP.

Local Structure Plan

The LSP design is shown in Figure 3. The LSP design promotes the following land uses:

- residential
- movement network
- Public Open Space (POS)
- primary school site.

Engineering Philosophy

The proposed engineering methodology consists of using compaction of the existing site and then pre-loading the majority of the site with engineering fill. The engineering drainage design involves using subsoil drains which directs groundwater to POS areas and a piped system linking areas of POS with water discharged into the Sub H and Sub F drains. The purpose of this methodology is to provide the following outcomes:

- Provide the required separation from groundwater.
- Minimise excavation works (e.g. sewer lines) and therefore potential impacts from acid sulfate soils.
- Meet Better Urban Water Management guideline stormwater design and water quality objectives.

Purpose of this Report

The City of Rockingham Town Planning Scheme (TPS) No. 2 requires a LSP to be prepared and submitted for "Residential Development Zones" prior to granting and/or recommending approval of any development within this zone.

The purpose of this Environmental Assessment Report (EAR) is to address the following:

1. The key factors outlined in the EPA assessment of the MRS Amendments.
2. Facilitate the approval of the LSP with the City of Rockingham.

EAR Objectives

This EAR describes the relevant environmental characteristics of the site and presents management and mitigation strategies in response to potential environmental impacts. These management and mitigation strategies aim to minimise the potential impact on the environmental values within the site.

Key Environmental Issues

Consistent with the EPA's assessment of the MRS Amendment, the following were considered the key environmental factors which required further consideration and management as part of the structure plan and subdivision process:

- Acid Sulfate Soils
- Water management
- Vegetation and flora
- Fauna
- Site Contamination

- Noise
- Fire management.

Key Environmental Outcomes

The key environmental outcomes of the proposed LSP include:

- providing an improvement in groundwater and surface water quality through residential development and implementation of water sensitive urban design and best stormwater drainage management practices
- landscaping and enhancing the existing vegetation within the Tramway Reserve
- implementation of management measures to reduce potential noise impacts on future residences.

Management Commitments

Table 1 summarises the key environmental issues and the proposed management commitments.

Table 1: Summary of Key Potential Environmental Impacts and Proposed Management Measures

Environmental Issue	Objective	Potential Impacts	Management Mechanism	Timing
Acid Sulfate Soils (ASS)	To ensure that ASS are not disturbed during earthworks and construction activities.	According to existing DEC mapping, the risk of ASS occurring within 3 m of the surface is moderate to low.	As outlined in the 'Engineering Philosophy' the final fill levels and subsequent excavation requirements will determine if an ASS and Dewatering Management Plan will be prepared to the satisfaction of the Department of Environmental Regulation (DER).	Prior to subdivision.
Site Contamination	To ensure previous land uses within and surrounding the sites do not impact on proposed development of the site.	The majority of the site has been used for grazing and agricultural purposes and there is very little likelihood of any potential contamination. However, there is potential for contamination on Lot 460 from sheds and machinery on site.	The site has historically been used for agricultural purposes. Prior to the subdivision preliminary site assessment in accordance with *Contaminated Sites Act 2006* will be finalised.	Prior to clearance of title.
Water Management	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected. To ensure stormwater run-off is adequately contained within the development, so as not to impact on the Peel–Harvey Catchment.	▪ Change in hydrological regime as a result of changed landforms (from earthworks), which may alter natural flows. ▪ Discharge of stormwater, which may affect water quality and alter the natural keyhole surface topography and landform.	▪ The LWMS details the integrated water management strategies to facilitate future urban water management planning. The LWMS will achieve integrated water management through the following design objectives – Effectively manage the risk to property damage and environmental degradation from water contamination, flooding and waterlogging. – Maintain and if possible improve water quality (surface and groundwater) within the development in relation to pre-development water quality. – Reduce potable water consumption within both public and private spaces through the use of practical and cost-effective measures. – Promote infiltration of surface water to minimise the risk of further water quality degradation in the Peel Harvey Catchment. – Implement best management practices in regards to stormwater management. – Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.	LWMS: at local structure plan stage. UWMP: Prior to subdivision approval.
Vegetation and Flora	To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	▪ Clearing ▪ Degradation of retained vegetation through uncontrolled public access and weed invasion	▪ Vegetation will be retained within the Tramway Reserve, with single access crossings to facilitate retention and natural regeneration of vegetation within the Tramway Reserve. ▪ Use of native species in areas of Public Open Space ▪ All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to – significant fauna species on the site – reporting procedures for environmental incidents.	Subdivision design. Construction
Fauna	To maintain the abundance, diversity, geographic distribution and productivity of native fauna at the species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	▪ Clearing ▪ Degradation of retained vegetation through uncontrolled public access and weed invasion	▪ All site staff should participate in site inductions informing them about the Environment, Health and safety aspects of the site. The induction should include, but not be limited to – significant fauna species on the site – reporting procedures for environmental incidents.	Subdivision design. Construction
Fire	To reduce the risk of bushfire to people, property and infrastructure in accordance with Draft SPP 3.7: *Planning for Bushfire Risk Management* (WAPC 2014).	People, property and infrastructure situated within the site being impacted by potential bushfires from areas of remnant bushland – e.g. Tramway Reserve.	▪ Fire Management Strategy will be prepared to support this LSP. A Fire Management Plan will be prepared and implemented at subdivision.	Fire Management Plan to be prepared at subdivision stage.
Kwinana Freeway (Noise)	To ensure surrounding land uses do not impact future development of the site.	Freeway Noise	▪ Noise received at residences located adjacent to the Kwinana Freeway and Baldivis Road in the year 2025 will exceed the "Noise Limits" as outlined in the WAPC Planning Policy 5.4 "Road and Rail Transport Noise and Freight Considerations in Land Use Planning". However, the level of exceedance would only be minor i.e. up to 2 dB(A), therefore reduction of noise received by residences can be reduced so that it is compliant with Planning Policies "Noise Limits" by the implementation of noise walls.	Subdivision design.

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1.0 INTRODUCTION

The Mirvac Local Structure Plan (LSP) (the site) includes Lots 746, 747,748,749, 750 and the neighbouring northern Lot 545. The site is bound by Kwinana Freeway to the east, Baldivis Road to the west and is located approximately 42 kilometres (km) south of the Perth Central Business District (Figure 1). The site extends over an area of approximately 37 hectares (ha) which is inclusive of Lot 545 (Figure 2).

Historically, the site has been extensively cleared for agricultural purposes; it therefore consists largely of grassed paddocks. Horses are currently being kept on the site.

1.1 Background

1.1.1 MRS Amendment 1128/41 Baldivis Urban Area Expansion - Area 2

Following initiation, the Western Australian Planning Commission (WAPC) referred the three original Metropolitan Region Scheme (MRS) Amendments (Amendment No 1127/41, 1128/41 and 1129/41 – East Baldivis) to the Environmental Protection Authority (EPA) in 2006 for its consideration. The EPA advised that following consideration of the information provided, it set the level of assessment at "Scheme Not Assessed – Advice Given".

The EPA advised the following key environmental factors required further consideration and management as part of the structure plan and subdivision process:

- wetlands
- noise
- acid sulfate soils (ASS)
- water management
- vegetation and flora
- potential land use conflict
- site contamination
- high pressure natural gas pipeline.

The EPA's assessment and advice in relation to the three MRS Amendments is provided in Appendix 1.

1.2 Current Zoning

1.2.1 Metropolitan Region Scheme

In January 2007 the WAPC combined Amendment 1128/41 with MRS Amendments 1127/41 and 1129/41 which related to land parcels in Baldivis located to the north and south of the Amendment 1128/41 land for advertising. In June 2009 the landholdings subject to the MRS amendments were subsequently rezoned in a modified form, from "Rural" to "Urban".

1.2.2 East Baldivis District Structure Plan

The site is located within the northern portion of the East Baldivis District Structure Plan (DSP) which comprises approximately 383 ha (Figure 2).

The East Baldivis DSP was endorsed by the City of Rockingham as a strategic planning instrument in February 2014.

RPS prepared an Environmental Assessment Report (EAR) for the DSP (RPS 2010). The DSP EAR addressed the key environmental factors and provided management commitments in accordance with local, state and federal environmental policies and guidelines.

1.2.2.1 DSP Key Commitments

1. An ASS investigation will be undertaken across the DSP site, and a subsequent management plan will be prepared (if required) to the satisfaction of the Department of Environmental Regulation (DER) prior to ground disturbing activities.

2. Local Water Management Strategies (LWMS) and Urban Water Management Plans (UWMP) will be prepared at appropriate planning and development stages in accordance with Better Urban Water Management Guidelines (WAPC 2008).

3. Native vegetation will be retained where possible across the site. Additionally, vegetation will be retained within the Tramway Reserve, with limited access crossings into the DSP area to allow retention and natural regeneration of vegetation within the Tramway Reserve.

4. If warranted, due to historical land uses, undertake a Preliminary Site Investigation (PSI) to confirm the presence/absence of contamination at the site prior to ground disturbing activities.

1.3 Purpose of this Report

The City of Rockingham Town Planning Scheme (TPS) No. 2 requires a LSP to be prepared and submitted for "Residential Development Zones" prior to granting and/or recommending approval of any development within this zone.

The purpose of this EAR is to address the following:

1. The key factors outlined in the EPA assessment of the MRS Amendments.
2. Facilitate the approval of the LSP with the City of Rockingham.

1.3.1 EAR Objective

The objective of the EAR is to describe the relevant environmental characteristics of the site and present management and mitigation strategies in response to potential environmental impacts. These management and mitigation strategies aim to minimise the potential impact on the environmental values within the site.

1.4 Associated Reports

Previous reports produced for the site (and adjacent landholdings) include:

- East Baldivis District Water Management Strategy (DWMS) by Parsons Brinckerhoff (October 2007). This report defined the water management strategy at the district level for the East Baldivis Structure Plan area.
- Draft Environmental Assessment Report – Baldivis East District Structure Plan (RPS 2010).
- Draft Local Water Management Strategy (LWMS). The LWMS details the integrated water management strategies which will be implemented at the site and demonstrates that the land is capable of facilitating urban development whilst achieving sustainable, water and environmental outcomes.
- Detailed Acid Sulfate Soil Investigation (RPS 2014).
- Bushfire Management Strategy (Emerge 2014).
- Noise Assessment (Herring Storer 2014).

2.0 LOCAL STRUCTURE PLAN

2.1 Description

The LSP has been developed to guide the subdivision and development of approximately 37 ha of undeveloped land within the East Baldivis DSP. The LSP for the site is shown in Figure 3.

The LSP promotes the following land uses:

- residential
- movement network
- Public Open Space (POS)
- primary school site.

This EAR identifies the measures proposed to mitigate and manage the environmental features of the site, and focuses on the natural areas to be retained within the LSP. This is discussed in more detail in the following sections.

2.2 Environmental Aspects of LSP Design

The site does not have a high level of ecological integrity as it was historically cleared of vegetation and used for agricultural purposes.

From an environmental perspective the key influences of the LSP were:

- water management / drainage
- enhancing the Tramway Reserve
- noise from the freeway.

A central engineering and water management design component of the LSP necessitates approximately 2 meters (m) fill requirement across the site in order to provide an appropriate separation distance from the maximum groundwater levels to the future residential dwellings.

In this context, the LSP has been designed to meet the following key environmental objectives:

- incorporate best practice water management into the urban design
- managing ASS in accordance with DER ASS guidelines.

The following values have been accounted for as part of the process of identifying POS areas in the LSP:

- recreation opportunities
- using native trees in POS and the Tramway Reserve

2.3 Engineering Philosophy

The proposed engineering methodology consists of using compaction of the existing site and then pre-loading the majority of the site with engineering fill (approximately 2 m). The engineering drainage design involves using subsoil drains which directs groundwater to POS areas and a piped system linking areas of POS with water discharged into the Sub H and Sub F drains. The purpose of this methodology is to provide the following outcomes:

- Provide the required separation from groundwater.
- Minimise excavation works (e.g. sewer lines) and therefore potential impacts from acid sulfate soils.
- Meet Better Urban Water Management guideline stormwater design and water quality objectives .

2.4 LSP Site

2.4.1 Land Use

There is very little native vegetation within the site (approximately six flooded gum trees). The majority of the site is cleared horse paddocks and dams (**Error! Reference source not found.**).

A review of historical aerial photography from 1953 to 2014 shows that the site has been cleared of native vegetation since 1953 (or before) and used for agriculture / broad-scale farming.

Plate A: Paddocks and fencing

2.4.1.1 Lot 545

The current land use of Lot 545 is similar to the neighbouring site with two large horse paddocks. The key native vegetation is the planted rows of flooded gums adjacent to the open Sub-H branch drain.

2.4.2 Surrounding Land Uses

The site is bound on the east by the Kwinana Freeway and borders to the west the Tramway Reserve which is reserved under the MRS for "Parks and Recreation" (Figure 4).

2.4.2.1 Peel Main Drain

The Peel Main Drain (PMD) is located on the eastern side of the Kwinana Freeway. The drain flows in a north-south direction prior to discharging into the Serpentine River. A portion of the main drain is protected under the *Environmental Protection (Swan Coastal Plain Lakes) Policy Approval Order 1992* and contained within the boundary of Bush Forever Site No. 418*: Folly Pool, Baldivis* (Figure 4).

3.0 LEGISLATION AND REGULATION

3.1 Legislation and Regulations

Urban development within the site, and Lot 545, is required to comply with environmental legislation and regulations. A summary of the key State and Commonwealth legislation and regulations is listed in Table 2.

Table 2: Key State and Commonwealth Legislation and Regulations

State Legislation	
Aboriginal Heritage Act 1972	*Heritage of Western Australia Act 1950*
Conservation and Land Management Act 1984	*Land Administration Act 1997*
Conservation and Land Management Regulations 2002	*Planning and Development Act 2005*
Environmental Protection Act 1986	*Rights in Water and Irrigation Act 1914*
Contaminated Sites Act 2003	*Wildlife Conservation Act 1950*
Environment Protection Regulations 1987	
Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992	
Environmental Protection (Noise) Regulations 1997	
Commonwealth Legislation	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Environment Protection and Biodiversity Conservation Regulations 2000

3.1.1 Applicable Guidelines and Standards

Development of the site, and Lot 545, is required to comply with applicable guidelines and standards developed by the EPA. These guidelines and standards assist proponents and the general public to understand the minimum requirements for the protection of elements of the environment that the EPA expects to be met during the assessment process. Table 3 details the key EPA standards, guidelines and state planning policies relevant to the site.

Table 3: Applicable EPA Standards, Guidelines and State Planning Policies

EPA Position Statements
Position Statement No. 2: *Environmental Protection of Native Vegetation in Western Australia*.
Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection*.
EPA Environmental Assessment Guidelines
Environmental Assessment Guideline No. 8: *Environmental factors and objectives.*
Environmental Assessment Guideline No. 9: *Application of significance framework in the environmental impact assessment process.*
EPA Guidance Statements
Guidance Statement No. 33: *Environmental Guidelines for Planning and Development*.
Guidance Statement No. 41: *Aboriginal Heritage Assessment.*
Guidance Statement No. 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*.
Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*.
Environmental Protection Policies
Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992
State Planning Policies
State Planning Policy 2.1: *Peel – Harvey Coastal Plain Catchment*
State Planning Policy 5.4: *Road and Rail Transport Noise*
State Planning Policy No. 3.7: Planning for Bushfire Risk Management

4.0 EXISTING ENVIRONMENT

4.1 Topography, Soils and Geology

4.1.1 Topography

The topography of the site, and Lot 545, is generally flat with a gradual decline from west to east. The western boundary of the site is approximately 9.0 metres Australian Height Datum (m AHD) and gradually declines to be above 3.5 m AHD on the eastern boundary (Figure 5).

4.1.2 Geology

The soil associations within the site, and Lot 545, are S8 Sands, in the west, and C2 Clays, in the east (Figure 5).

The S8 Sands are comprised of very light grey sand at the surface, with yellow sand at depth. The sand is fine to medium grained, sub rounded moderately sorted quartz of aeolian origin (Department of Industry and Resources 1999).

The C2 Clays comprise of strong brown and dark grey clays that are plastic in places, soft when wet, have variable silt content and are of alluvial origin (Department of Industry and Resources 1999).

4.1.3 Acid Sulfate Soils (ASS)

The ASS risk mapping indicates that the entire extent of the site, and Lot 545 is mapped as "Moderate to Low" risk of ASS occurring within 3 m of the natural soil surface (Figure 6).

A Detailed ASS Site Assessment has been undertaken. This assessment concluded acidity (actual, potential and retained) was detected across the majority of the site. Pyritic acidity was identified mainly in deeper soils with actual and retained acidity present in the upper profile (RPS 2014). This is mostly likely due to the upper soils being in a wetting and drying cycle due to the high water table and drainage channel, thus leading to oxidation and release of potential acidity and in some occasions precipitation of sulfate species. Noting the homogeneity of soil associations across Lot 545, it is expected that a similar ASS risk would be present.

As outlined in the "Engineering Philosophy" the final fill levels and subsequent excavation requirements (e.g. for sewer lines / engineering services) will determine if an ASS and Dewatering Management Plan is required to be prepared prior to subdivision.

4.2 Surface Hydrology

4.2.1 Drainage

The site is located within the Peel Estuary–Serpentine River Catchment. The PMD is situated east of the freeway and the site which drains stormwater run-off from the East Baldivis catchment into the Serpentine River and ultimately the Peel Inlet-Harvey Estuary.

The drainage on the site is managed through the Sub H and Sub F drains (Figure 7). Stormwater run-off flows into the Sub H and F drains which then flows out of the site via a culvert beneath the freeway to Folly Pool and ultimately the PMD.

4.2.2 Wetlands

Multiple Use Wetland (UFI 15785) is mapped for a significant portion of the site and Lot 545. This wetland is an extensive palusplain wetland which has been subject to various impacts associated with past and current land uses across its extent.

The PMD adjacent is mapped as Resource Enhancement Wetland (REW) (UFI 14659) (Figure 8).

The Multiple Use wetland is in a highly degraded condition based on historical clearing and agricultural land use. Further, the LSP has proposed to adopt all reasonable measures to retain the site's hydrological functions (including on-site water infiltration). Accordingly, the Multiple Use wetland can be developed in accordance with the "Urban" land use zoning.

The REW is located on the eastern side of the Kwinana Freeway, over 100 m from the site boundary. The development of the site, in particular with the adoption of Better Urban Water Management practices, will not have any impacts on this REW.

4.2.3 Flood Plain

The *Serpentine River Floodplain Management Study, Floodplain Management Strategy* (SKM 2010) for the Serpentine, Baldivis, Karnup and Keralup recommends floodplain management strategies to ensure proposed development in flood prone areas are acceptable with regard to major flooding. The recommended flood plain management strategies for the Serpentine River floodplain are as follows:

- Proposed development located outside the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.5 m above the adjacent 1 in 100 year ARI flood level is recommended to provide adequate flood protection.

- Proposed development located within the floodway is considered obstructive to major flows and is not acceptable, as it would increase flood levels upstream. No new buildings are acceptable in the floodway.

Flood mapping indicates a large portion of the site is within the floodplain of the PMD during major river flows (Figure 7).

The Department of Water (DoW) guidance states to ensure adequate flood protection that development within the flood fringe is 0.5 m above the 100 year ARI when setting the minimum habitable floor levels.

4.2.4 Groundwater

The *Perth Groundwater Atlas* (DoW 2014) estimates the groundwater levels at approximately 2 m below the natural surface of the ground. Pre-development observations indicate the site has the potential to become inundated during the winter months.

Groundwater monitoring results show groundwater levels range from 3.5 m AHD to 4.4 m AHD. Local groundwater flow is generally towards the Sub H or F drains.

The engineering response detailed in the LSP outlines groundwater levels will be controlled by a combination of fill and sub-surface drainage.

4.3 Vegetation and Flora

Due to historical land uses, particularly agricultural activities, the site and Lot 545 have been extensively cleared of native vegetation. There are approximately 6 flooded gums in the site (all within Lots 746 and 750).

Within Lot 545 the key remnant vegetation is the planted rows of flooded gum trees either side of the Sub-H Drain.

The vegetation condition within the site is "Completely Degraded" due to historical clearing and agricultural land uses.

4.3.1.1 Protected Flora

A search of the Department of Parks and Wildlife (DPaW) *NatureMap* database using 5 km buffer located centrally within the site recorded one priority flora species (*Dodonaea hackettiana* [Hackett's Hopbush]) within the search area (Appendix 2).

Acknowledging the extensive historical clearing and ongoing use as horse paddocks, it is considered highly unlikely any Priority or protected flora will be located within the site or Lot 545.

4.3.2 Tramway Reserve

The Tramway Reserve traverses parallel to Baldivis Road along the western boundary of the site and Lot 545.

The vegetation within the Tramway Reserve consists of patches of *Eucalyptus rudis* with *Corymbia calophylla*. There are groups of trees particularly in the northern end of the Tramway Reserve in "Good" condition, however the Tramway is also dominated by large open areas supporting weed growth.

The City of Rockingham has requested the number of access points through the reserve to be limited with the objective of minimising potential impacts to the vegetation within the reserve. The LSP has a single access road through the reserve (Figure 4).

4.4 Fauna

The majority of the site has been historically cleared and as a consequence significant fauna habitat has been largely removed.

A search of the Commonwealth Department of the Environment (DoE) website for Matters of National Environmental Significance (MNES) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) highlighted a number of listed fauna species that potentially may utilise the small amount of remaining habitat.

Of this list, the key species that could potentially be impacted through development of the site, (based on the fauna habitats remaining) are listed below:

Scattered stands of or individual *Eucalyptus rudis* trees:

- Forest red tailed black cockatoo (*Calyptorhynchus banksii naso*)
- Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)
- Baudin's black cockatoo (*Calyptorhynchus baudinii*).

The remnant trees may be utilised opportunistically by native fauna species moving through the Baldivis landscape. Given the trees occur independently of native vegetation extents it is considered unlikely that the trees are utilised by native fauna species on a permanent basis.

Potential habitat on the site for black cockatoo species comprises of less than 0.01 ha (and less than 0.5 ha in Lot 545) of poor foraging quality *Eucalyptus rudis* trees within the site. There is no roosting or breeding habitat within the site.

The LSP site has limited fauna habitat values, limiting access through the Tramway Reserve will assist in preserving avifauna habitat.

4.5 Contamination

A review of the DER's Contaminated Sites Database determined there are no registered contaminated sites within the site or Lot 545.

However, prior to subdivision further investigations may be required on Lot 545 to confirm there is no potential contamination on the site.

4.6 Social Surroundings

4.6.1 Noise

An Acoustic Assessment for the East Baldivis DSP project area (Herring Storer Acoustics 2009), which included the site and Lot 545, was undertaken due to the project area's proximity to the Kwinana Freeway and local arterial routes of Mundijong and Baldivis Roads.

The results of the acoustic assessment indicate that noise received at residences located adjacent to the Kwinana Freeway and Baldivis Road in the year 2025 will exceed the "Noise Limits" as outlined in State Planning Policy 5.4: *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC 2009). However, the level of exceedance would only be minor i.e. up to 2 dB(A).

Given the possible level of exceedance, Herring Storer Acoustics (2009) concluded that compliance with the WAPC (2009) "Noise Limits" can be achieved through a combination of construction of noise walls, building design and notification on titles.

A more detailed Traffic Noise Assessment has been prepared by Lloyd George Acoustics in support of this LSP, and is included as a separate report.

4.6.2 Heritage

4.6.2.1 Aboriginal Heritage

A search of the Department of Aboriginal Affair's Aboriginal Heritage Inquiry System was undertaken on 20 March 2014 and no matches were recorded for the site or Lot 545.

4.6.2.2 European Heritage

A search of the Heritage Council's inHerit database and the City of Rockingham's Municipal Heritage Inventory (City of Rockingham 2012) was undertaken on 20 March 2014 with no matches found for the site or Lot 545.

4.6.3 Fire

There are a number of vegetated areas which require consideration in terms of future bushfire hazards; these have been comprehensively addressed in the Fire Management Strategy (Emerge Associates 2014) prepared for the site. Vegetation within and surrounding the site has been classified according to AS 3959 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2009). Hazard ratings have been based on the vegetation classifications which in turn define necessary responses within the LSP and for future development.

Vegetation that is to be permanently retained surrounding the site will pose permanent bushfire hazard considerations. In the same way, vegetation that is to be cleared for future urban purposes in the short to medium term will pose only temporary bushfire management considerations. Remnant vegetation within the site is limited in extent, and is intended to be largely cleared for urban development, and therefore does not require consideration in terms of posing future bushfire hazards.

All areas within 100 m of the site boundary have been assessed for vegetation classification and bushfire hazard rating levels. It has been determined that all proposed future dwellings arising from the LSP will fall within the acceptable level of risk. Based on the East Baldivis DSP, urban development is planned for landholdings directly adjacent to the northern and southern boundaries of the site. Therefore, vegetation within these lots will pose only temporary bushfire management considerations within the LSP area until such a time as the areas are cleared or managed as part of the development process.

Permanent bushfire hazard considerations are posed by the remnant vegetation within the Tramway Reserve adjacent to the western boundary of the site, and by vegetation within the Kwinana Freeway road reserve adjacent to the eastern boundary of the site.

Future management of the Tramway Reserve and Kwinana Freeway reserve may alter the hazard ratings associated with these areas of vegetation (should fuel loads be increased or decreased) and mitigation responses may need to be revisited during subdivision application stage. Ongoing discussions with the City of Rockingham and Main Roads regarding the management of fuel loads within the Tramway Reserve and Freeway reserve respectively aim to ensure a long term "Low Threat" interface with development within the site. Therefore detailed Fire Management Plans will be prepared for areas within 100 m of classified vegetation (referred to as Bushfire Prone Areas) as part of subdivision.

A Bushfire Management Strategy has been prepared for this LSP and is included as a separate appendix.

5.0 CITY OF ROCKINGHAM RELEVANT ENVIRONMENTAL POLICIES AND GUIDELINES

5.1 Environmental Guidance Documents

5.1.1 City of Rockingham Local Bushland Strategy

The City of Rockingham's Planning Policy 7.2 – Local Bushland Strategy aims to:

> Provide Council with guidance in the assessment of proposals to rezone, subdivide and develop land in the City where remnant bushland is present.

The policy guides the assessment of the ecological value of remnant bushland on the subject site to assist in determining the suitability of development over the land proposed to be developed. In line with the policy directives, the bushland on site has been assessed in accordance with the Policy's following criteria:

5.1.1.1 Presence of Rare Species or Threatened Ecological Communities

The site has very limited remnant vegetation, with the only example of pre-European vegetation within the site consisting of scattered pockets of native trees. In addition, remnant understorey across the site has been cleared, indicating a very low likelihood for any rare flora species or threatened ecological communities being present on the site.

5.1.1.2 Rarity of the Vegetation Complex Present (i.e. is the Complex Present One of Those Where Less Than 10% Remains in Secure Conservation Reserves, Either in a Regional or Locally Representative Context)

The remnant vegetation is mapped by Heddle et al. (1980) as belonging to the Serpentine River Complex and Bassendean Complex – Central and South. However, the basic vegetation structures typically associated with the mapped regional complexes have been severely impacted from the historical clearing and agricultural land use; in particular there has been high disturbance to the understory vegetation.

The Serpentine River Complex is described as closed scrub of *Melaleuca* spp. and fringing woodland of E. *rudis* – M. *rhaphiophylla* along streams (Heddle et al. 1980). The Bassendean Complex – Central and South is described as vegetation ranging from woodlands of *Eucalyptus marginata – Casuarina fraserana – Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites.

Bush Forever (Government of Western Australia 2000) shows 9% of the Serpentine River Complex exists in the Perth Metropolitan Region of the Swan Coastal Plain. Approximately two per cent of the original Serpentine River Complex extent is located in areas with existing protection (e.g. Parks and Recreation Reserves).

The Bassendean complex meets the state's target of at least 10% of the original extent proposed for protection.

5.1.1.3 Vegetation Diversity

Remnant vegetation has been vastly cleared due to historical agricultural activities, with limited diversity in the vegetation remaining, which primarily consists of very few scattered flooded gum trees and a "Completely Degraded" (pasture) understorey.

5.1.1.4 Vegetation Condition (Level of Degradation, Structure Retained)

The vegetation condition is "Completely Degraded" due to its agricultural history.

5.1.1.5 Connectivity as a Wildlife Corridor

Review of aerial photography and through undertaking a site visit indicates that surrounding landholdings contain very limited ecological value. The landholdings to the south and north have been historically used for agriculture and are in similar degraded condition to the LSP site.

Retention of the vegetation within the Tramway Reserve will be undertaken, in accordance with the City of Rockingham's objectives for this area. In addition, significant trees and areas of bushland within the site will be retained wherever possible. Access points to the subdivision will also be minimised to prevent adverse impacts on the connectivity of the Tramway Reserve for transient fauna.

5.1.1.6 Significant Because it is Isolated and is the only Remaining Bushland in that Area (Particularly Important in Developed Areas)

The remnant vegetation on the site is very limited. There are properties and Bush Forever sites within less than 2 km that contain more intact areas of native vegetation that better represent the bushland locally.

5.1.1.7 Social Value (e.g. Educational Resource, Recreational Area, Locally Admired for Rural or Visual Amenity)

The site has historically and is currently being used for small-scale agricultural activities and does not represent a significant social value in respect to the environmental values of the site.

5.1.1.8 Acts as a Buffer Between Potentially Conflicting Land Uses

The vegetation within the site does not contain any value as a buffer to conflicting land uses.

5.1.1.9 Impact from Removal or Modification on Other Parts of the Environment

Given the limited environmental value attributed to the remaining vegetation on site, there will likely be negligible impacts to other parts of the environment.

5.1.1.10 Other Significant Attributes

Given the limited ecological value of the remnant vegetation on site, and in consideration of the responses to each of the criteria outlined above, the LSP design and management commitments outlined in this document meet the City of Rockingham's objectives for bushland retention as outlined in the Planning Policy 7.2 – *Local Bushland Strategy*.

6.0 POTENTIAL ENVIRONMENTAL IMPACTS AND MANAGEMENT MEASURES

The key environmental factors are considered applicable to the site include:

- ASS
- water management
- vegetation and flora
- fauna
- site contamination
- noise
- fire management.

6.1 Acid Sulfate Soils

6.1.1 Environmental Objective

To maintain the integrity, ecological functions and environmental values of the soil.

6.1.2 Policy and Standards

- Assessment Levels for Soil, Sediment and Water (DER 2010).
- Acid Sulfate Soils Guideline Series. Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes (DER 2011).
- Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes (DER 2013).

6.1.3 Potential Impacts

ASS soils are stable when left undisturbed, but when they are exposed to air, during excavation or dewatering, this can set off a reaction resulting in acidity (sulfuric acid) being produced.

The potential impacts relate to the potential for oxidation of excavated or in situ ASS generating acidic conditions, and possibly releasing metals into groundwater and surrounding freshwater environment of the PMD / Folley Pool.

6.1.4 Management Response

As outlined in the "Engineering Philosophy" the final fill levels and subsequent excavation requirements will determine if an ASS and Dewatering Management Plan is required to be prepared prior to subdivision.

However if required, the ASSDMP will outline the soil management measures, the groundwater and dewatering effluent monitoring measures and the contingency management measures required to minimise any environmental impacts.

6.1.5 Predicted Outcome

The excavation of ASS and dewatering during the construction phase of the project will be managed in accordance with the engineering design, and excavation requirements. If required the ASSDMP will be prepared to the satisfaction of DER.

6.2 Water Management

The EPA water management objectives include:

- to maintain the quantity of water (surface and ground) so that existing and potential environmental values are protected
- to ensure that the quality of water emissions (surface and ground) do not adversely affect environmental values or the health, welfare and amenity of people and land uses, and meets statutory requirements and acceptable standards.

6.2.1 Relevant Policies, Guidelines and Standards

The key water and nutrient management policies are outlined below.

6.2.1.1 *Environmental Protection (Peel Inlet–Harvey Estuary) Policy 1992*

The objective of the *Environmental Protection (Peel Inlet–Harvey Estuary) Policy 1992* (Peel–Harvey EPP) is to reduce the input of nutrients, particularly phosphorus, into the Peel Inlet–Harvey Estuary System through a number of means including appropriate land management by landowners in the policy area.

6.2.1.2 Statement of Planning Policy 2.1 (Peel–Harvey Coastal Plain Catchment) 2003

The objectives of Statement of Planning Policy (SPP) 2.1 reflect the environmental objectives of the Peel–Harvey EPP and aim to ensure that changes to land use within the catchment are controlled so as to avoid and minimise environmental damage.

The SPP contains a number of general and specific policy provisions relating to drainage. The policy states that subdivision proposals shall make provision for a drainage system which maximises the consumption and retention of drainage on site. Biological wetland filters or other means of drainage water retention or treatment approved by the EPA are to be incorporated into drainage designs, possibly by amendment of the soils in drainage basins or by the provision of wetland filters with nutrient-retentive soil amendments.

6.2.1.3 Peel–Harvey Water Sensitive Urban Design (WSUD) Local Planning Policy

The Peel–Harvey WSUD Local Planning Policy (Peel Development Commission 2006) was developed through the federal government's Coastal Catchments Initiative Project and endorsed by the EPA. It aims to assist local government in integrating catchment management objectives with land and resource planning in urban landscapes.

This policy identifies broad objectives against which strategic and statutory proposals can be assessed. WSUD principles in order of priority are provided to:

- Provide protection to life and property from flooding that would occur in a 100-year Average Recurrence Interval (ARI) flood event.
- Manage rainfall events to minimise run-off as high in the catchment as possible. Use multiple low cost "in-system" management measures to reduce run-off volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material).
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor.
- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater run-off and prevent or treat stormwater pollution).
- Maximise water use efficiency, reduce potable water demand, and maximise the reuse of water harvested from impermeable surfaces.

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

In addition, stormwater management is stated as having to provide (as compared to a development that does not actively manage stormwater quality):

- at least 80% reduction of total suspended solids
- at least 60% reduction of total phosphorus

- at least 45% reduction of total nitrogen
- at least 70% reduction of gross pollutants.

The policy is consistent with the *Decision Process for Stormwater Management in WA* (DoE and SRT 2005) which is appended to the policy, and is consistent with the objectives of the Peel Inlet–Harvey Estuary EPP.

6.2.1.4 Water Quality Improvement Plan for the Rivers and Estuary of the Peel–Harvey System

The development of the *Water Quality Improvement Plan* (WQIP) *for the Rivers and Estuary of the Peel–Harvey System* (WQIP) (EPA 2008) is a result of the Commonwealth Government's Coastal Catchments Initiative (CCI). Seven CCI projects contributed to and assisted in the preparation of the draft WQIP.

These CCI projects were as follows and their reports are included as appendices in the WQIP:

- Decision Support System for Water Quality Protection
- Support System for the Phosphorus Reduction Decisions
- Water Quality Monitoring Program
- Water Sensitive Urban Design
- Regulation/ Licensing Review
- Targeted Assistance to Intensive Agricultural Industries
- Stock Exclusion from Catchment Waterways.

The aim of the draft WQIP is to improve water quality by changing land use planning, agricultural and urban practices in order to reduce phosphorus being discharged from the catchment.

The draft WQIP identifies the following:

- current status of phosphorus loads
- identifies the environmental values of water bodies
- the water quality objectives that will protect the environmental values and identifies a set of management measures and control actions to achieve and maintain those environmental values and water quality objectives.

The Water Quality Objective of the WQIP is:

- median loadings of total phosphorus to estuarine waters should be less than 75 tonnes per annum in an average year
- the median load of total phosphorus flowing in the estuary from the Serpentine River being less than 21 tonnes

- the median load of total phosphorus flowing in the estuary from the Murray River being less than sixteen tonnes

- the median load of total phosphorus flowing in the estuary from the Harvey River being less than thirty-eight tonnes.

In order to meet this water quality objective, the WQIP proposes the following management measures and control actions across the coastal section of the Peel Inlet – Estuary Harvey Catchment:

1. Use a slow-release, low water soluble fertiliser, applied after the break of season, preferably in spring and at reduced rates, on sandy soils in rural areas.

2. Undertake soil amendment on sandy soils in rural areas.

3. Use low water soluble fertiliser in urban areas.

4. Connect all existing homes to infill sewerage.

5. Zero discharge from licensed agricultural premises.

6. Improve other agricultural practices to reduce phosphorus discharges.

7. Undertake strategic reafforestation of agricultural land.

8. Connect to sewerage all homes and properties for new urban developments.

9. Undertake soil remediation in all new urban developments with sandy soils.

10. Implement Local Planning Policies, Strategies and Planning Conditions that incorporate Best Management Practices where applicable.

11. Incorporate water sensitive urban design in all new developments.

12. Improve the agricultural and urban drainage system.

6.2.2 Potential Impacts

The identified key potential impacts include:

- Groundwater at the site flows towards the PMD which then drains into Folly Pool which is an environmentally sensitive receptor (Parsons Brinckerhoff 2008). Therefore, impacts to groundwater quality on site may also impact sensitive receptors downstream.

6.2.3 Environmental Management and Mitigation

6.2.3.1 Overview

A number of management/design measures will be implemented to reduce the impact of the development on groundwater flows, levels or quality, the function and environmental values of the site, or its interconnected areas. Management measures relevant to construction and the residential-living phase are described under the relevant headings below.

6.2.3.2 Urban Water Management

The LWMS has been prepared in accordance with East Baldivis DWMS and has been developed with reference to the following guidance documents:

- Serpentine River Floodplain Management Study and Modelling Report (SKM 2010)
- Interim: Developing a Local Water Management Strategy (Department of Water 2008a)
- Better Urban Water Management (WAPC 2008)
- District Water Management Strategy East Baldivis (Parsons Brinkerhoff 2007)
- Western Australian State Water Plan (Government of Western Australia 2007)
- Stormwater Management Manual for Western Australia (Department of Water 2004–2007)
- Liveable neighbourhoods (2nd Edition) (WAPC 2000)
- Water Quality Improvement Plan for the Rivers and Estuary of the Peel – Harvey system – Phosphorus Management. (EPA 2008).

The LWMS details the integrated water management strategies to facilitate future urban water management planning. The LWMS will achieve integrated water management through the following design objectives:

- Effectively manage the risk to human life, property damage and environmental degradation from water contamination, flooding and waterlogging.
- Maintain and if possible improve water quality (surface and groundwater) within the development in relation to pre-development water quality.
- Reduce potable water consumption within both public and private spaces through the use of practical and cost-effective measures.

- Promote infiltration of surface water on site to minimise the risk of further water quality degradation in the Peel Harvey Catchment.
- Implement best management practices in regards to stormwater management.
- Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.

6.2.3.3 Stormwater Management

The LWMS has incorporated the following structural Best Management Practices (BMPs) will be used to address water quality for the LSP:

- A conceptual drainage strategy demonstrates that the land is capable of retaining the 100 ARI event while providing an indicative location of stormwater detention.
- Structural and non-structural controls will be used to improve stormwater quality, as compared to a development that does not actively manage stormwater.
- Rainfall from 1 year ARI (Annual Recurrence Interval) events will be retained and infiltrated as close to the source as possible.
- All residential lots will confine run-off from roofs and paving within the property boundary.
- Large rainfall events (10 ARI to 100 ARI) will be conveyed and retained through a network of roads, drainage reserves and POS within each catchment.
- It is anticipated that there will be no impacts from stormwater run-off to downstream ecosystems.

6.2.4 Predicted Outcome

It is expected that development of the site will have a positive impact on groundwater quality through BMPs and the treatment of stormwater prior to infiltration, as discussed below:

- The stormwater structural controls will improve infiltrating stormwater water quality through reducing water velocities, biological uptake and increasing infiltration areas.
- Water quality will be improved through minimising and controlling the levels of fertilisers and pesticides applied to the site through appropriate plant selection and operation and maintenance.

The management of stormwater and nutrients is in accordance with State Planning Policy No. 2.1: Peel Harvey Coastal Plain Catchment, WQIP for the Rivers and Estuary of the Peel – Harvey system – Phosphorus Management and Better Urban Water Management practices. Based on the investigations undertaken and the management measures proposed, it is not expected that any changes to groundwater flows, levels or quality will have an adverse impact on the function and environmental values of the site.

6.3 Flora and Vegetation

The EPA flora and vegetation objective is:

- to maintain the abundance, diversity, geographic distribution and productivity of flora at the species and ecosystem levels through the avoidance or management of adverse impacts and through improvement in knowledge.

6.3.1 Applicable Policies, Guidelines and Standards

EPA Position Statement No 2: Environmental Protection of Native Vegetation in Western Australia provides an overview of the EPA position on the clearing of native vegetation in Western Australia.

City of Rockingham Planning Policy 7.2 – Local Bushland Strategy.

6.3.2 Potential Impacts

The site's historical use for agriculture and grazing has completely degraded the vegetation on site and reduced the native vegetation cover to minimal areas containing scattered trees including those located along fence lines, with no or very limited native understorey.

Consequently, it is anticipated that the proposed development would have very little impact on native vegetation.

6.3.3 Environmental Management and Mitigation

The following management measures have been developed and incorporated into the LSP to reduce the likelihood of impacts to vegetation and flora. These measures have been developed with the aim of retaining the key existing biological values of the site:

- vegetation will be retained within the Tramway Reserve, with single access crossings to facilitate retention and natural regeneration of vegetation within the Tramway Reserve

- use of native vegetation species in areas of POS.

6.3.4 Predicted Outcome

The proposal is very unlikely to have any impact on flora or vegetation due to the lack of native vegetation within the site. Any potential impacts will be reduced through the following:

- Retention and replanting of areas of POS and within the Tramway Reserve will be undertaken, in accordance with the City of Rockingham's objectives for this area. This will be detailed in a future Landscape Plan.

6.4 Fauna

EPA fauna objective is outlined below.

- To maintain the abundance, diversity, geographic distribution and productivity of native fauna at the species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

6.4.1 Applicable Policies, Guidelines and Standards

For the LSP site, the key EPA policies and guidelines relating to the identification and management of potential impacts on fauna are:

- EPBC Act 1999
- Guidance Statement No 33: Environmental Guidance for Planning and Development
- City of Rockingham Planning Policy 7.2 – Local Bushland Strategy.

6.4.2 Potential Impact

However, noting the majority of the site has been historically cleared and as a result, fauna habitat has largely been removed. The only potentially significant fauna habitat on site is:

- Potential habitat on the site for black cockatoo species comprises of less than 0.01 ha (and less than 0.5 ha in Lot 545) of poor foraging quality *Eucalyptus rudis* trees within the site. There is no roosting or breeding habitat within the site.

6.4.3 Environmental Management and Mitigation

The following management measures have been developed and incorporated into the LSP to reduce the likelihood of impacts to native fauna:

- Regional fauna corridors will be retained through the Tramway Reserve.

6.4.4 Predicted Outcome

The proposal may result in minimal disturbance, which is not likely to impact any individual animals, (given the historically cleared nature of the site).

6.5 Site Contamination

EPA objective

- To ensure previous land uses within and surrounding the site, do not impact on proposed development of the site.

6.5.1 Applicable Policies, Guidelines and Standards

The applicable Contaminated Sites policies and standards include:

- *Contaminated Sites Act 2006.*

6.5.2 Potential Impact

The site has been used for grazing and agricultural purposes and there is very little likelihood of any potential contamination. However, there is potential for contamination on Lot 545 due to historical land use.

6.5.3 Environmental Management and Mitigation

Prior to the subdivision a contamination assessment in accordance with *Contaminated Sites Act 2006* may be required on Lot 545.

6.6 Noise

6.6.1 Kwinana Freeway

The EPA in its assessment of the proposed MRS amendment for the East Baldivis area identified noise impacts from the adjacent Kwinana Freeway as a potential constraint to future development of the site.

Herring Storer Acoustics undertook an assessment of freeway noise and proposed future residential development within the Baldivis East DSP area. The results of the acoustic assessment indicates that noise received at residences located adjacent to the Kwinana Freeway, Mundijong and Baldivis Road in the year 2025 will exceed the "Noise Limits" as outlined in the WAPC Planning Policy 5.4 "Road and Rail Transport Noise and Freight Considerations in Land Use Planning". However, the level of exceedance would only be minor, i.e. up to 2 dB(A).

Given the possible level of exceedance, Herring Storer concluded in their assessment that compliance with the Planning Policies "Noise Limits" can be achieved by the implementation of earth bunding or noise walls.

6.6.1.1 Environmental Management and Mitigation

LSP design has accommodated the following noise management measures (for the first row of houses within the development adjacent to the freeway only):

- construction of a noise wall or other mitigation measures e.g. bund along the length of the LSP site adjacent to the freeway.

Subdivision controls include:

- implementation of a "Quiet House" design for those houses adjacent to the freeway
- notifications on Title are placed on those houses located adjacent to the freeway regarding likely vehicle noise.

6.7 Fire

6.7.1 Environmental Objectives

To reduce the risk of bushfire to people, property and infrastructure.

6.7.2 Policy and Standards

Draft SPP 3.7: *Planning for Bushfire Risk Management* (WAPC 2014).

6.7.3 Potential Impacts

The implementation of the LSP will result in an increased risk to people, property and infrastructure being impacted by potential bushfires in the Tramway Reserve.

6.7.4 Management Response

In accordance WAPC (2014) a Fire Management Plan will be required to be prepared at subdivision stage.

6.7.5 Predicted Outcome

The proposed development will have the appropriate level of bushfire protection, relative to the surrounding land use context, to manage the risk to people, property and infrastructure posed by bushfire.

7.0 MANAGEMENT COMMITMENTS AND CONCLUSIONS

Table 1 in the executive summary details the key environmental issues and the proposed management commitments. These include:

- ASS
- water management
- vegetation and flora
- fauna
- site contamination
- noise
- fire management.

The proposed LSP recognises the importance of the key environmental and landscape attributes of the area, and incorporates these in an urban form, that creates an environmentally responsive urban development that meets the EPA and City of Rockingham's environmental requirements. Consequently the environmental outcomes of the proposed LSP are considerable and include:

- providing an improvement in groundwater and surface water quality through residential development and implementation of water sensitive urban design and best stormwater drainage management practices

- landscaping and enhancing the existing vegetation within the Tramway Reserve

- implementation of management measures to reduce potential noise impacts from the adjacent freeway on future residences

- using native vegetation and trees in POS where possible

- limiting access points through the tramway reserve to the subdivision to prevent adverse impacts particularly for transient fauna.

8.0 REFERENCES

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SKM. 2010. Serpentine River Floodplain Management Study, Flood Plain Management Strategy. Brisbane: Queensland.

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Western Australian Planning Commission. 2014. State Planning Policy No. 3.7: Planning for Bushfire Risk Management. Perth: Western Australia.

FIGURES

RPS

Job Number: L1404002
Doc Number: 001
Date: 17.07.14
Scale: Map 1:500000 Inset 1:25000 @ A4
Created by: MA
Source: Imagery - Landgate

Figure 1

Site Location

38 Station Street, Subiaco | T +61 8 9211111 | F +61 8 9211122 | www.rpsgroup.com.au

Note:

1. Further investigation of the Resource Enhancement Wetland & Buffers to be undertaken as part of the preparation of Local Structure Plans.
2. Further investigation of the Noise Attenuation along Mundijong Road to be undertaken as part of the preparation of Local Structure Plans.
3. Further investigation of the Dampier to Bunbury pipeline buffer to be undertaken as part of the preparation of Local Structure Plans.
4. Bush Fire Strategy shall be prepared as part of the preparation of Local Structure Plans.

MILLER ROAD
43Km to PERTH
DRAIN RESERVE
BALDIVIS ROAD
1.0km
MILLER ROAD WEST
400m
PUG ROAD
POS
PS
RESERVE
TRAMWAY
APPROX 2Km to MANDURAH ROAD
MUNDIJONG ROAD
400m
MUNDIJONG ROAD
KEROSENE
LANE
1.0km
NAIRN ROAD (FUTURE)
GAS PIPELINE EASEMENT
400m
400m
PS
POS
HS
DOS
ROAD
KWINANA FREEWAY
ZIG ZAG ROAD
FIFTY ROAD
BALDIVIS
RESERVE
PEMBERTON BVD
TRAMWAY
POS
400m
1.0km
TAMWORTH BVD
KEY CLOSE
DISTRICT CENTRE
SAFETY BAY ROAD
APPROX 2Km to MANDURAH ROAD
23Km to MANDURAH

LEGEND

- SITE BOUNDARY
- LOT 545
- SUBJECT LAND
- NEIGHBOURHOOD CONNECTOR ROADS
- DRAINAGE ROUTE
- PUMP STATION
- RESIDENTIAL
- FUTURE FREEWAY SERVICE CENTRE
- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS
- PS PRIMARY SCHOOL
- HS HIGH SCHOOL
- KEY PUBLIC OPEN SPACE (Must be shown on Local Structure Plans in this location and provided)
- TRAMWAY RESERVE
- RESOURCE ENHANCEMENT WETLAND (Indicative Buffer)
- * FUTURE STAGGERED T-JUNCTIONS (from Baldivis onto Mundijong Road, with Mundijong Road as the priority route.)

POS DISTRIBUTION

LOCAL @ 150 - 300m CATCHMENT

NEIGHBOURHOOD @ 400m CATCHMENT

DISTRICT @ 600 - 1000m CATCHMENT

RPS

Job Number: L1404002
Doc Number: 002
Date: 17.07.14
Scale: 1: 20,000 @ A3
Created by: MA
Source: DSP - City Of Rockingham, 2304-74B-01 26.11.13

0 250 500 750 1000 m

Figure 2

East Baldivis District Structure Plan

38 Station Street, Subiaco | T +61 8 92111111 | F +61 8 92111122 | www.rpsgroup.com.au

38 Station Street, Subiaco | T +61 8 9211111 | F +61 8 9211122 | www.rpsgroup.com.au

This Plan has been prepared for illustrative purposes only and represents an indicative land use concept of what may occur, once and if appropriate approvals are in place. The proposals depicted on this Plan generally have no formal approval status and can be varied by CLE or the landowner without notice. This Plan remains the property of CLE.

(Development by others)

POS

Lot 545 subject to acquisition by Mirvac

545

746

747

748

749

750

Public Open Space

Public Open Space

Public Open Space

Public Open Space

Public Open Space

Portion of Primary School

Portion of Primary School

Pump Station

TRAMWAY

ROAD

PEMBERTON BOULEVARD

BALDIVIS

BALDIVIS

FREEWAY

KWINANA

(Development by others)

Site Area - 36.98ha

POS - 4.04ha (11%)

POS required after deductions 2.90ha

20m BPZ from Baldivis Tramway

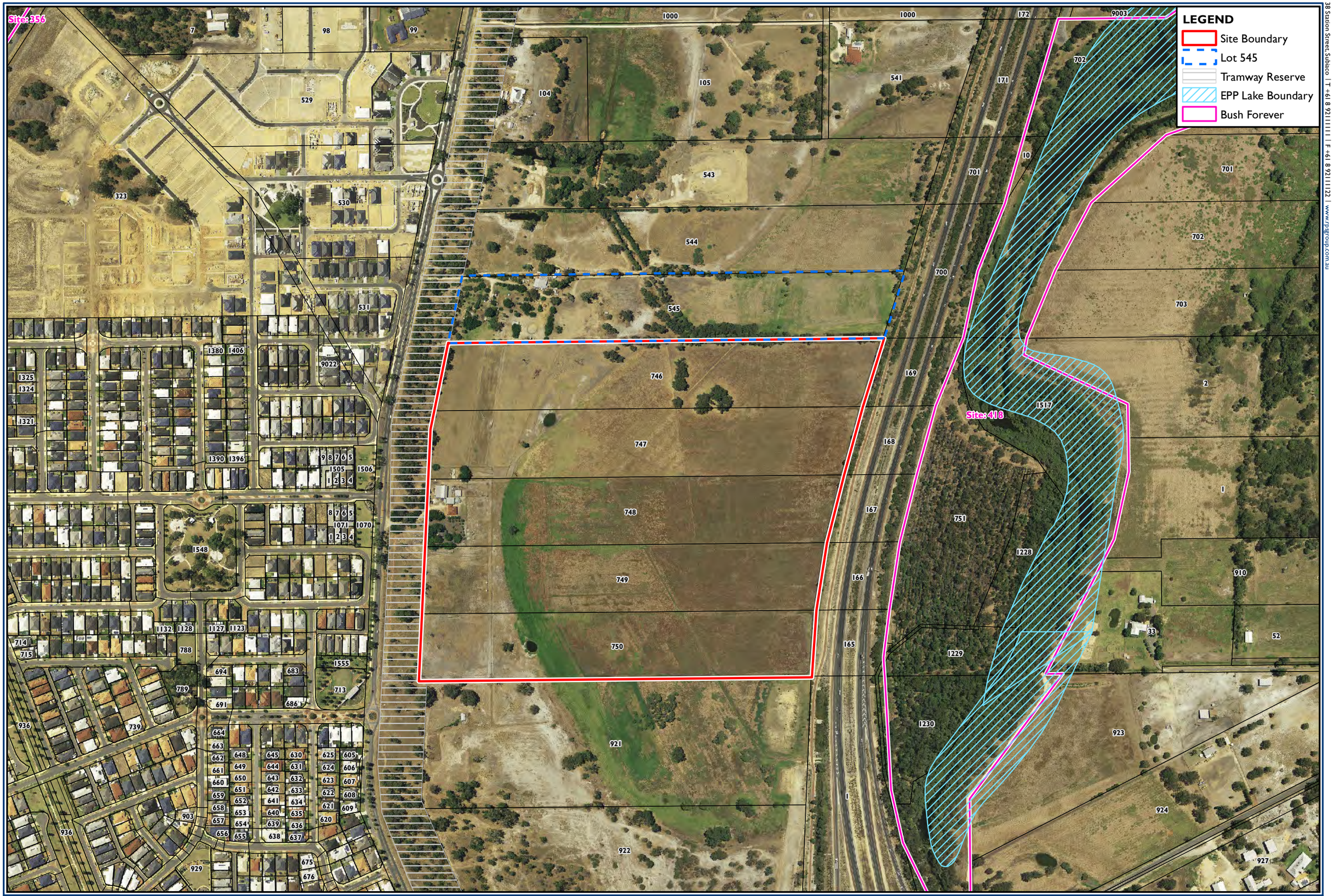
NOTE: Public Open Space areas are indicative only and subject to confirmation of drainage requirements.

RPS

Job Number: L1404002
Doc Number: 003
Date: 17.07.14
Scale: 1:3,000 @ A3
Created by: MA
Source: CLE - Proposed Subdivision, 2353-07i-01 15.07.14

Figure 3

Proposed Local Structure Plan



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RPS

Job Number: L1404001
Doc Number: 004
Date: 17.07.14
Scale: 1:5,000 @ A3
Created by: MA
Source: Orthophoto and Cadastre - Landgate, 2013 EPP Lakes - EPA, 1992 Bush Forever - DPS, 2009

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 4

Surrounding Land Uses

LEGEND

- Contours (mAHD)
- Site Boundary
- Lot 545

Environmental Geology

- C2 - CLAY - strong brown and dark grey clay, plastic in places, soft when wet, variable silt content in matrix, of alluvial origin
- Mc2 - CLAYEY SILT - dark greyish brown, mottled in part, soft when wet, plastic in part, blocky, variable clay content, of alluvial origin
- S8 - SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin as relatively thin veneer over C2, M4 and Mc2
- Water

S8

C2

Water

Mc2

RPS

Job Number: L1404001
Doc Number: 005
Date: 17.07.14
Scale: 1:3,500 @ A3
Created by: MA
Source: Orthophoto, Cadastre, Contours - Landgate, 2013 Geology - DoIR, 1999

GDA 1994 MGA Zone 50

0 15 30 60 90 120 m

Figure 5

Topography and Geology

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LEGEND

- Site Boundary
- Lot 545

Acid Sulfate Soil Risk Mapping

- High to Moderate Risk
- Moderate to Low Risk

RPS

Job Number: L1404001
Doc Number: 006
Date: 17.07.14
Scale: 1:5,000 @ A3
Created by: MA
Source: Orthophoto, Cadastre, Contours - Landgate, 2013 ASS Mapping - DEC, 2010

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 6

Acid Sulfate Soils

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LEGEND

- Culvert
- Open Channel Drain
- Peel Main Drain
- Site Boundary
- Lot 545
- 100 Yr ARI Floodplain
- Catchment Area 2
- Catchment Area 3
- Catchment Area 4

SUB H BRANCH DRAIN

SUB F BRANCH DRAIN

Forty Pool

Forty Pool

RPS

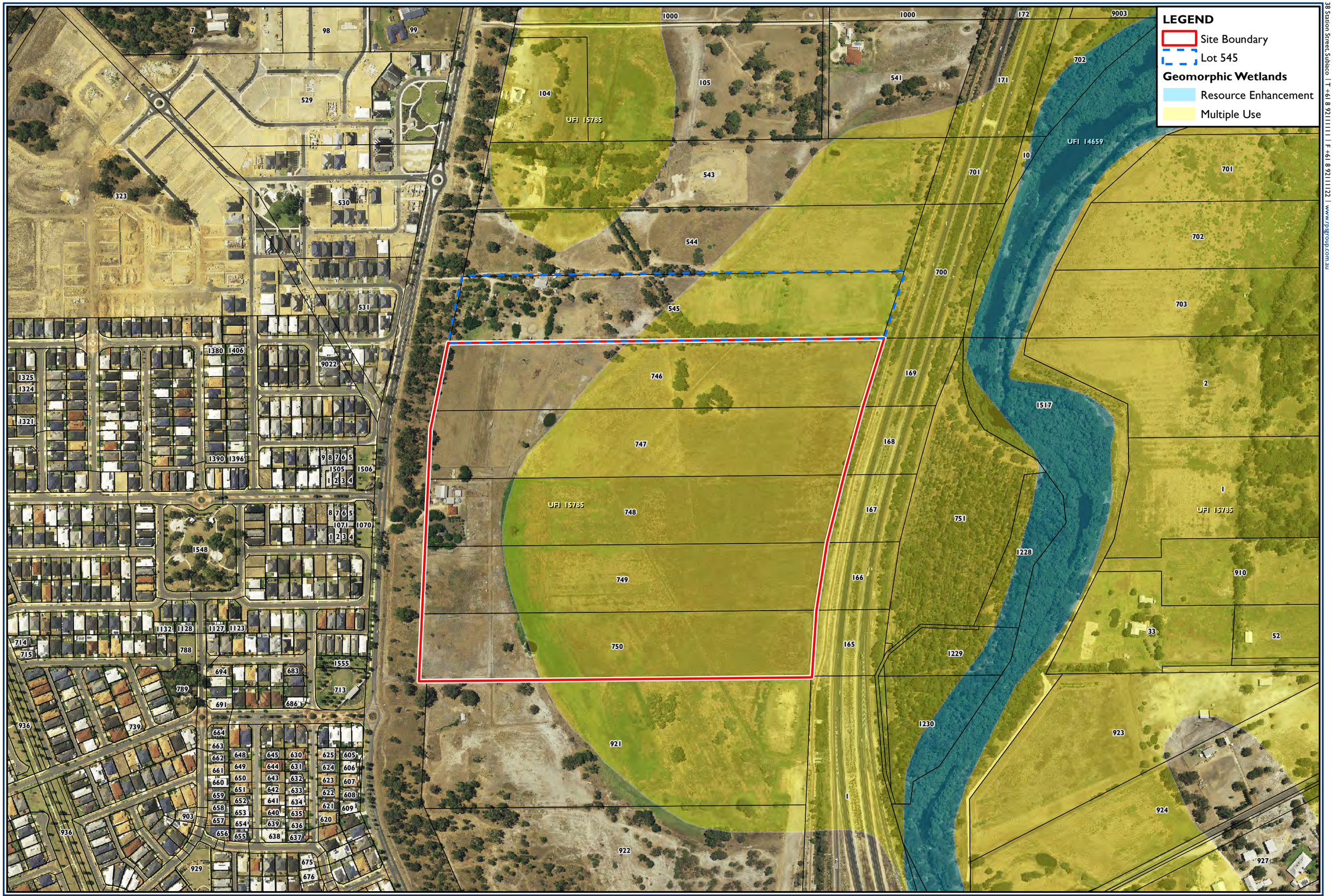
Job Number: L1404001
Doc Number: 007
Date: 17.07.14
Scale: 1:5,000 @ A3
Created by: MA
Source: Orthophoto, Cadastre, Contours - Landgate, 2013 SW Drainage - Parsons Brinckerhoff, Dwg: 2140259A-CIV-F109 05.07.07

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 7

Surface Drainage and Flood Mapping



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RPS

Job Number: L1404001
Doc Number: 008
Date: 17.07.14
Scale: 1:5,000 @ A3
Created by: MA
Source: Orthophoto, Cadastre, Contours - Landgate, 2013 Wetlands - DEC, 2013

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 8

Wetlands

APPENDIX I

EPA Assessment and Advice

Environmental Protection Authority

The Atrium,
Level 8, 168 St Georges Terrace,
Perth, Western Australia 6000.
Telephone: (08) 6364 6500. Facsimile: (08) 6364 6522.

Postal Address: PO Box K822,
Perth, Western Australia 6842.
Website: www.epa.wa.gov.au

Secretary
Western Australian Planning Commission
469 Wellington Street
PERTH WA 6000

Our Ref CRN220603
Enquiries Glen McLeod-Thorpe

SCHEME AMENDMENT TITLE:	**MRS Amendment 1128/41 Baldivis Urban Area Expansion - Area 2**
SCHEME AMENDMENT LOCATION:	**Lots 104 & 105, 532-538, 540 & 541, 543-545, 746-750, 921 & 922 Baldivis Road**
LOCALITY:	**Baldivis**
RESPONSIBLE AUTHORITY:	**Western Australian Planning Commission**
LEVEL OF ASSESSMENT:	**Scheme Amendment Not Assessed - Advice Given Under Section 48a(1)(A) (no appeals)**

Thank you for your letter of 26 September 2006 referring the above proposed scheme amendment.

After consideration of the information provided by you, the Environmental Protection Authority (EPA) considers that the proposed scheme amendment should not be assessed under Part IV Division 3 of the *Environmental Protection Act 1986* (EP Act) but nevertheless provides the following advice and recommendations.

ADVICE AND RECOMMENDATIONS

1. Environmental Issues

- Noise
- Acid Sulfate Soils
- Water Management
- Vegetation and Flora
- Potential Land Use Conflict
- Site Contamination
- High Pressure Natural Gas Pipeline

2. Advice and recommendations regarding Environmental Issues

Noise
The subject site abuts the Kwinana Freeway and future noise-sensitive land uses may be subject to excessive noise levels. Noise issues should be addressed at the subsequent stages of planning through compliance with the WAPC's *Draft Statement of Planning Policy Road and Rail Transport Noise* and *Draft Statement of Planning Policy Metropolitan Freight Network.*

It is also expected that appropriate studies be carried out to determine noise insulation requirement within future mixed use zones or residential zones adjacent to commercial and/or transport nodes. It should be noted that the accepted methodology for prediction of noise impacts and attenuation due to noise barriers is currently under review by Main Roads WA, and studies should be carried out in accordance with their new guidelines expected to be issued in 2006.

Acid Sulfate Soils
According to the Western Australian Planning Commission's (WAPC) *Planning Bulletin No. 64 – Acid Sulfate Soils* the subject land is mapped as having a moderate to low risk of Actual Acid Sulfate Soils and Potential Acid Sulfate Soils at depths greater than 3 metres. Regardless of the generic mapping provided, please note that investigation of local site characteristics is needed, and if these lead to the view that there is a risk of disturbing acid sulfate soils, then more detailed site investigations and management in accordance with *Planning Bulletin No. 64* and the DEC's *Acid Sulfate Soils Management Series* are appropriate.

Water Management
A large portion of the subject site is identified as a Multiple Use wetland on the DEC's Geomorphic Wetlands Swan Coastal Plain dataset and is relatively low-lying and subject to seasonal inundation.

The subject land is within the Peel-Harvey catchment and the provisions of the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* and the *Statement of Planning Policy No 2.1 - The Peel-Harvey Coastal Plain Catchment* shall apply. Careful management of stormwater, nutrients, other contaminants and retention of native vegetation is expected consistent with these policies. There shall not be any direct stormwater discharge into any rural drains or wetlands. Stormwater management should be consistent with the DEC's *Stormwater Management Manual for Western Australia*.

Water management is an important issue for the locality, and the broader Peel-Harvey catchment, and the subject site contains areas of low lying land. It is recommended that site planners keep abreast of the initiatives to protect water quality in the Peel-Harvey catchment and the urban water management framework being developed for the Perth metropolitan area. The next stages of planning should be accompanied by water management plans/strategies based on adequate site monitoring and modelling consistent with the urban water management framework and advice of the DEC. In particular, it is expected that there will be negligible nutrient export. There is also an expectation that the site can be serviced by reticulated sewer.

Vegetation and Flora
Aerial photography of the site indicates the subject land is sparsely vegetated. Existing vegetation, including mature trees, of good condition should be retained within the proposed development where possible. As discussed, the subject land is located within the Peel Harvey Catchment where remaining areas of native vegetation are very important for protecting water quality and biodiversity. Under the provisions of the *Statement of Planning Policy No 2.1 - The Peel-Harvey Coastal Plain Catchment*, the proponent is encouraged to retain all areas of native vegetation and to protect them from further degradation.

All native vegetation should be preserved so far as practicable during and after clearing for site works and services to accommodate the proposed subsequent urban development. Measures should be taken to ensure the identification, protection and management of any significant vegetation on site worthy of retention prior to the commencement of site works. It is noted that the proponent proposes to maintain existing hollow-bearing trees as potential habitat for the Carnaby's Black Cockatoo.

Potential Land Use Conflict
It is noted that the site is located in close proximity to several potentially conflicting land uses including a poultry farm and nursery. It is considered that the resolution of potential land use conflicts is a key planning issue that planning authorities are best positioned to resolve, having regard for local planning directions and knowledge and the results of accredited technical studies, on advice from appropriate government agencies. In the absence of site specific technical studies, the EPA's *Guidance Statement No. 3 Separation Distances Between Industrial and Sensitive Land Uses* should be utilised as a guide for generic separation distances.

It is noted that the subject site is located within the generic separation distances for both the poultry farm and the nursery. With regard to managing potential adverse impacts from the poultry farm, the WAPC's *Statement of Planning Policy No 4.3 – Poultry Farms Policy* should be utilised. Assumptions regarding the size and intended operations of the poultry farm should not be relied upon however, and an assessment should be carried out to demonstrate that any potential impacts can be managed. It is considered that any potential impacts from the nursery can be adequately managed and addressed at the next stages of planning.

Site Contamination
A previously submitted report regarding the subject land indicates that there may be a possibility of soil and/or groundwater contamination as a result of historical land use. It is noted that

a Preliminary Site Investigation (PSI) has been carried out which indicates that samples from the site contain zinc at concentrations greater than the environmental investigation levels and petroleum hydrocarbons at a concentration greater than the human health investigation levels. Accordingly, the proponent should be advised to liaise with the DEC's Land and Water Quality Branch and a Site Remediation and Validation Report should be produced in consultation with the DEC's Land and Water Quality Branch.

Preliminary and detailed site investigation and subsequent management plans should be prepared and implemented in accordance with the DEC's *Contaminated Sites Management Series* and to the satisfaction of the DEC's Land and Water Quality Branch.

High Pressure Natural Gas Pipeline

It is noted that the Dampier to Bunbury high pressure natural gas pipeline is located in close proximity to the subject land. Further advice should be sought from the Department of Consumer and Employment Protection, who is the lead agency for the consideration of public risk.

3. General Advice

- For the purposes of Part IV of the EP Act, the scheme amendment is defined as an assessed scheme amendment. In relation to the implementation of the scheme amendment, please note the requirements of Part IV Division 4 of the EP Act.
- There is no appeal right in respect of the EPA's decision on the level of assessment of scheme amendments.
- A copy of this advice will be sent to the relevant authorities and will be available to the public on request.

Yours faithfully

W H Tacey
A/Director
Environmental Impact Assessment

23 October 2006

cc: Department for Planning & Infrastructure

RPS

APPENDIX 2

Database Searches

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report (5km)

Created By Guest user on 12/06/2014

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115°49' 22" E,32°19' 18" S
Buffer 5km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	30032	*Acacia saligna subsp. saligna*			
2.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
3.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
4.	24262	*Acanthiza inornata (Western Thornbill)*			
5.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
6.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
7.	25536	*Accipiter fasciatus (Brown Goshawk)*			
8.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
9.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
10.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
11.	4582	*Adriana quadripartita (Bitter Bush)*			
12.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
13.	1728	*Allocasuarina fraseriana (Sheoak, Kondil)*			
14.	-12228	*Aname mainae*			
15.	-13162	*Aname tepperi*			
16.	24312	*Anas gracilis (Grey Teal)*			
17.	24315	*Anas rhynchotis (Australasian Shoveler)*			
18.	24316	*Anas superciliosa (Pacific Black Duck)*			
19.	24561	*Anthochaera carunculata (Red Wattlebird)*			
20.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
21.	202	*Anthoxanthum odoratum (Sweet Vernal Grass)*	Y		
22.	1117	*Aphelia cyperoides*			
23.	25554	*Apus pacificus (Fork-tailed Swift)*		IA	
24.	24285	*Aquila audax (Wedge-tailed Eagle)*			
25.	25558	*Ardea ibis (Cattle Egret)*		IA	
26.	41324	*Ardea modesta (Eastern Great Egret)*		IA	
27.	24341	*Ardea pacifica (White-necked Heron)*			
28.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
29.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
30.	7851	*Asteridea pulverulenta (Common Bristle Daisy)*			
31.	17240	*Austrostipa flavescens*			
32.	234	*Avena fatua (Wild Oat)*	Y		
33.	24318	*Aythya australis (Hardhead)*			
34.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
35.	1819	*Banksia grandis (Bull Banksia, Pulgarla)*			
36.	1830	*Banksia littoralis (Swamp Banksia, Pungura)*			
37.	1834	*Banksia menziesii (Firewood Banksia)*			
38.	32077	*Banksia sessilis var. cygnorum*			
39.	32080	*Banksia sessilis var. sessilis*			
40.	740	*Baumea arthrophylla*			
41.	743	*Baumea juncea (Bare Twigrush)*			
42.	24319	*Biziura lobata (Musk Duck)*			
43.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
44.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
45.	244	*Briza maxima (Blowfly Grass)*	Y		
46.	245	*Briza minor (Shivery Grass)*	Y		
47.	249	*Bromus diandrus (Great Brome)*	Y		
48.	24359	*Burhinus grallarius (Bush Stone-curlew)*		P4	
49.	25715	*Cacatua roseicapilla (Galah)*			
50.	25716	*Cacatua sanguinea (Little Corella)*			
51.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
52.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
53.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
54.	1276	*Caesia micrantha (Pale Grass Lily)*			
55.	2854	*Calandrinia granulifera (Pygmy Purslane)*			
56.	2856	*Calandrinia liniflora (Parakeelya)*			
57.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
58.	24784	*Calidris ferruginea (Curlew Sandpiper)*		T	
59.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
60.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
61.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
62.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
63.	2957	*Cassytha racemosa (Dodder Laurel)*			
64.	6542	*Centaurium tenuiflorum*	Y		
65.	1125	*Centrolepis drummondiana*			
66.	1129	*Centrolepis glabra (Smooth Centrolepis)*			
67.	2889	*Cerastium glomeratum (Mouse Ear Chickweed)*	Y		
68.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
69.	1280	*Chamaescilla corymbosa (Blue Squill)*			
70.	24376	*Charadrius rubricollis (Hooded Plover)*		P4	
71.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
72.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
73.	24833	*Cincloramphus cruralis (Brown Songlark)*			
74.	24288	*Circus approximans (Swamp Harrier)*			
75.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
76.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
77.	24399	*Columba livia (Domestic Pigeon)*	Y		
78.	4555	*Comesperma integerrimum*			
79.	4564	*Comesperma virgatum (Milkwort)*			
80.	1418	*Conostylis aculeata (Prickly Conostylis)*			
81.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
82.	25592	*Corvus coronoides (Australian Raven)*			
83.	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
84.	24671	*Coturnix pectoralis (Stubble Quail)*			
85.	25595	*Cracticus tibicen (Australian Magpie)*			
86.	25596	*Cracticus torquatus (Grey Butcherbird)*			
87.	3137	*Crassula colorata (Dense Stonecrop)*			
88.	3140	*Crassula glomerata*	Y		
89.	30893	*Cryptoblepharus buchananii*			
90.	25020	*Cryptoblepharus plagiocephalus*			
91.	25027	*Ctenotus australis*			
92.	25039	*Ctenotus fallens*			
93.	6663	*Cuscuta epithymum (Lesser Dodder, Greater Dodder)*	Y		
94.	24322	*Cygnus atratus (Black Swan)*			
95.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
96.	7454	*Dampiera linearis (Common Dampiera)*			
97.	3845	*Daviesia triflora*			
98.	1259	*Dianella revoluta (Blueberry Lily)*			
99.	1287	*Dichopogon capillipes*			
100.	-13407	*Dingosa serrata*			
101.	12939	*Diuris magnifica*			
102.	4763	*Dodonaea hackettiana (Hackett's Hopbush)*		P4	
103.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
104.	16244	*Drosera gigantea subsp. geniculata*			
105.	3106	*Drosera macrantha (Bridal Rainbow)*			
106.	13216	*Drosera menziesii subsp. penicillaris*			
107.	3131	*Drosera stolonifera (Leafy Sundew)*			
108.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		
109.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
110.	24567	*Epthianura albifrons (White-fronted Chat)*			
111.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
112.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
113.	5659	*Eucalyptus gomphocephala (Tuart, Duart)*			
114.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
115.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
116.	25622	*Falco cenchroides (Australian Kestrel)*			
117.	25623	*Falco longipennis (Australian Hobby)*			
118.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
119.	24041	*Felis catus (Cat)*	Y		
120.	25727	*Fulica atra (Eurasian Coot)*			
121.	907	*Gahnia trifida (Coast Saw-sedge)*			
122.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
123.	25530	*Gerygone fusca (Western Gerygone)*			
124.	1518	*Gladiolus angustus (Long Tubed Painted Lady)*	Y		
125.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
126.	6587	*Gomphocarpus fruticosus (Narrowleaf Cottonbush)*	Y		
127.	3957	*Gompholobium tomentosum (Hairy Yellow Pea)*			
128.	24443	*Grallina cyanoleuca (Magpie-lark)*			
129.	2119	*Grevillea vestita*			
130.	12824	*Grevillea vestita subsp. vestita*			
131.	2175	*Hakea lissocarpha (Honey Bush)*			
132.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*		IA	
133.	24295	*Haliastur sphenurus (Whistling Kite)*			
134.	3961	*Hardenbergia comptoniana (Native Wisteria)*			
135.	25410	*Heleioporus eyrei (Moaning Frog)*			
136.	3016	*Heliophila pusilla*	Y		
137.	25119	*Hemiergis quadrilineata*			
138.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
139.	5162	*Hibbertia racemosa (Stalked Guinea Flower)*			
140.	25734	*Himantopus himantopus (Black-winged Stilt)*			
141.	24491	*Hirundo neoxena (Welcome Swallow)*			
142.	6222	*Homalosciadium homalocarpum*			
143.	12859	*Hovea trisperma var. trisperma*			
144.	5216	*Hybanthus calycinus (Wild Violet)*			
145.	43384	*Hydrophis platurus (Yellow-bellied Seasnake)*			
146.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
147.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
148.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
149.	910	*Isolepis cernua (Nodding Club-rush)*			
150.	917	*Isolepis marginata (Coarse Club-rush)*	Y		
151.	919	*Isolepis oldfieldiana*			
152.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
153.	25563	*Ixobrychus minutus (Little Bittern)*		P4	
154.	20454	*Juncus acutus subsp. acutus*	Y		
155.	1189	*Juncus pauciflorus (Loose Flower Rush)*			
156.	4044	*Kennedia prostrata (Scarlet Runner)*			
157.	5832	*Kunzea ericifolia (Spearwood, Pondil)*			
158.	28342	*Landoltia punctata (Thin Duckweed)*			
159.	1309	*Laxmannia squarrosa*			
160.	925	*Lepidosperma angustatum*			
161.	937	*Lepidosperma longitudinale (Pithy Sword-sedge)*			
162.	944	*Lepidosperma scabrum*			
163.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
164.	6436	*Leucopogon propinquus*			
165.	25005	*Lialis burtonis*			
166.	25661	*Lichmera indistincta (Brown Honeyeater)*			
167.	4362	*Linum marginale (Wild Flax)*			
168.	7408	*Lobelia tenuior (Slender Lobelia)*			
169.	6515	*Logania vaginalis (White Spray)*			
170.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
171.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
172.	1246	*Lomandra suaveolens*			
173.	1198	*Luzula meridionalis (Field Woodrush)*			
174.	1097	*Lyginia barbata*			
175.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
176.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
177.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
178.	25654	*Malurus splendens (Splendid Fairy-wren)*			
179.	24583	*Manorina flavigula (Yellow-throated Miner)*			
180.	17747	*Meeboldina decipiens*			
181.	25758	*Megalurus gramineus (Little Grassbird)*			
182.	5952	*Melaleuca preissiana (Moonah)*			
183.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
184.	5978	*Melaleuca teretifolia (Banbar)*			
185.	4084	*Melilotus albus*	Y		
186.	25184	*Menetia greyii*			
187.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
188.	955	*Mesomelaena pseudostygia*			
189.	485	*Microlaena stipoides (Weeping Grass)*			
190.	15419	*Microtis media subsp. media*			
191.	7085	*Misopates orontium (Lesser Snapdragon)*	Y		
192.	7410	*Monopsis debilis*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
193.	24184	*Mormopterus planiceps (Southern Freetail-bat)*			
194.	24223	*Mus musculus (House Mouse)*	Y		
195.	24738	*Neophema elegans (Elegant Parrot)*			
196.	25748	*Ninox novaeseelandiae (Boobook Owl)*			
197.	25252	*Notechis scutatus (Tiger Snake)*			
198.	24798	*Numenius madagascariensis (Eastern Curlew)*		T	
199.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
200.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
201.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
202.	14292	*Oenothera stricta subsp. stricta*	Y		
203.	7348	*Opercularia hispidula (Hispid Stinkweed)*			
204.	18255	*Opercularia vaginata (Dog Weed)*			
205.	1372	*Ornithogalum arabicum (Lesser Cape Lily)*	Y		
206.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
207.	24328	*Oxyura australis (Blue-billed Duck)*			
208.	25679	*Pachycephala pectoralis (Golden Whistler)*			
209.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
210.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
211.	25682	*Pardalotus striatus (Striated Pardalote)*			
212.	528	*Paspalum distichum (Water Couch)*	Y		
213.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
214.	30471	*Patersonia occidentalis var. angustifolia*			
215.	4346	*Pelargonium littorale*			
216.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
217.	2273	*Persoonia saccata (Snottygobble)*			
218.	24659	*Petroica goodenovii (Red-capped Robin)*			
219.	2299	*Petrophile linearis (Pixie Mops)*			
220.	25697	*Phalacrocorax carbo (Great Cormorant)*			
221.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
222.	25699	*Phalacrocorax varius (Pied Cormorant)*			
223.	551	*Phalaris minor (Lesser Canary Grass)*	Y		
224.	552	*Phalaris paradoxa (Paradoxa Grass)*	Y		
225.	24409	*Phaps chalcoptera (Common Bronzewing)*			
226.	1478	*Phlebocarya ciliata*			
227.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
228.	4675	*Phyllanthus calycinus (False Boronia)*			
229.		*Phytophthora cinnamomi*			
230.	5254	*Pimelea leucantha*			
231.	5261	*Pimelea rosea (Rose Banjine)*			
232.	7303	*Plantago lanceolata (Ribwort Plantain)*	Y		
233.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
234.	24842	*Platalea regia (Royal Spoonbill)*			
235.	25720	*Platycercus icterotis (Western Rosella)*			
236.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
237.	25704	*Podiceps cristatus (Great Crested Grebe)*			
238.	8175	*Podolepis gracilis (Slender Podolepis)*			
239.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
240.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
241.	25722	*Polytelis anthopeplus (Regent Parrot)*			
242.	4691	*Poranthera microphylla (Small Poranthera)*			
243.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
244.	25732	*Porzana pusilla (Baillon's Crake)*			
245.	24771	*Porzana tabuensis (Spotless Crake)*			
246.	25511	*Pseudonaja affinis (Dugite)*			
247.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
248.	25271	*Ramphotyphlops australis*			
249.	24245	*Rattus rattus (Black Rat)*	Y		
250.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
251.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
252.	1556	*Romulea rosea (Guildford Grass)*	Y		
253.	6483	*Samolus junceus*			
254.	13182	*Scaevola repens var. repens*			
255.	982	*Schoenus clandestinus*			
256.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
257.	8224	*Siloxerus filifolius*			
258.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
259.	30948	*Smicrornis brevirostris (Weebill)*			
260.	7022	*Solanum nigrum (Black Berry Nightshade)*	Y		
261.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
262.	1312	*Sowerbaea laxiflora (Purple Tassels)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
263.	4828	*Spyridium globulosum (Basket Bush)*			
264.	2918	*Stellaria media (Chickweed)*	Y		
265.	25597	*Strepera versicolor (Grey Currawong)*			
266.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
267.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
268.	7806	*Stylidium utricularioides (Pink Fan Triggerplant)*			
269.	2329	*Synaphea spinulosa*			
270.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
271.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
272.	24185	*Tadarida australis (White-striped Freetail-bat)*			
273.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
274.	15741	*Tamarix aphylla (Athel Tree)*	Y		
275.	24844	*Threskiornis molucca (Australian White Ibis)*			
276.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
277.	1319	*Thysanotus arenarius*			
278.	1338	*Thysanotus manglesianus (Fringed Lily)*			
279.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
280.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
281.	25207	*Tiliqua rugosa subsp. rugosa*			
282.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
283.	6266	*Trachymene coerulea (Blue Lace Flower)*			
284.	6280	*Trachymene pilosa (Native Parsnip)*			
285.	4383	*Tribulus terrestris (Caltrop)*	Y		
286.	39097	*Trichia decipiens*			
287.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
288.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
289.	4292	*Trifolium campestre (Hop Clover)*	Y		
290.	4295	*Trifolium dubium (Suckling Clover)*	Y		
291.	4313	*Trifolium subterraneum (Subterranean Clover)*	Y		
292.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
293.	24808	*Tringa nebularia (Common Greenshank)*		IA	
294.	8255	*Ursinia anthemoides (Ursinia)*	Y		
295.	38388	*Ursinia anthemoides subsp. anthemoides*	Y		
296.	24386	*Vanellus tricolor (Banded Lapwing)*			
297.	8257	*Vellereophyton dealbatum (White Cudweed)*	Y		
298.	24206	*Vespadelus regulus (Southern Forest Bat)*			
299.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
300.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
301.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		P4	
302.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
303.	1049	*Zantedeschia aethiopica (Arum Lily)*	Y		
304.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

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

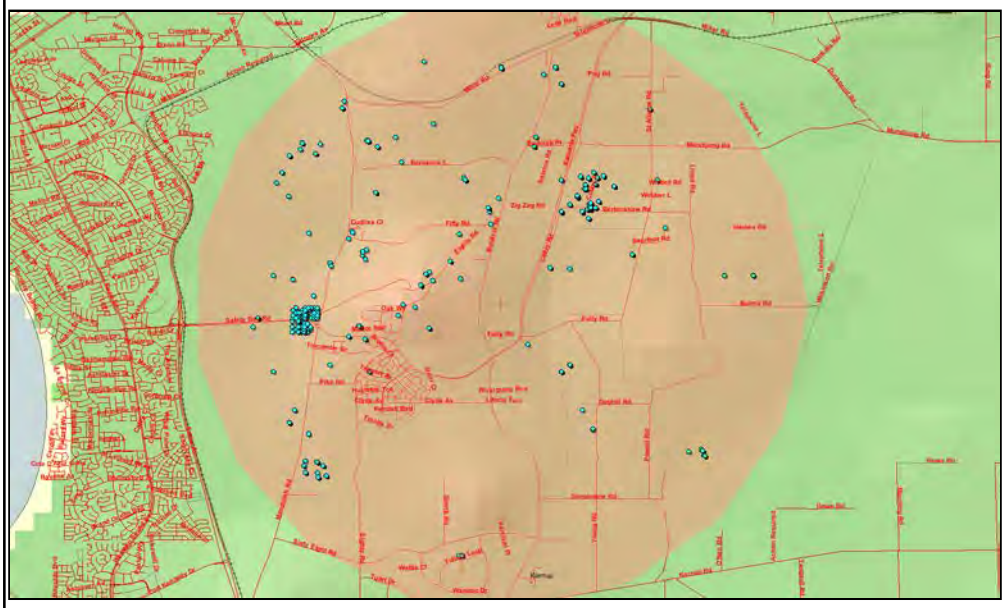
[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only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

NatureMap
Mapping Western Australia's biodiversity

NatureMap Search 5km

Printed by Guest user on 12/6/2014

Query details : Current Names Only=Yes; Core Datasets Only=Yes; Method='By Circle'; Centre=115°49' 22" E,32°19' 18" S; Buffer=5km;



NatureMap is a collaborative project of the Department of Environment and Conservation, Western Australia, and the Western Australian Museum.

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

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

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

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

Report created: 13/06/14 12:07:24

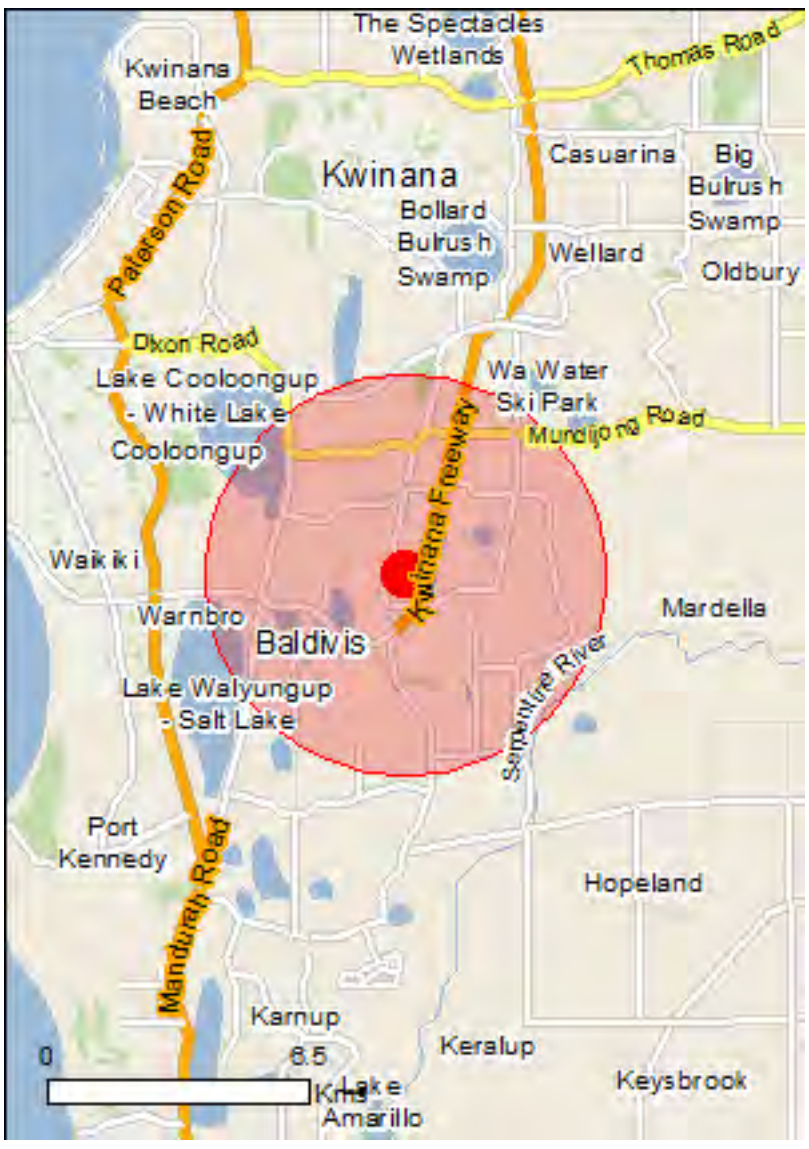
Summary

Details

- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat

Acknowledgements



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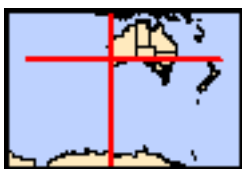
Coordinates

Buffer: 5.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	22
Listed Migratory Species:	15

Other Matters Protected by the EPBC Act

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

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

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

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

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	24
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

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

Place on the RNE:	8
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	36
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (RAMSAR) [Resource Information]

Name	Proximity
Becher point wetlands	Within 10km of Ramsar
Peel-yalgorup system	Upstream from Ramsar

Listed Threatened Ecological Communities [Resource Information]

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

Name	Status	Type of Presence
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community known to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir [25911]	Vulnerable	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Synaphea stenoloba Dwellingup Synaphea [66311]	Endangered	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat likely to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Species or species habitat known to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa		
Black-tailed Godwit [845]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa glareola		
Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

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

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Baldivis Swamp	WA	Indicative Place
Folly Pool	WA	Indicative Place
Leda Area	WA	Indicative Place
Maramanup Pool	WA	Indicative Place
Outridge Swamp	WA	Indicative Place
Tamworth Hill Swamp	WA	Indicative Place
Lakes Cooloongup and Walyungup and Surrounds	WA	Registered
Lowlands West Block	WA	Registered

State and Territory Reserves [Resource Information]

Name	State
Leda	WA

Invasive Species

[Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
[Tamarix aphylla](#) Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
[Hemidactylus frenatus](#) Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-32.32104 115.82326

Caveat

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

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

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

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

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

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

- migratory and
- marine

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

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

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

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

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

Acknowledgements

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

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

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

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

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APPENDIX 4:

Local Water Management Strategy - RPS

LOCAL WATER MANAGEMENT STRATEGY

Lots 746–750 and 545 Baldivis Road, Baldivis

LOCAL WATER MANAGEMENT STRATEGY

Lots 746–750 and 545 Baldivis Road, Baldivis

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Report No: D1401201
Version/Date: Rev 0, October 2014

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	Draft for Client Review	JenLon	CarDav/ShaMcS	03.10.14	SN 06.10.14		
Rev 0	Final for Issue	JenLon	CarDav/ShaMcS	06.10.14	SN 07.10.14	C. Davies	07.10.14

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SUMMARY

Mirvac proposes to progress the residential development of Lots 746–750 Baldivis Road, Baldivis. Lot 545 Baldivis Road will be developed by another party, but for drainage design purposes and consistency with the LSP design area has been included within this document.

The site is generally flat with pre-development observations indicating that large portions of the site become inundated in the winter months. The site has two distinctive predevelopment drainage features on site the Sub H and the Sub F drains, both of which direct water from the site to culverts under the Kwinana Freeway, and ultimately to the Peel Main Drain.

RPS has worked closely with project engineers, Development Engineering Consultants to manage both surface and groundwater through the implementation of water sensitive urban design (WSUD) principles and best management practices.

It is important to note that this LWMS should be read in conjunction with the Groundwater Modelling Report, Lots 746–750 Baldivis Road, Baldivis (RPS 2014) which has been produced for the site to detail the management of post-development groundwater. This document has been included as Appendix I and Table I below highlights the key elements of the LWMS.

Table I: Summary of Key Elements of LWMS

Key LWMS Elements	Design and Compliance to Objectives
Topography (Section 2.2)	▪ Elevations range from 9.5 m AHD in the eastern portion of the site to 3.5 m AHD in the low-lying areas along the alignment of the Sub F drain.
Geology and Soils (Section 2.3)	▪ Geology mapping indicates the eastern two-thirds of the site are underlain by brown clay of the Guildford Formation. The Bassendean Sand is exposed along a north–south ridge near the western edge of the site. It is a light grey, fine to medium-grained sand of eolian origin.
Acid Sulfate Soils (Section 2.4)	▪ DEC regional mapping identifies the site as having a “moderate to low” risk of encountering Acid Sulfate Soils (ASS) within 3 m of the natural soil surface. ▪ In 2014 RPS undertook a detailed Site Assessment for Acid Sulfate Soils
Surface Hydrology and Wetlands (Section 2.6)	▪ The Peel Main Drain (PMD) is situated east of the site and drains stormwater run-off from the catchment into the Serpentine River and ultimately the Peel-Harvey Inlet. ▪ The drainage on the site is managed through two open agricultural drains; the Sub H and the Sub F drain. ▪ The site contains a Multiple Use management category wetland that has been subject to various impacts associated with past and current land use.
Flood Plain Mapping (Section 2.6.2)	▪ A portion of the site is located within the flood fringe of the Peel Main Drain which is connected to the Serpentine River; the 100 year ARI flood level is estimated to be 2.5-4.20 m AHD at the site.
Groundwater Elevation and Flow Direction (Section 2.7.2)	▪ The AAMGL is calculated to range from approximately 4.5 m AHD at the south west corner of the site to 3.8 m AHD along the eastern boundary, with groundwater migrating to the east-north-east towards the Peel Main Drain.

Key LWMS Elements	Design and Compliance to Objectives
Water Conservation Strategy (Section 3.0)	▪ Waterwise front yard landscaping package will be promoted and all new homeowners will be provided with the opportunity to purchase a package. ▪ Education and information will be provided to all new homeowners to encourage Waterwise practices within the home and garden. ▪ Native gardens and Waterwise plants will be used within POS, with gravel mulching and intermittent tree planting being implemented to reduce the site's irrigation water needs.
Stormwater Management (Section 4.0)	▪ A conceptual drainage strategy demonstrates that the land is capable of detaining up to and including the 100 year ARI event distributed on site within four POS areas. ▪ Rainfall from 1 year ARI (Annual Recurrence Interval) events will be detained and treated using biological treatment as close to the source as possible. Some infiltration will occur during lower groundwater level periods. ▪ Large rainfall events (5 ARI to 100 ARI) will be conveyed and detained through a network of roads and drainage basins or swales within Public Open Space (POS) areas located in each catchment. ▪ Outflow from the site will occur via one of two existing culverts, beneath the Kwinana Freeway to the east of the site, which ultimately deliver water to the Peel Main Drain ▪ Structural and non-structural controls will be used to improve stormwater quality.
Groundwater Management (Section 5.0)	▪ Subsoil drainage will be used to control groundwater levels to pre-development levels. ▪ A groundwater model has been undertaken by RPS (2014) to demonstrate the functionality of the proposed subsoil system. ▪ Soil amendment of the base of the infiltration/detention areas will assist in the treatment of stormwater prior to infiltration into the groundwater. ▪ Vegetated swales and basins will assist in the uptake of pollutants and nutrients within the water prior to infiltration through the soil profile.
Monitoring (Section 6.0)	▪ Post-development groundwater monitoring will be undertaken monthly for levels and quarterly for quality for a period of three years after development. ▪ Contingency measures will be implemented in the event of trigger values being exceeded in two consecutive monitoring events.

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1.0 INTRODUCTION

1.1 Background

Mirvac proposes to progress the residential development of Lots 746–750 Baldivis Road, Baldivis. Lot 545 Baldivis Road will be developed by another party, but for drainage design purposes and consistency with the LSP design area, has been included within this document. Therefore, for the purposes of this LWMS "the site" includes Lots 746–750 and 545 Baldivis Road, Baldivis (the site).

It is important to note that this LWMS should be read in conjunction with the Groundwater Modelling Report, Lots 746–750 Baldivis Road, Baldivis (RPS 2014), details the management of post-development groundwater at the site. This document has been included as Appendix 1.

The area proposed for development covers approximately 37 hectares (ha) of land and is located within the municipality of the City of Rockingham, approximately 40 kilometres (km) south of the Perth Central Business District. Figure 1 highlights the site area.

1.2 Planning Background

1.2.1 State Approval Background

In 2009, a Metropolitan Region Scheme (MRS) Amendment rezoned approximately 383 hectares (ha) in Baldivis (including the site) from "Rural" to "Urban Deferred". This rezoning was endorsed by the Western Australian Planning Commission (WAPC) and subsequently promulgated by parliament.

The Environmental Protection Authority (EPA) assessed the MRS Amendment in 2006. The EPA advised that the appropriate level of assessment was "Scheme Not Assessed – Advice Given".

1.2.2 East Baldivis District Structure Plan

A District Structure Plan (DSP) for the 383 ha area was prepared to provide further definition of the intended land uses, urban design and environmental management against the zonings set out in the MRS.

A District Water Management Strategy (DWMS) (Parsons Brinckerhoff 2007) was prepared in October 2007 in support of the DSP. The DWMS defined the water management objectives at the district level for the East Baldivis DSP. The DWMS was approved by the Department of Water (DoW) in November 2007. The management objectives from the DWMS have been incorporated into this site specific Local Water Management Strategy (LWMS) to support the Local Structure Plan (LSP).

1.2.3 Local Structure Plan

The LSP design is shown in Figure 2 and the proposed design promotes the following land uses:

- residential
- movement network
- Public Open Space (POS)
- primary school site.

The City of Rockingham Town Planning Scheme (TPS) No. 2 requires a LSP to be prepared and submitted for "Residential Development Zones" prior to granting and/or recommending approval of any development within this zone.

The purpose of this LWMS is to support and facilitate approval of the LSP with the City of Rockingham and details the integrated water management strategies that will be implemented at the site, and demonstrates that the land is capable of facilitating urban development whilst achieving sustainable, water and environmental outcomes.

1.3 Design Objectives

This document has been prepared in accordance with State Planning Policy No. 2.1: Peel Harvey Coastal Plain Catchment (February 1992) and has been developed with reference to the following guidance documents:

- Water Resource Considerations When Controlling Groundwater Levels in Urban Development (DoW 2013)
- Murray Drainage and Water Management Plan (DoW 2011)
- District Water Management Strategy East Baldivis (Parsons Brinkerhoff 2007)
- Serpentine River Floodplain Management Study and Modelling Report (SKM 2010)
- Interim: Developing a Local Water Management Strategy (Department of Water 2008a)
- Better Urban Water Management (WAPC 2008)
- Western Australian State Water Plan (Government of Western Australia 2007)
- Stormwater Management Manual for Western Australia (Department of Water 2004–2007)

- Liveable neighbourhoods (2nd Edition) (WAPC 2000)

- Water Quality Improvement Plan for the Rivers and Estuary of the Peel – Harvey system – Phosphorus Management. (EPA 2008).

The LWMS will detail the integrated water management strategies to facilitate future urban water management planning and will achieve integrated water management through the following design objectives:

- Effectively manage the risk to human life, property damage and environmental degradation from water contamination, flooding and waterlogging.

- Maintain quality (surface and groundwater) within the development in relation to pre-development water quality.

- Reduce potable water consumption within both public and private spaces using practical and cost-effective measures.

- Promote infiltration of surface water to minimise the risk of further water quality degradation in the Peel Harvey Catchment.

- Implement best management practices in regards to stormwater management.

- Incorporate where possible, low maintenance, cost-effective landscaping and stormwater treatment systems.

1.4 Other Studies

Technical documents relating to the environmental conditions at the site include:

- Environmental Assessment Report, Lots 746–750 Baldivis Road (RPS 2014)

- Geotechnical Investigation Lot 746–750 Baldivis Road (Structerre Consulting Engineers, May 2014)

- East Baldivis District Water Management Strategy (DWMS) by Parsons Brinckerhoff (October 2007)

- Environmental Assessment Report, Baldivis East District Structure Plan (RPS 2010 draft)

- Detailed Acid Sulfate Soil Investigation (RPS 2014)

- Bushfire Management Strategy (Emerge 2014)
- Noise Assessment (Herring Storer 2014).

2.0 EXISTING ENVIRONMENT

2.1 Site Location and Existing Land Use

The site is presented in Figure 1 and it encompasses approximately 37 ha of land that is bound by Baldivis Road to the west, Lot 921 Baldivis Road to the south, Lot 544 Baldivis Road to the north and the Kwinana Freeway to the east. The site is located within the City of Rockingham, approximately 40 km south of the Perth Central Business District.

Historically the land has been used for agriculture/broad-scale farming purposes and consequently the majority of the land has been cleared. The land is primarily pasture with a small number of remnant trees. The subject land has been impacted by disturbance, historical vegetation clearing and agricultural land uses.

2.2 Topography

The site is relatively low-lying and thus susceptible to seasonal inundation in some areas. The western boundary of the subject land is approximately 9.5 metres Australian Height Datum (m AHD) and gradually declines to approximately 3.5 m AHD across the central low-lying areas before very slightly increasing in elevation to an approximate maximum elevation of 4.5 m AHD on the site's eastern boundary. The topography of the site is illustrated in Figure 3.

Site topography has been previously modified by constructing open drains across the site to manage drainage. The Sub F drain runs generally north–south through the low-lying centre of Lots 748, 749 and 750, with a base elevation (interpreted from LiDAR) of between approximately 3 and 3.7 m AHD. The Sub H drain traverses the northern Lot 545 in a west–east direction with an elevation ranging from approximately 2.8 m AHD (west) to 2.4 m AHD (east). Water from this drain discharges to the Peel Main Drain via a culvert with an invert of 2.37 m AHD. Plate 1 (below) provides a view of the on-site paddocks and Figure 4 illustrates the site's pre-development drainage features.

Plate 1: Paddocks and Fencing

2.3 Geology and Soils

Department of Industry and Resources (DoIR) geology mapping (DoIR 1999) indicates the eastern two-thirds of the site is underlain by brown clay of the Guildford Formation. The Bassendean Sand is exposed along a north–south ridge near the western edge of the site. It is a light grey, fine to medium-grained sand of eolian origin.

Regionally, the Tamala Limestone is exposed at the western part of the model domain (shown in Appendix 1) and is a hard crème limestone of eolian origin. The Spearwood Sand, which is derived from the Tamala Limestone, is exposed along the centre and southern areas of the model domain and it typically overlies the Tamala Limestone at depth. It is a pale yellowish brown, medium to coarse-grained sand. The Bassendean Sand is exposed along a thin band through the eastern part of the model domain. Brown clays and silts of the Guildford Formation occupy a north–south band adjacent to the Peel Main Drain. Regional surficial geology mapping is shown on Figure 5.

2.3.1 Geotechnical Investigation

A detailed geotechnical investigation was undertaken by Structerre Consulting Engineers in April 2014 and is contained in Appendix 2. Further information regarding the site's geotechnical characteristics and the influence on water management has also been included in the Groundwater Modelling Report (RPS 2014) provided in Appendix 1.

2.4 Acid Sulfate Soils

The WAPC, in consultation with the Department of Environment Regulation (DER), has compiled Acid Sulfate Soil (ASS) risk maps that are based on surface geology mapping and they provide a broad scale indication of the risk of occurrence of ASS. The ASS risk mapping indicates that the entire extent of the subject land is mapped as "Moderate to Low" risk of ASS occurring within 3 metres of the natural soil surface (Figure 6).

In 2014, RPS undertook a Detailed Site Assessment (DSA) for acid sulfate soils across the site. The principal objective of the DSA was to present relevant soils, groundwater and surface water quality baseline data for the site. Actual ASS and Potential ASS are prominent across the majority of the site, and therefore they will require management during construction, along with any dewatering required. An Acid Sulfate Soils and Dewatering Management Plan (ASSDMP) will be required to be prepared to outline the soil management measures; the groundwater and dewatering effluent monitoring measures; and the contingency management measures required to minimise any environmental impacts. The ASSDMP will be forwarded to the Department of Environment Regulation (DER) for approval prior to the commencement of works.

2.5 Contaminated Land

A review of the DER's Contaminated Sites Database on 20 March 2014 has determined that there are no registered contaminated sites within the project area.

2.6 Surface Hydrology and Wetlands

2.6.1 Predevelopment Drainage

The site is located within the Peel Estuary–Serpentine River Catchment and Peel Main Drain Sub-Catchment. The Peel Main Drain (PMD) is situated east of the site and drains stormwater run-off from the catchment into the Serpentine River and ultimately the Peel–Harvey Inlet.

The PMD is a major drainage system that is owned and managed by the Water Corporation and was constructed in the 1930s to facilitate agricultural development within the surrounding waterlogged land. The PMD currently flows alongside the Kwinana Freeway, into Folly Pool and then reforms into the PMD after Folly Road.

The site is within the mapped area of the Mundijong Surface Water Catchment, which is one of the six Rural Drainage Districts owned and operated by the Water Corporation. However, on the progression of urban zoning of the land, drainage within this area becomes a management function of the City of Rockingham.

The existing topography of the site is generally flat, with elevations between approximately 9.5 and 3.5 m AHD. The Sub F branch drain traverses the lower lying central and south-eastern sections of the site. Rainfall run-off from the majority of the site is captured by this branch drain, a portion of which is directed through a 450 mm diameter culvert under the Kwinana Freeway, before discharging into the PMD. The northern portion of the site's surface water is also directed into the Sub F drain before discharging into the Sub H drain, which is located within Lot 545.

The Sub H drain conveys drainage from all lots north of the site to Zig Zag Road and flows east through Lot 545 towards a 1070 mm diameter culvert under the Kwinana Freeway. Surface water not conveyed via the open drains would otherwise sheet flow off the site until it reaches these culverts. Figure 4 highlights the site's pre-development drainage features, including the location of the sub-drains.

2.6.2 Flood Plain Mapping

SKM was commissioned by the DoW to develop the Serpentine River Floodplain Management Study (2010) for the Serpentine, Baldivis, Karnup and Keralup area. This mapping has since been revised by the DoW in early 2014; however the previous management strategies for the Serpentine River flood plain, listed below, remain the same:

- Proposed development located outside the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.50 m above the adjacent 1 in 100 year ARI flood level is recommended to provide adequate flood protection.

- Proposed development located within the floodway, and is considered obstructive to major flows, is not acceptable as it would increase flood levels upstream. No new buildings are acceptable in the floodway.

Results of the DoW's 2014 study have not been formally published, however a recent enquiry to the DoW's Flood Protection Branch highlighted that the flood levels within this area had been revised. The revised flood mapping relevant to the site was provided and is included as Figure 7. The mapping indicates that the 100 year ARI flood level on the site is now estimated to be between 3.5 and 4.2 m AHD.

2.6.3 Wetlands

Figure 8 highlights the mapped geomorphic wetlands in proximity to the site as per the Department of Parks and Wildlife's Geomorphic Wetlands Swan Coastal Plain dataset. As shown, Multiple Use (MU) management category Palusplain (UFI 15785) is mapped for a significant portion of the site. This wetland is an extensive palusplain wetland that has been subject to various impacts associated with past and current land uses across its extent.

In accordance with the Environmental Protection Authority Guidance Statement 33, wetlands classified as MU are described as:

> Wetlands with few important ecological attributes and functions remaining and use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning.

The PMD is located east of the site and runs adjacent to the Kwinana Freeway. The PMD is mapped as a Resource Enhancement (RE) wetland (UFI 14659) and it receives stormwater flows from the Sub F and Sub H branch drains via a number of piped culverts underneath the Kwinana Freeway.

The nearest Conservation Category Wetland (CCW) is Folly Pool, located at least 120 m east of the site and on the opposite side of the Kwinana Freeway. Folly Pool is also classified as an Environmental Protection Policy wetland.

2.7 Groundwater

2.7.1 Groundwater Aquifers

The site is located within the Stakehill Groundwater Area and more specifically the Tamworth Swamp and Stakehill Confined sub-areas. The aquifers within each respective groundwater sub-area comprise the Superficial Swan (Tamworth Swamp), Cattamarra, Leederville and Yarragadee North (Stakehill Confined).

2.7.2 Groundwater Elevation and Flow Direction

2.7.2.1 Predevelopment Observations

Pre-development observations indicate that portions of the site become inundated in the winter months, with a large portion of the site being underlined with Guildford Formation soils of low permeability.

Groundwater levels have been monitored as below, with the locations of the monitoring bores shown on Figure 9:

- from six bores (WMW1 to WMW6) in the landholding immediately south from May 2012 to April 2013, capturing the 2012 annual high
- from four on site bores (MB01 to MB04) that were installed as part of the ASS investigations, in April 2013 and July 2014. Monitoring bores MB03 and MB04 were installed in immediate proximity to WMW2 and WMW1 respectively
- from seven bores immediately north (MW25 to MW31) and one bore immediately south (MW32) of the site. Monitoring was undertaken from September 2005 to February 2007, capturing annual high groundwater levels in 2005 in 2006. Sampling was also undertaken from these bores in October 2010
- sampling by DoW from three regional bores; from 1975 to 2013 (two bores) and 1975 to 2008 (one bore)
- Peel Main Drain elevations as interpreted from Folly Pool monitoring data from 2002 to 2013.

2.7.2.2 Maximum and Annual Average Maximum Groundwater Levels

The Maximum Groundwater Level (MGL) and Average Annual Maximum Groundwater Level (AAMGL) have been calculated using July 2014 on-site monitoring, correlated to adjacent bores to provide two winter highs of monitoring data.

Groundwater levels from on-site bores (MB03 and MB04) measured in July 2014 were compared with the AAMGL calculated from 2012 and 2014 monitoring at WMW1/MB04 and WMW2/MB03. This is appropriate as monitoring bores MB03 and MB04 were installed in immediate proximity to WMW2 and WMW1 respectively. The comparison indicates that July 2014 levels at MB03 were 0.08 m higher than the AAMGL measured over two winter peaks, while July 2014 levels at MB04 were 0.06 m lower.

This indicates that July 2014 levels were very similar (<0.1 m) to the AAMGL measured over two winter peaks (2012 and 2014). Consequently, the July 2014 measured levels in the other on-site bores (MB01 and MB02) are considered appropriate to use as an AAMGL. Table 2 summarises the AAMGL and MGL information.

Table 2: AAMGL and MGL Calculation

Name	Year of Annual High Monitored	AAMGL (m AHD)	MGL (m AHD)	AAMGL Minus 2014 Site Monitoring (m)
61410061	1975 to 2008	2.43	3.13	
61410064	1975 to 2013	2.54	3.03	
61410073	1975 to 2013	2.04	2.93	
MB01	2014	3.92	3.92	
MB02	2014	3.68	3.68	
MB03	2014	4.56	4.56	
MB04	2014	3.84	3.84	
WMW2/MB03	2012, 2014	4.49	4.56	-0.08
WMW1/MB04	2012, 2014	3.89	3.95	0.06
MW25	2005, 2006, 2010	3.75	4.11	
MW26	2005, 2006, 2010	4.13	4.74	
MW27	2005, 2006, 2010	4.18	4.62	
MW28	2005, 2006, 2010	4.03	4.36	
MW29	2005, 2006, 2010	4.43	4.75	
MW30	2005, 2006, 2010	4.25	4.72	
MW31	2005, 2006, 2010	3.88	4.26	
MW32	2005, 2006, 2010	4.55	4.79	
WMW1	2012	3.95	3.95	
WMW2	2012	4.41	4.41	
WMW3	2012	4.41	4.41	
WMW4	2012	4.42	4.42	
WMW5	2012	4.38	4.38	
WMW6	2012	4.35	4.35	
Folly Pool (Peel Main Drain)	2002 to 2013	2.82	3.54	

Figure 10 shows the AAMGL calculated from monitoring bores on site. The AAMGL was calculated by interpolating between monitoring bores using the Kriging method. The lack of smoothness along contour lines is a function of the interpolation method. The lines within the site are the approximate locations of the Sub F and Sub H drains.

The AAMGL is calculated to range from approximately 4.5 m AHD at the south-west corner of the site to 3.8 m AHD along the eastern boundary, with groundwater migrating to the east-north-east towards the Peel Main Drain.

The local groundwater elevation is significantly higher than regional monitoring shows and the local flow direction is towards the east, not the west as is indicated in the regional mapping (DoW 2014a). This is due to local groundwater mounding, with discharge being particularly impeded to the east due to the presence of low permeability soils adjacent to the Peel Main Drain.

Based on the AAMGL method of calculation, the AAMGL exceeds the topography over large areas of the site. This is due to a combination of the AAMGL interpolation, which is directly between monitoring bores and does not directly include the influence of open drains, and the site itself being depressed in its central area.

2.7.3 Groundwater Quality

Groundwater quality has been monitored by RPS since April 2014. This monitoring program included one acid sulfate soil (ASS) baseline water quality sampling event and monthly groundwater level and physico-chemical parameter measurements during the winter months of 2014.

Parson's Brinkerhoff (PB) conducted groundwater quality sampling on the landholdings directly adjacent to the north and the south of the site. Groundwater quality monitoring of the adjacent northern landholding was conducted from October 2005 to September 2007. Groundwater monitoring of the adjacent southern landholding was conducted between May 2012 and April 2013. Figure 9 shows the locations of all the monitoring locations within and adjacent to the site.

Table 3 below presents the groundwater quality from the on-site bores and the nearest bores in the adjacent landholdings to the north and the south.

Table 3: Groundwater Quality of On-site Bores and Adjacent Landholdings

Sample ID	Date	Field Parameters					Nutrients				
		pH	E.C	Redox	DO	Total P	Reactive P	Total N	TKN	NH_4-N	NOx-N
		-	-	-	-	0.01	0.01	0.1	0.1	0.01	0.01
		6.5–8.5	NG	NG	NG	0.06 [c]	0.03 [c]	1.5 [c]	NG	0.04 [c]	0.1 [c]
On-site Monitoring Locations											
MB1	03.04.14	5.79	200	68	0.35	0.60	<0.005	5.4	2.90	0.04	2.50
MB2	03.04.14	7.12	1166	-73	0.02	0.15	<0.005	0.2	0.20	0.12	0.02
MB3	03.04.14	5.98	228	12	0.07	0.26	<0.005	5.4	2.20	0.36	3.20
MB4	03.04.14	6.17	4320	-84	0.19	0.16	<0.005	0.9	0.90	0.03	<0.005
Northern Landholding Monitoring Locations (Averages)											
MB30	2012–2013	6.13	4446	NA	NA	0.062	0.05	1.67	1.67	0.12	0.03
MB31	2012–2013	5.3	588	NA	NA	0.02	0.006	1.77	1.7	0.30	0.05
Southern Landholding Monitoring Locations (Averages)											
MW1	2005–2007	7.49	4016	NA	NA	0.1	NA	3.64	NA	0.3	2.72
MW2	2005–2007	7.51	1055	NA	NA	0.08	NA	3.79	NA	0.53	2.07

c) Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

The groundwater quality results indicate that nutrient concentrations exceed ANZECC (2000) freshwater guideline in all on-site bores, with higher nutrients in the western bores located in sand (MB01, MB03) compared with the eastern bores located in clay (MB02 and MB04). Total nitrogen concentrations exceed the guideline for the two western bores, and total phosphorus exceeds the guideline at all monitored locations within the site. The elevated nutrient concentrations, which are also encountered in the groundwater from adjacent landholdings, are potentially related to the semi-rural and historical agricultural land uses at the site and within the greater catchment area.

The electrical conductivity (EC), redox, TN and TKN results also indicate that water quality differs between the eastern and western areas of the site.

2.8 Vegetation and Flora

Due to historical land uses, particularly agricultural activities, the site has been extensively cleared of native vegetation. There are approximately six flooded gums in the site (all within Lots 746 and 750).

Within Lot 545, the key remnant vegetation is the planted rows of flooded gum trees either side of the Sub-H Drain.

The vegetation condition within the site is "Completely Degraded" due to historical clearing and agricultural land uses.

2.8.1 Tramway Reserve

The Tramway Nature Reserve runs parallel to Baldivis Road and it is situated in the road reserve adjacent to the western boundary of the site. Patches of vegetation in this reserve are in good condition however, there is some evidence of disturbance. Access points through the reserve from the development will be managed to minimise disturbance.

Further detail on vegetation and flora management, including the protection of the Tramway Reserve is outlined within the Environmental Assessment Report (RPS 2014).

2.8.2 Bush Forever Site

No Bush Forever Sites (BFS) are located within the development area, however approximately 35 ha of the land including Folly Pool to the east of the site are classified as Bush Forever Site (No. 418). Around 15 ha of the BFS consist of bushland and 7 ha of EPP wetland (PB 2007).

2.9 Fauna

As discussed previously, the majority of the site has been historically cleared of native vegetation with only a small amount of remnant trees remaining, primarily within Lot 746. Therefore, the site is considered to be of low habitat value to native fauna species (RPS 2014).

The remnant trees may be utilised opportunistically by native fauna species moving through the local landscape. Given that the trees occur independently of native vegetation extents, it is considered unlikely that the trees are utilised by native fauna species on a permanent basis.

The EAR report considers the intact vegetation extents contained within Bush Forever Site No. 418: Folly Pool, Baldivis are of higher habitat value to fauna species when compared to the trees in the subject land. It is considered likely that fauna species moving through the local landscape would prefer to use opportunistically the vegetation contained within Bush Forever Site ahead of the remnant trees in the subject land (RPS 2014).

2.10 Heritage

2.10.1 Aboriginal Heritage

A search of the Department of Indigenous Affair's (DIA) Aboriginal Heritage Inquiry System was undertaken on 20 March 2014 and no matches were recorded for the subject land.

The Aboriginal Heritage Inquiry System identified that 13 Heritage Surveys have been undertaken by different proponents that have included the site. Given that no Aboriginal Heritage Sites have been identified on the site by these surveys and that the site has been previously developed for agricultural land, it is considered unlikely that Aboriginal Heritage Sites are present within the site.

2.10.2 European Heritage

A search of the Heritage Council's inHerit database and the City of Rockingham's Municipal Heritage Inventory (City of Rockingham 2012) was undertaken on 20 March 2014 and no matches were found for the subject land.

3.0 WATER CONSERVATION STRATEGY

The State Water Plan (2007) is a strategic policy and planning framework to meet the state's water demands to the year 2030. One of the key targets is to reduce potable water consumption to 40 kL–60 kL per person per year. In order to meet this target, several water saving initiatives to reduce potable water use will be investigated and implemented where practical within the development. Potential options currently being considered include the following:

- the provision of a Waterwise landscaping package for buyers encouraging the use of minimal turfed areas and the use of species with low water requirements
- the provision of educational material to buyers regarding appropriate irrigation operation and hydro-zone planting
- installation of AAA water efficient appliances including but not limited to washing machines, toilets and taps.

3.1 Waterwise Landscape Package

Front yard landscaping packages will be promoted and provided to all new homeowners. This will include the use of plant species particularly those with low water requirements and minimal turf.

All front yard landscaping and irrigation works will be managed by the proponent using a reputable contractor experienced in the Waterwise concepts being employed.

Irrigation of front gardens will be the responsibility of the owner following occupancy and irrigation operational procedures will be provided to ensure controlled application rates are implemented.

3.2 Education

The proponent plans to provide education and information material to all new homeowners within the development. The package will include Waterwise tips and encourage "eco-friendly" practices within the home and garden.

Irrigation operational procedures will be outlined within the package, they will focus on the responsibility of the homeowner to comply with irrigation restrictions, and rosters set by the Water Corporation. Recommended irrigation times will also be provided.

The education and information package will be used to promote the use of water efficient fixtures and appliances.

3.3 Broad POS Landscaping and Irrigation Approach

The landscape design has incorporated a number of measures to minimise irrigation requirements to create a Waterwise urban development. The Landscape Strategy is illustrated in Appendix 5 and the following information has been provided in accordance with information received from the project's landscape architect Emerge Associates.

The site contains 4 ha of POS that comprises of formal POS areas, POS verges, green links, entry areas and access ways. Approximately 0.7 ha of this POS will receive drainage for events between the 1 in 1 year and 1 in 5 year ARI events. Drainage will be directed towards landscaped infiltration basins and bio-retention areas within each POS area.

In addition to the POS discussed above, the site also has provision for a future sporting oval to be provided in the southern area of the LSP, as part of the proposed primary school site. The primary school location is also highlighted in Appendix 5. Irrigation for the school site has been secured by Perron Developments, located immediately to the south of the project site.

3.3.1 Irrigation Strategy

The planting design of all Streetscape and Public Open Space areas will consist of predominantly endemic native species. Planting design is proposed to include a water sensitive design approach and will seek to reduce irrigation rates over the long term to planting areas to promote a longer-term water saving strategy for the development.

Hydro-zoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together. This will facilitate irrigation efficiencies that can be made across the scheme.

Areas within the drainage swales and retention basins are proposed to be in the main non-irrigated and will be planted with native sedges and rushes to facilitate with the drainage engineering required for the site. The water table in these areas will be close to the surface particularly in winter months possibly limiting the need for irrigation within swales.

The annual irrigation requirements for these landscaped areas are summarised in Table 4 below.

Table 4: Preliminary Irrigation Estimate

Item POS		Area	Irrigated	Irrigated	ltr/Week	ltr/Annum	Kl/Annum
		m^2	Area%	Area m^2	m^2 × 10 ltr × 2	ltr/wk × 52 Weeks	
1	Entry Statement and widened median	2,000	100	2,000	40,000	2080000	2080
2	Verges to Entry Road only	4,100	100	4,100	82,000	4264000	4264
3	POS A	13,600	85	11,560	231,200	12022400	12022.4
4	POS B	7,400	85	6,290	125,800	6541600	6541.6
5	POS C	3,700	85	3,145	62,900	3270800	3270.8
6	POS D	14,400	85	12,240	244,800	12729600	12729.6
7	POS E	1,000	95	950	19,000	988000	988
Subtotal		46,200		40,285			**41896.4**
Total POS Area		4.62	hectares				34,650.00
Total POS Irrigated area				4.0285	hectares		30,213.75

Exclusions Irrigation to sales office, verges of POS, primary school and north–south connector road verge.
Note 1. The irrigation required will be staggered over the life of the project to reflect the stages of the project and the hardening off of planting prior to council hand over.

(Emerge Associates)

The irrigation volumes have been based on the application of the standard DoW irrigation rate of 7,500 KL/ha/annum. Waterwise native planting will be implemented in addition to "dry gardens" (i.e. gravel mulching with intermittent tree planting) where practical. Due to the low water requirements of this design, approximately 15% of the total landscaped area will not require irrigation.

Tree species that will provide shade and enhance the natural environment will be used within the landscaped areas. Appendix 5 illustrates the Street Tree Master Plan with the following tree species proposed:

- *Agonis flexuosa*, native peppermint xx
- *Corymbia ficifolia*, red flowering gum
- *Eucalyptus leucoxylon* "*Rosea*", pink flowering gum
- *Melaleuca quinquenervia*, broad leafed paperbark
- *Tipuana tipu*, rosewood.

As seen in the Landscape Master Plan (Appendix 5), numerous areas have been designated as POS in the form of local, feature and neighbourhood parks, all of which will be used for active and passive recreational activities.

POS areas labelled as A, B, C, D and E will co-function as drainage storage areas and will perform as bio-retention swales and detention basins during stormwater events.

Storm events greater than the 1 in 5 year ARI event will be detained within the parkland areas of the POS which will be predominantly turf, whilst the storm events less than the 1 in 5 year ARI event will be contained within the bio-retention areas of the basins which will be planted with the appropriate nutrient stripping vegetation.

POS designs and plans will be subject to review at the detailed planning stage and further detailed information, including further refinement of the projects irrigation needs, will be included in subsequent UWMP's for the project.

3.3.2 Irrigation Source

Enquiries to the Department of Water in October 2013 indicated that the superficial aquifer underlying the site was 95% allocated. The remaining groundwater available equates to approximately 163,308 kL/yr of groundwater available before the aquifer would become fully allocated.

A Licence to Take Water and a Licence to Construct a Well was issued by the Department of Water on the 1 July 2014 for a total volume of 70,000 kL from the Superficial aquifer (GWL 178323 and CAW 179359). This total volume included provisions for dust suppression and construction use, as well as the establishment and long-term irrigation of the POS.

3.4 Servicing

3.4.1 Potable Water

A reticulated water main is located within Baldivis Road and a trunk main is located within Eighty Road, Fifty Road and Baldivis Road. Works will be undertaken to extend the water main into the development site by the Water Corporation.

Further detail on the reticulated water supply to the site can be found within the Servicing Report provided by Development Engineering Consultants (Appendix 4).

3.4.2 Sewerage

The project site falls between two existing sewer catchments, with each catchment being directed towards one of two Waste Water Pump Stations (WWPS) located within directly adjacent developments to the north and south of the site.

The northern half of the site is located within the Water Corporation's Catchment "I" and will be an extension of the sewer infrastructure being installed as part of the Australand (Baldivis Parks) development to the north of the site.

The southern portion of the site falls within the Water Corporations Catchment "C" with the WWPS for this land to be constructed within the Perron land holding immediately to the south of the project site.

It is anticipated that the first stages of the development will occur within Catchment "I" and will therefore allow for the construction of the new pump station in Catchment "C" to be undertaken prior to the development of this portion of the site.

The Water Corporation has recently achieved appropriate approvals for the linkage of the Baldivis mains sewer into the existing East Rockingham Wastewater Treatment Plant, allowing development to proceed within this corridor.

Further detail on the reticulated sewerage works for the site can be found within the Servicing Report provided by Development Engineering Consultants (Appendix 4).

4.0 STORMWATER MANAGEMENT

4.1 Drainage Plan

The stormwater modelling and drainage design for the site has been completed by Development Engineering Consultants. The site will effectively manage stormwater through the implementation of water sensitive urban design (WSUD) principles and best management practices (BMPs) to control water quality and quantity from both minor and major storm events.

In accordance with the Stormwater Management Manual for Western Australia (DoW 2004–2007), the drainage system will aim to achieve the following objectives:

- Maintain existing hydrological regime and minimise fill requirements.
- Effectively manage the risk to human life, property damage and environmental degradation from flooding and waterlogging.
- Improve stormwater quality, as compared to a development that does not actively manage stormwater.
- Rainfall from 1 year ARI (Annual Recurrence Interval) events will be detained and treated using biological treatment as close to the source as possible. Some infiltration will occur during lower groundwater level periods.
- Large rainfall events (5 ARI to 100 ARI) will be conveyed and detained through a network of roads and drainage basins or swales within Public Open Space (POS) areas located in each catchment.
- Outflow from the site will occur via one of two existing culverts, beneath the Kwinana Freeway to the east of the site, which ultimately deliver water to the Peel Main Drain

4.1.1 Surface Water Management Plan Overview

Drainage practices and concepts intended for stormwater management are described below and they will be subject to further design and engineering specifications during the detailed design phase, with this information included in any subsequent UWMPs.

The site comprises of four main catchment areas, labelled as NE, NW, SW and SE as shown in the "Drainage Catchment Plan" included as Appendix 5. Each catchment will direct surface water into one of four detention basins located within the POS of each respective catchment. Appendix 5 also shows the locations of the basins and the directional flows of each catchment. The drainage plan has been designed to maximise

opportunities for infiltration throughout the site and as close to source as possible, helping to reduce the export of nutrients or pollutants in stormwater run-off from the site during the more frequent storm events.

All events will eventually be discharged off site via a piped drainage network, which will ultimately direct flows into one of two culverts under the Kwinana Freeway, to Folly Pool and eventually the PMD. The Water Corporation controlled Sub H and Sub F drains that traverse the site (discussed in Section 2.6.) currently exist as open drainage channels. However, as part of the drainage plan for the site, these drains are proposed to be piped, and will follow the internal road network as detailed in Appendix 5.

Additional detail has been included in Appendix 8 to demonstrate the sizing of the SE basin within the site. This detail has been included only to reflect the storage capacities needed for the project site and to demonstrate that adequate POS has been assigned for the management of drainage on site. This POS and drainage basin will eventually form part of an integrated POS area with the Perron landholding immediately to the south of this site (Lot 921). It is acknowledged by both parties that the integration of drainage and landscaping works for this POS area is desirable for the best outcome in terms of appearance and useability of the POS.

To this end, discussions have been held with all relevant parties and a conceptual integrated landscape and basin design has been provided by Emerge Associates and is included as shown in Appendix 9. This plan indicatively details how the POS area and drainage basins will function. Both sites will ultimately discharge their drainage through the existing Sub F culvert beneath the Kwinana Freeway located immediately adjacent to this POS area.

4.2 Structural Controls

4.2.1 Minor Drainage System

Design of the minor drainage system focuses on maximising on site infiltration and reducing the volume of water discharging off site. For regular rainfall events, stormwater be retained on site and infiltrated as close to source as possible to mimic the pre-development flow patterns. This will implemented be by use of bottomless pits and subsoil infiltration systems at the base of drainage basins.

A pit and pipe system within the internal road network will be utilised to convey surface waters generated from all impervious road surfaces within the site. Lot run-off from roofs and paving will be confined within the property boundary for all lots greater than 300 m^2. These lots will be fitted with two soak wells (1.5 m × 1.2 m) within the front gardens to cater for this run-off. Due to size constraints, lots less than 300 m^2 will be directly connected to the road drainage system; although a small amount of storage, equivalent to one 1.5 m by 1.2 m soakwell, will be installed for each home to ensure the 1 in 1 year 1 hour storm is detained on site by each lot. Larger ARI storms will surcharge and contribute to the flows to basins for all lots.

Bio-retention areas will be located within the each drainage basin and will be designed to suit the recommended area of 2% of the connected impervious catchment area. As outlined above, the lower ARI storms will be infiltrated into a subsurface subsoil system prior to flowing into the outlet drainage system. All basins will be designed to detain the 100-year outflow rate with all outflows being limited to pre-development rates as supplied by the Water Corporation based on their modelling for the Peel Main Drain. As outlined above, all basins will offer some infiltration opportunities prior to outflow occurring through a controlled outlet. This in turn links to a piped network, which will then exit the site into the piped Sub H drain though POS located in the north-eastern corner of the site.

The basin located in catchment "SE" will discharge via a controlled outlet into the Sub F culvert located in the south-eastern corner of the site. This basin will ultimately be combined with the Perron drainage basin located within the adjacent POS and therefore detailed design of this basin will be determined at the UWMP phase of the project.

The outlets of basins NE, NW and SW are proposed to be constructed as a rectangular tiered weir or a controlled orifice arrangement to limit outflow rates for minor ARI events and maximise opportunities for nutrient uptake. Basin cross-sections highlighting top water levels, inundation areas and inverts of the inlets and outlets are provided in Appendix 5. Appendix 6 details the drainage calculations for each basin.

4.2.2 Major Drainage System

Stormwater run-off for major events will be directed via overland flow and the piped drainage network to each catchment's respective drainage basin (Basin NE, NW, SW, and SE). These basins have been designed to detain all flows up to the 100-year ARI event. Appendix 5 highlights the top water levels for the 100-year ARI and details the areas required to detain each event. Appendix 6 details the drainage calculations provided by Development Engineering Consultants, used to size each basin.

Once the water reaches the 100-year top water level (TWL), stormwater will outflow through a rectangular weir structure or a controlled orifice, which will provide a controlled outlet for each basin.

Each outlet will then overtop into a piped overflow network, which will direct water offsite, ultimately to the PMD.

Basins NE and NW and SW will discharge to the piped Sub H drain located within Lot 545, before exiting the site via a 1070 mm diameter culvert with an invert of 2.37 m AHD. This culvert passes under the Kwinana Freeway before delivering the water to the PMD.

Ultimately, basin SE will be constructed as a combined basin with the Perron landholding as discussed above in Section 4.1.1 and, therefore, discharge from this location will be via an existing 450 mm culvert located adjacent to the site and passing into the freeway reserve. This culvert currently directs flows from the Sub F drain to the PMD.

4.3 Flood Management

Recent flood modelling for the Serpentine River, produced by the DoW has determined that the 100-year ARI flood level within the vicinity of the site is between approximately 3.5–4.5 m AHD. Recent flood advice and mapping was provided by the DoW and has been included as Figure 7. Minimum habitable floor levels will be set at a minimum separation of 0.5 m AHD above the 100 year flood level. The finished lot levels across the site are illustrated in the drainage catchment plan provided in Appendix 5 and demonstrate more than the required 0.5 m separation from the estimated flood levels.

4.4 Surface Water Discharge to the Peel Main Drain

The site is located within the catchment of Water Corporation's Peel Main Drain and outflows are subject to outflow rates as determined by the Water Corporation and the Department of Water. These have been utilised to determine outflow rates from the site to the PMD.

The catchment area for the existing portion of the Sub H drain is 58.4 ha. Correspondence from the Water Corporation in 2007 (Appendix 7) indicates that the permissible 10 year and 100 year flow off this area to the PMD is 3 L/s/gross ha and 4.5 L/s/gross ha respectively. Based on the 4.5 L/s/ha, a flow of approximately 243 L/s will be conveyed off site via the Sub H drain culvert. This rate takes into consideration the greater catchments to the north as well as flows generated from the project site.

Discharge from the Sub F catchment area is directed off site via the Sub F drain to an existing culvert located adjacent to the Perron landholding. The outflow from the project site to this culvert has been calculated based on a maximum discharge rate of 4.5 L/sec/ha for a 100 year ARI event and will be eventually combined with the discharge from the Perron landholding.

4.5 Water Quality Treatment

4.5.1 Vegetation

Vegetation will be included in all suitable stormwater structural controls to help prevent erosion, maintain soil infiltration, restrict water flows and remove particulate and soluble pollutants, particularly nitrogen. Planting will occur within the bio-retention areas of the basins over an area that will be equivalent to at least 2% of the connected impervious surfaces for the site. The plants will be appropriately selected based on their intended function using native vegetation as much as possible. The plant species intended within the bio-retention areas will be identified within the subsequent UWMPs.

4.5.2 Soil Amendment

Soil amendment with a PRI value of at least 10 mL/g will be utilised within the base of the bio-retention areas to a minimum depth of 300 mm above the Controlled Groundwater Level (CGL) for retaining phosphorus for the majority of the minor storm events.

5.0 GROUNDWATER MANAGEMENT

5.1 Groundwater Quality

Many of the proposed stormwater measures will improve stormwater quality and subsequently groundwater quality through the following mechanisms:

- increasing biological uptake through the establishment of vegetation, some of which will have nutrient stripping capabilities within bio-retention areas
- reducing water velocities by diverting water through drainage basins within the site before discharging to the PMD
- minimise and control the levels of fertilisers and pesticides applied to the site through appropriate plant selection, and operation and maintenance procedures after development
- the use of soil amendment within bio-retention areas to encourage nutrient retention and condition the soil
- monitoring groundwater quality leaving the site to verify that pre-development values are being maintained or improved.

5.2 Groundwater Modelling

5.2.1 Results Summary

Groundwater across the site is generally at a shallow depth, with surface expressions in winter. Coupled with the expected increase in groundwater recharge rates associated with urban development, groundwater levels at the site will need to be controlled. This will be achieved by the installation of subsurface drains. RPS has been commissioned by Mirvac Pty Ltd to prepare a computer generated groundwater flow model, which has been used to assess the impact of the subsurface drains on controlling groundwater levels.

The groundwater modelling predicts that urban development will cause groundwater levels to rise, resulting in inundation of the site. The subsurface drainage system as designed by the site engineers (Development Engineering Consultants) is predicted to inhibit inundation in areas outside of Public Open Space (POS). For an average winter-rainfall event, the model predicts groundwater clearance to exceed 0.8 m, except for POS and some areas at the south and north-west of the site. For a high winter rain event (1991 rainfall), the model predicts groundwater clearance to exceed 0.8 m over most of the site, except for POS and areas at the south, centre and north-west of the site.

Detailed outcomes of the modelling has are provided in Appendix 1.

5.2.2 Subsoil Drainage Design

A subsoil drainage system is proposed to be installed throughout the road network and beneath each drainage basin to manage groundwater on the site and provide a controlled groundwater level (CGL) on site.

The location of the proposed subsoil system is highlighted on the post-development drainage plan provided in Appendix 5. The subsoil system proposes to mimic the existing drainage scenario currently provided by the Sub H and the Sub F drains on site.

The majority of the subsoil drainage will be located within the fill material on site, before discharging into the bio-filtration areas of each POS basin. Subsoils installed beneath the western bio-retention areas (NW and SW Basins) will connect to the controlled drainage outlets (discussed in Section 4.2.1) to facilitate infiltration.

The subsoil drainage under basin NE and SE basin will be installed at levels that are reflective of the base level of the Sub H and the Sub F in these locations. The subsoil drains installed under the SE basin will directly discharge to the Sub F culvert, which has an invert of 3.78 m AHD. The subsoil under the NE basin will discharge into the piped Sub H drain at an invert of approximately 3.6 m AHD. The Sub H drain has a base invert of approximately 2.6 m AHD and the Sub H culvert invert under the Kwinana Freeway is 2.37 m AHD.

6.0 MONITORING

6.1 Pre-development

Groundwater monitoring at the site has been completed to determine the baseline conditions and to allow for a direct comparison during and after development. The results of the monitoring programs undertaken to date have been detailed in Section 2.7.3 of this report.

6.2 After Development

Groundwater monitoring will be undertaken monthly for levels and quarterly for quality for a period of three years after development. The same parameters required during pre-development will be analysed and if possible, Bores MB1 to MB4, which were monitored before development, will be used after development. Where bores are destroyed or no longer available for use, a new bore shall be installed in a location as close as possible to ensure consistency in the monitoring regime.

6.3 Reporting

The post-development results of the monitoring program will be compared against the pre-development data and reported annually to the City of Rockingham (CoR) and DoW.

The report will provide details of any variations the development has had on the hydrological conditions and propose necessary contingency plans where required.

6.4 Contingency Plans

It is proposed that trigger levels for groundwater quality will be determined at UWMP phase of the project in conjunction with the CoR. In an event where the post-development monitoring exceeds the trigger values on two consecutive occasions, the CoR and DoW will be notified and an investigation will be undertaken to determine the cause of the exceedance, the impacts and the required contingency measures. Possible contingency measures may include:

- identification and removal of pollution source, if possible
- Infiltration areas: further soil amendment (in relation to quality) or engineering to facilitate infiltration (in relation to levels)

- increased planting of nutrient stripping vegetation in infiltration areas
- reintroduce or increase the education and public awareness program
- confirmation that the POS operating and maintenance strategy is being implemented.

Additional detail of the post-development monitoring plan, including triggers and contingencies will be provided in future UWMPs for the site.

7.0 IMPLEMENTATION

7.1 Roles and Responsibilities

Table 5: Developer Roles and Responsibilities

Principles	Role	Responsibility	Time-scale
Water levels and quality	Groundwater	The proponent	Monthly for levels and quarterly for quality until three years after practical completion of the development
	Surface water	The proponent	Opportunistically during winter, until three years after practical completion of the development
Public open space	Fertiliser application	The proponent	As required during revegetation and ongoing maintenance until hand over to CoR
	Plant establishment (via planting and irrigation regime)	The proponent	One to two years after planting or as agreed with the CoR.
	Irrigation scheduling	The proponent	As required following planting until hand over to CoR
Drainage infrastructure	Maintenance of drainage infrastructure	The proponent	As required until three years after completion of the development. The extent of the maintenance commitment will be confirmed with the City of Rockingham at the UWMP stage of the development.
Subdivision management	Construction and site works management	The proponent	As required during construction until hand over to CoR
	Erosion control	The proponent	As required during construction
	Waste and pollution management	The proponent	As required during construction until hand over to CoR
Reporting	Report on monitoring results	The proponent	Annually, until three years after practical completion of the development

7.2 Further Work

The preparation of UWMPs will be required as a condition of subdivision approval and will include the following design measures in more detail:

- compliance with this LWMS criteria and objectives to the satisfaction of the CoR and DoW
- in-depth stormwater drainage design including final bio-retention and detention basin dimensions

- final subsoil drainage design
- final subdivision layout including final cut and fill levels, minor and major drainage layouts and overland flow paths
- POS management, including fertiliser regimes and irrigation scheduling
- detailed monitoring program for groundwater, subsoil drainage and stormwater monitoring including sampling locations
- finalised monitoring performance values and list of likely contingency measures
- finalised implementation plan including roles and responsibilities of all parties involved.

8.0 REFERENCES

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FIGURES

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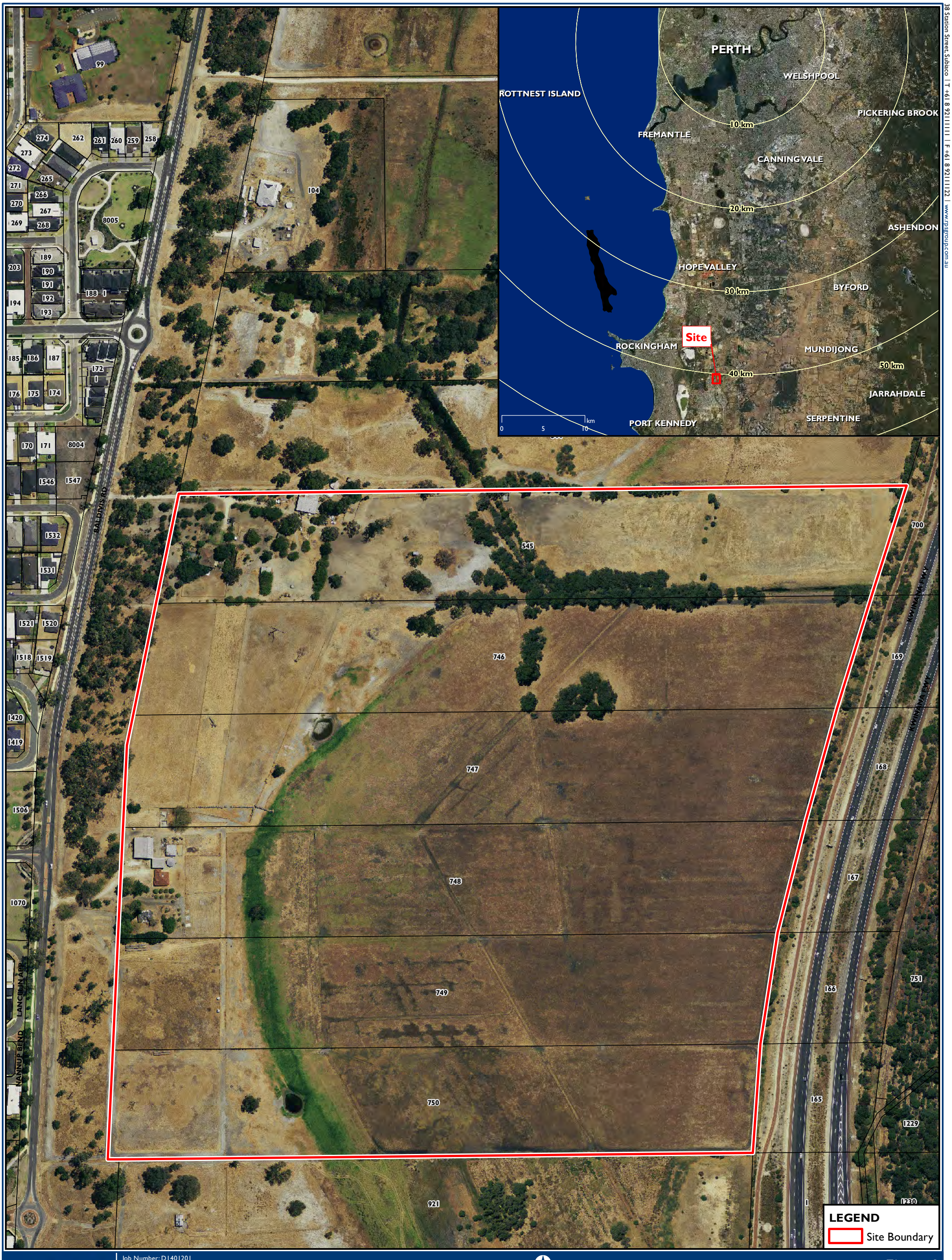

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Source: Cadastre - Landgate, 2014 Orthophoto - Landgate, 2014

GDA 1994 MGA Zone 50

0 12.5 25 50 75 100 m

Figure 1

Site Location and Layout

This Plan has been prepared for illustrative purposes only and represents an indicative land use concept of what may occur, once and if appropriate approvals are in place. The proposals depicted on this Plan generally have no formal approval status and can be varied by CLE or the landowner without notice. This Plan remains the property of CLE.

(Development by others)

POS

545

746

747

748

749

750

Public Open Space

Portion of Primary School

Lot 545 not under Mirvac ownership

TRAMWAY

ROAD

PEMBERTON BOULEVARD

BALDIVIS

BALDIVIS

FREEWAY

KWINANA

15

10

5

Site Area - 36.98ha

RAFT

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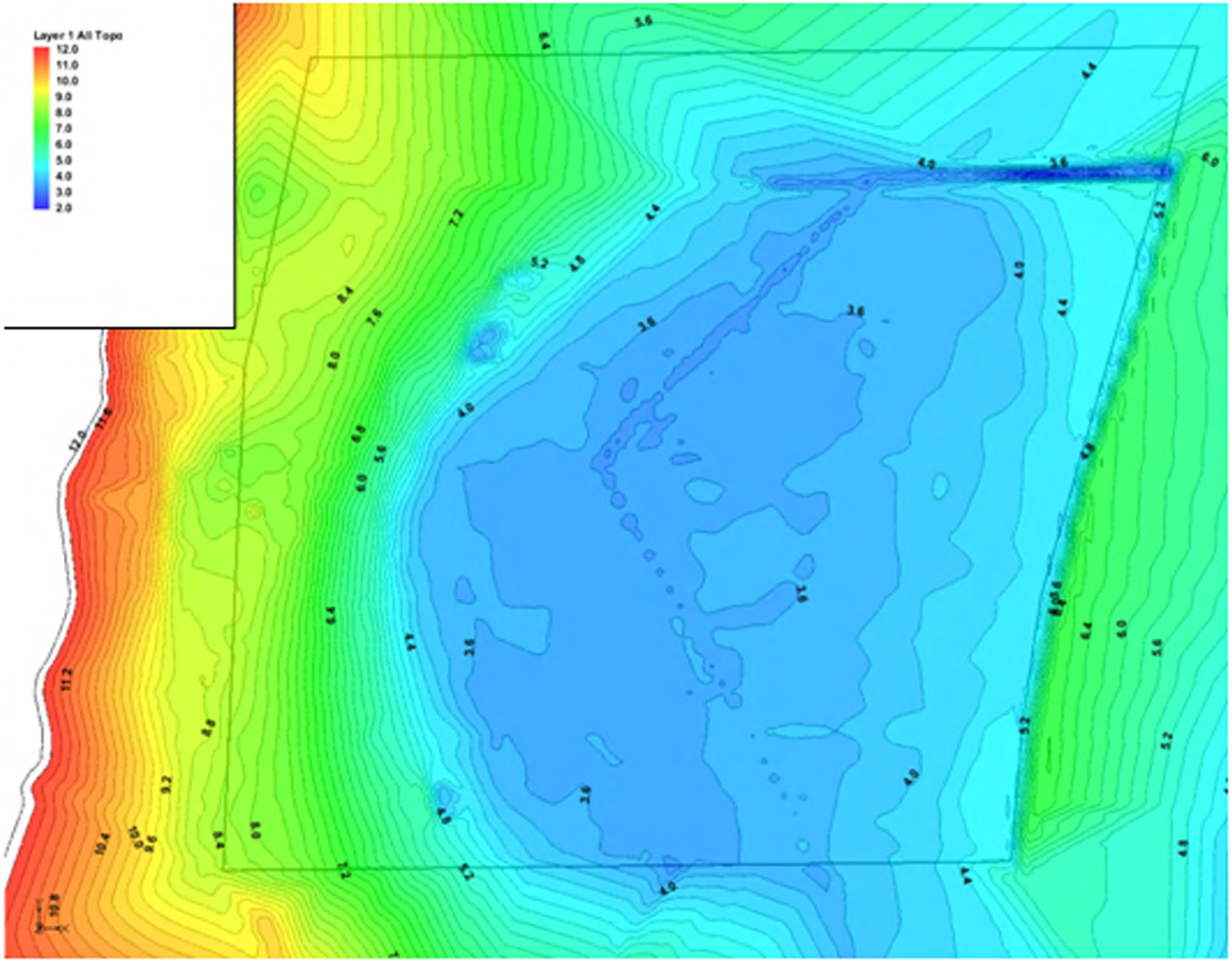
Figure 2

Proposed Local Structure Plan



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Source: Lidar

GDA 1994 MGA Zone 50

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Figure 3

Lidar Topography

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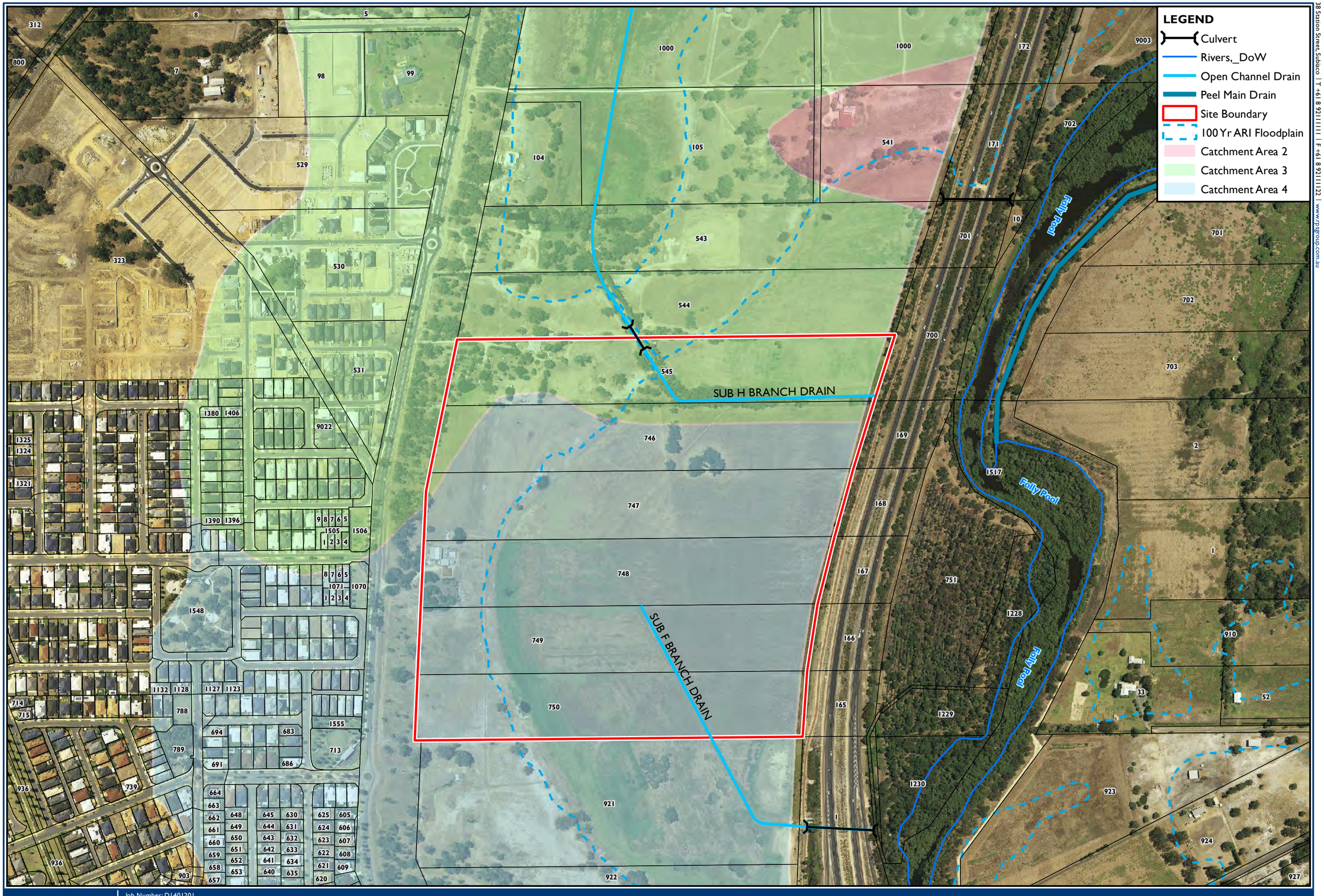

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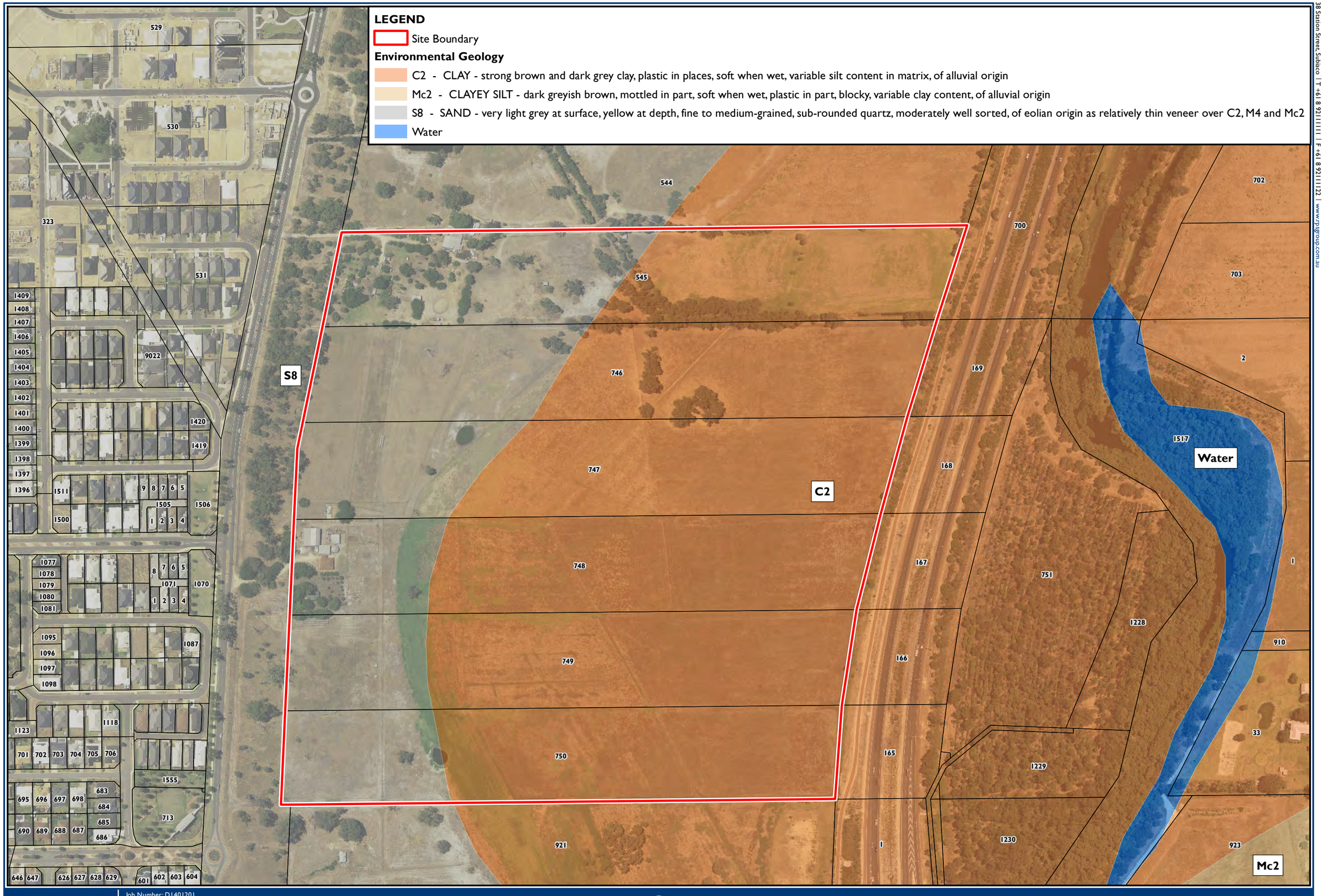
Source: Orthophoto, Cadastre, Contours - Landgate, 2013 SW Drainage - Parsons Brinckerhoff, Dwg: 2140259A-CIV-F109 05.07.07

GDA 1994 MGA Zone 50

0 25 50 100 150 200 m

Figure 4

Predevelopment Drainage Features



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Source: Orthophoto, Cadastre - Landgate, 2014 Geology - DoIR, 1999

GDA 1994 MGA Zone 50

0 15 30 60 90 120 m

Figure 5

Regional Geology

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Source: Orthophoto, Cadastre - Landgate, 2014 ASS Mapping - Landgate, 2010

GDA 1994 MGA Zone 50

0 15 30 60 90 120 m

Figure 6

Acid Sulphate Soil Risk Mapping

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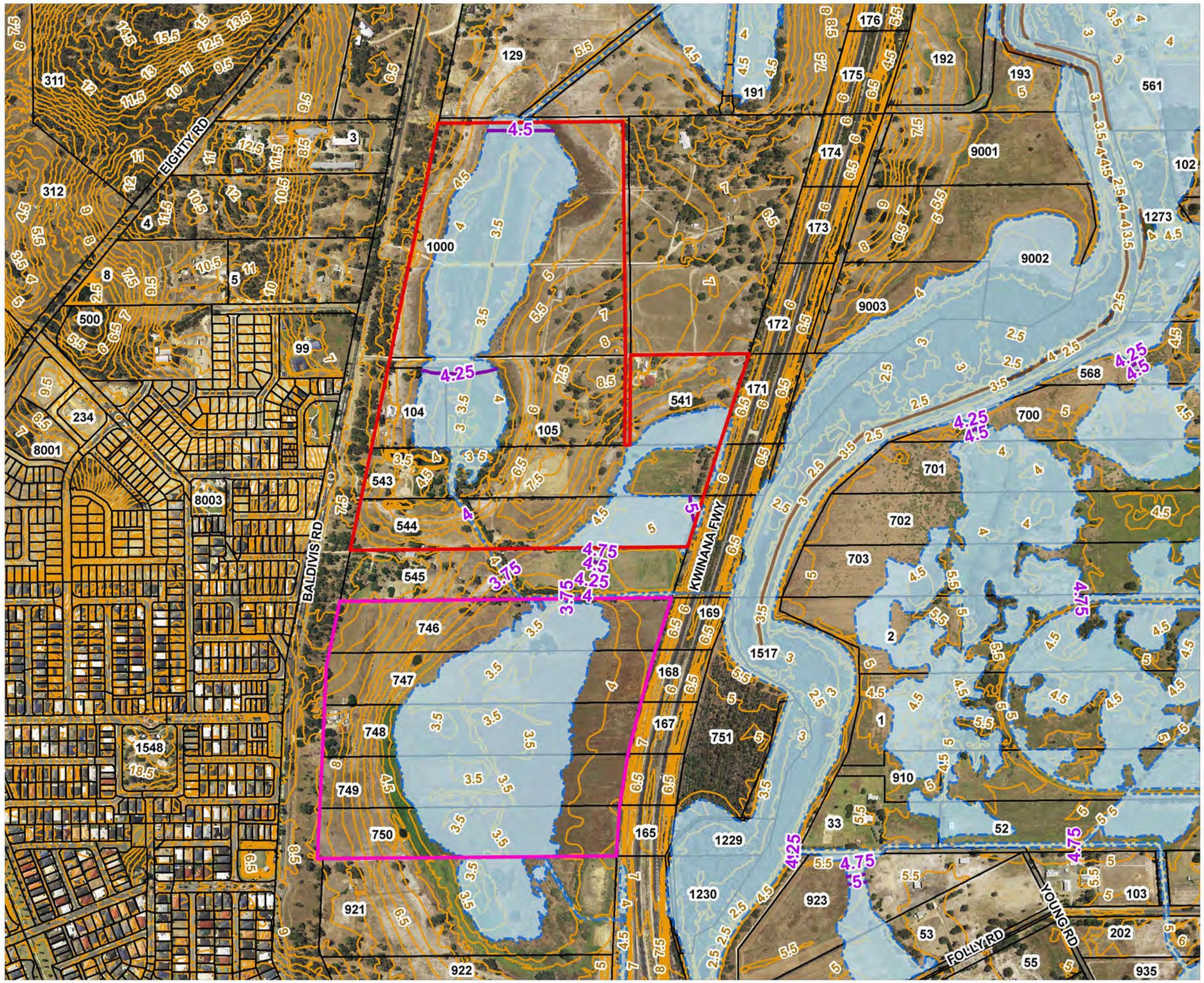
Mirvac Properties
Lots 746-750 Baldivis Rd
Australand Properties
Lots 104,105,541,543,544 & 1000 Baldvis Rd
Baldivis



LEGEND

- Lots 104-5,541,543-4 & 1000 Baldivis Rd
- Lots 746-750 Baldivis Rd
- Levee
- Bridges/Culverts
- 100Yr ARI Flood contours (m AHD)
- 100Yr ARI Floodplain
- Cadastre
- 0.5m LiDAR Contours

N

0 100 200 300
Metres

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD71)
Horizontal Datum: GDA94 MGAz50
Projection: Universal Traverse Mercator (UTM)
Spheroid: Geodetic Reference System (GRS80)

Project Information
Client: Rick Bretnall
Map Author: Andrew Watson
Task ID: B1305
Compilation date: 10/07/2014
Edition: Version 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Road Centrelines, DLI - Landgate - 31/01/2014
Spatial Cadastral Database - Landgate – 01/06/2014
Swan Coastal Plain Central Jan 2013 15cm - Landgate - 29/01/2013

Government of Western Australia
Department of Water

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This map was produced with the intent that it be used for display purposes at the scale of 1:10,000 when printing at A4.

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Figure 7

DoW Flood Mapping

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Created by: MA
Source: Orthophoto, Cadastre - Landgate, 2014 Wetlands - Landgate, 2013

GDA 1994 MGA Zone 50

0 15 30 60 90 120 m

Figure 8

Geomorphic Wetland Mapping

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LEGEND

Site Boundary

MW29 MW28 MW27 MW26 MW25 MW31 MW30 MB01 MB02 MB03 MB04 WMW2 WMW1 WMW3 MWM4 MW32 MWM6 MWM5 61410064

GDA 1994 MGA Zone 50

0 55 110 220 330 440 m

RPS

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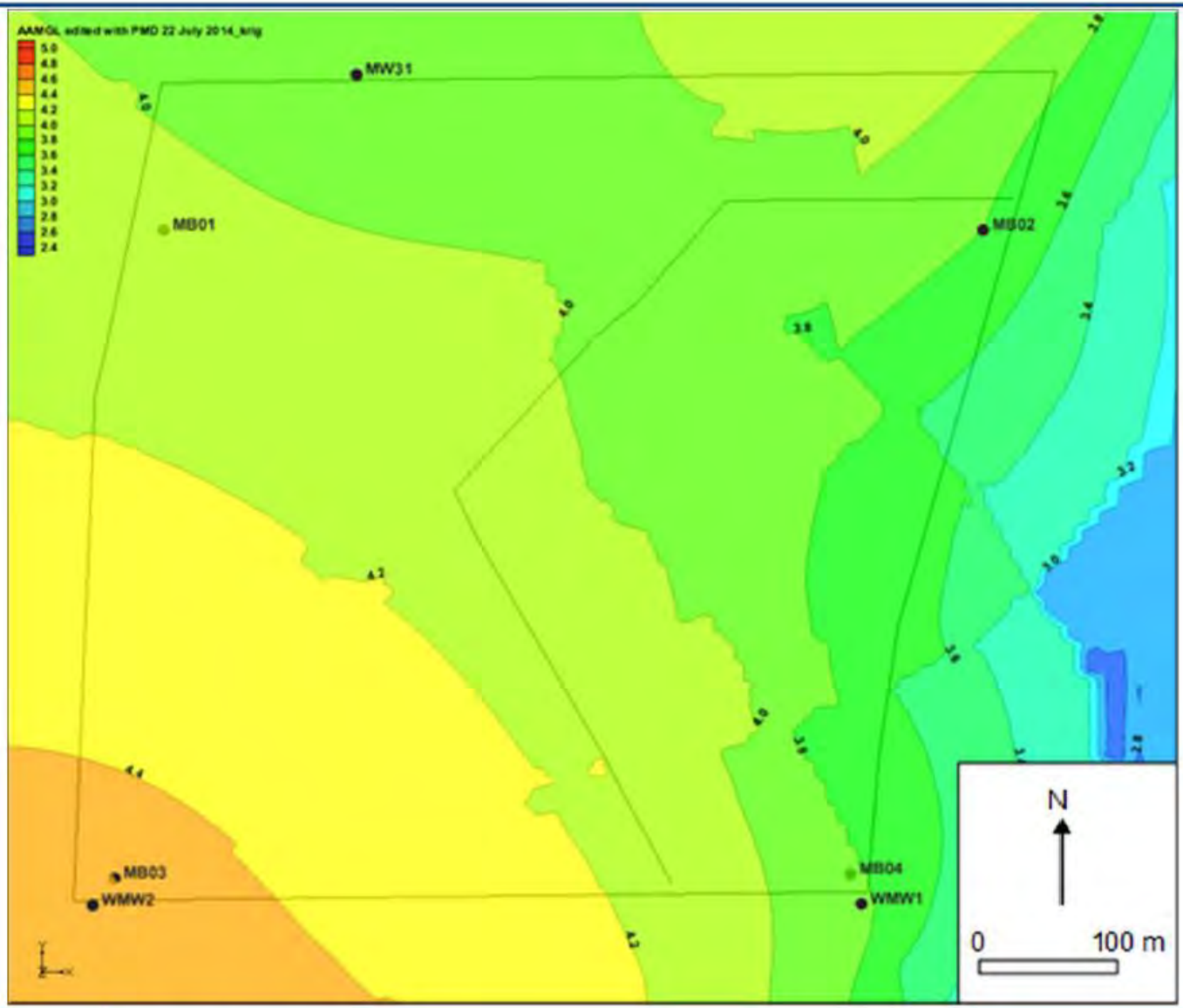
Figure 9

Monitoring Bore Locations



RPS

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Source: RPS, 2014

Figure 10

Mapped AAMGL

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APPENDIX I

Groundwater Modelling Report, Lots 746–750 Baldivis Road, Baldivis

GROUNDWATER MODELLING REPORT

Lots 746–750 Baldivis Road, Baldivis

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Report No: D1401204
Version/Date: Rev 0, October 2014

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	Draft for Client Review	CarDav	JenLon	11.09.14	SN 12.09.14		
Rev 0	Final for Issue	ShaMcS	CarDav	06.10.14	SN 07.10.14	C. Davies	07.10.14

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SUMMARY

Mirvac Pty Ltd proposes to progress the residential development of Lots 746–750 Baldivis Road, Baldivis that covers approximately 37 hectares of land. The site is located approximately 40 kilometres south of the Perth Central Business District in the City of Rockingham.

Groundwater across the site is generally at a shallow depth, with surface expressions in winter. Coupled with the expected increase in groundwater recharge rates associated with urban development, groundwater levels at the site will need to be controlled. This will be achieved by the installation of subsurface drains.

A computer generated groundwater flow model has been used to assess the impact of the subsurface drains on controlling groundwater. The groundwater modelling predicts that urban development will cause groundwater levels to rise, resulting in inundation of the site. The subsurface drainage system as designed by the site engineers (Development Engineering Consultants) is predicted to inhibit inundation in areas outside of Public Open Space (POS). For an average winter rainfall event, the model predicts groundwater clearance to exceed 0.8 m, except for POS and some areas at the south and north-west of the site. For a high winter rain event (1991 rainfall), the model predicts groundwater clearance to exceed 0.8 m over most of the site, except for POS and areas at the south, centre and north-west of the site.

The modelling does not include the proposed subsurface drainage in the location of the existing Sub H drain. Although this subsurface drain is at a relatively low elevation (~2.5 mAHD), it may not be free flowing for extended time periods; hence inclusion of subsurface drainage into the model at this location is not considered appropriate.

The model results (Scenario 1 and 2) are sensitive to the presence and functionality of the subsurface drains; as such, it is important the drains are constructed properly and are free from significant clogging.

Limitations

Interpreting the results of a groundwater model requires some caution. There is an inherent compromise between the complexity of the actual hydrogeological system and the relative simplicity of a computer model. This can be particularly important when relatively large cells with homogeneous properties are used to model heterogeneous geological materials. Also, many of the model parameters are not known with detailed accuracy across the model domain, instead the parameters are adjusted during calibration of the model to simulate the observed behaviour. Despite these limitations, groundwater modelling, when properly applied, is a versatile and powerful tool that often provides the best available answer to complex problems.

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APPENDIX 1: Bore Logs

1.0 INTRODUCTION

Mirvac Pty Ltd proposes to progress the residential development of Lots 746–750 Baldivis Road, Baldivis that covers approximately 37 hectares (ha) of land. The site is located approximately 40 kilometres (km) south of the Perth Central Business District in the City of Rockingham.

Groundwater across the site is generally at a shallow depth, with surface expressions in winter. Coupled with the expected increase in groundwater recharge rates associated with urban development, groundwater levels at the site will need to be controlled. This will be achieved by the installation of subsurface drains.

The objective of this report is to assess the impact of subsurface drainage on controlling groundwater levels at the site and is intended to support the Local Water Management Strategy (LWMS) and subsequent Urban Water Management Plans (UWMPs). A computer generated groundwater flow model has been completed with the following approach:

- construction of a calibrated pre-development groundwater flow model
- construction of a model that incorporates urban recharge rates and importation of sand fill, but no subsurface drainage, in order to predict groundwater levels without subsurface drainage
- incorporation of subsurface drainage to the model and prediction of the impact on controlling groundwater levels.

2.0 BACKGROUND

2.1 Site Description

2.1.1 Location and Land Uses

The site is presented in Figure 1 and encompasses approximately 37 ha of land that is bound by Baldivis Road to the west, the Kwinana Freeway to the east and cleared land to the north and south. The site is located within the City of Rockingham, approximately 40 km south of the Perth Central Business District (Figure A). The proposed development plan is shown on Figure B.

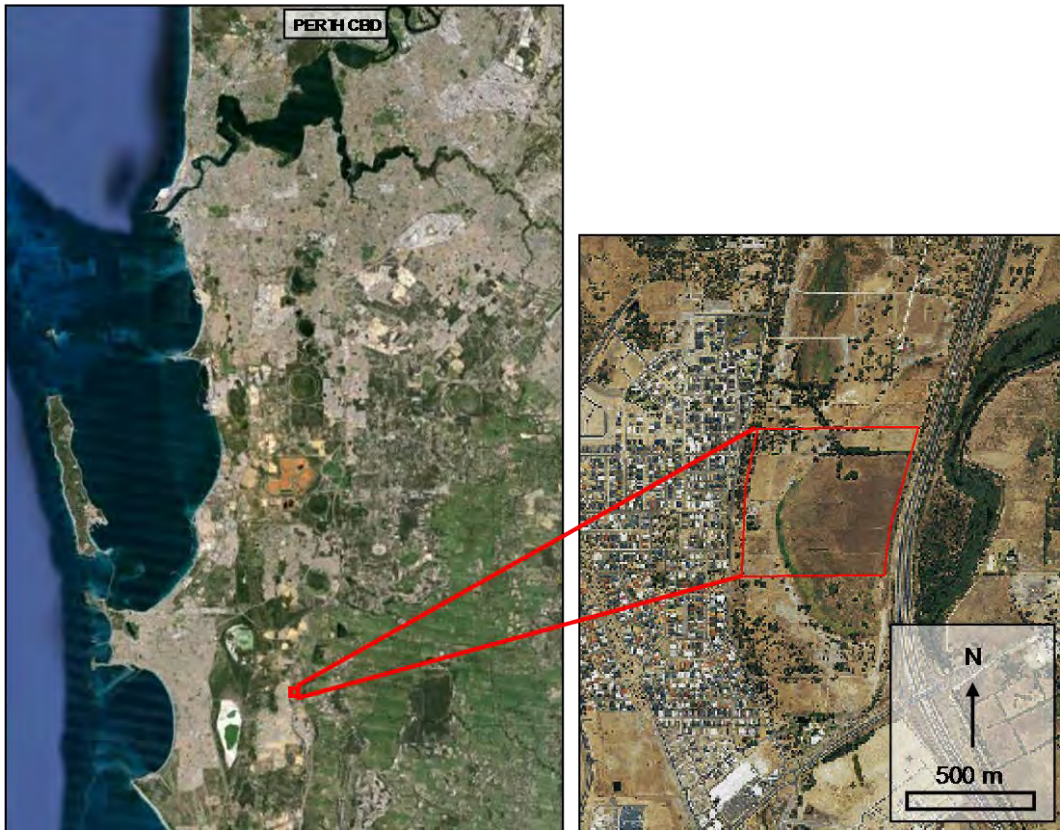


Figure A: Site Location

Figure B: Proposed Development Plan (Source DEC)

Historically the land has been used for agriculture/broad scale farming purposes and consequently the majority of the land has been cleared. The Tramway Nature Reserve is parallel to Baldivis Road along the western boundary of the site and contains patches of vegetation in "Good" condition; however, the majority of the Tramway Reserve opposite the land holdings has been historically cleared.

2.1.2 Topography

The site is low-lying and is consequently subject to seasonal inundation in some areas. Topography (interpreted from LiDAR) is elevated (up to ~ 9.5 mAHD) within the Bassendean Sand ridge along the western edge of the site. Elevations within the clayey area range from approximately 5 mAHD along the eastern boundary of the site, down to approximately 3.5 mAHD in the site's central portion, forming a localised basin.

Site topography has been modified by constructing open drains across the site to manage drainage. The Sub F drain runs generally north–south through the low-lying centre of Lots 748, 749 and 750, with a base elevation (interpreted from LiDAR) of between approximately 3 and 3.7 mAHD. The Sub H drain traverses the northern Lot 545 in a west–east direction with an elevation ranging from approximately 2.8 mAHD (west) to 2.4 mAHD (east). Water from this drain discharges to the Peel Main Drain via a culvert with an invert of 2.37 mAHD. Figure C shows the site topography.

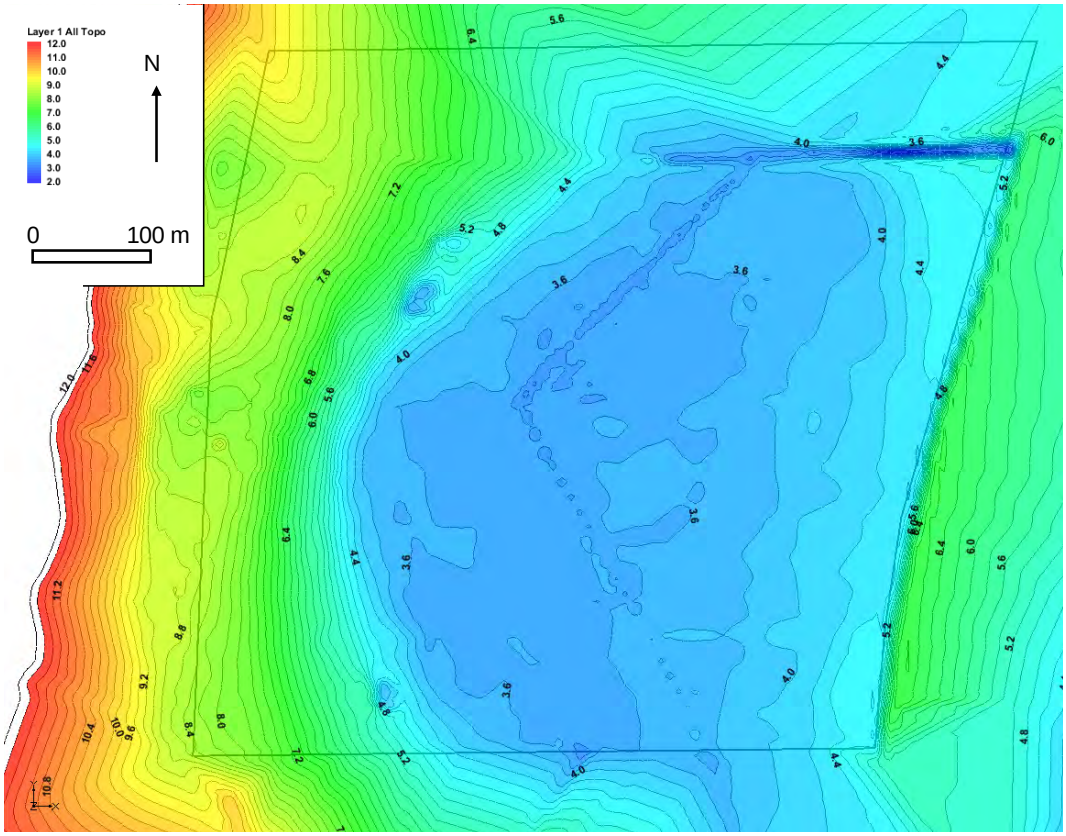


Figure C: Site Topography

2.2 Climate and Rainfall

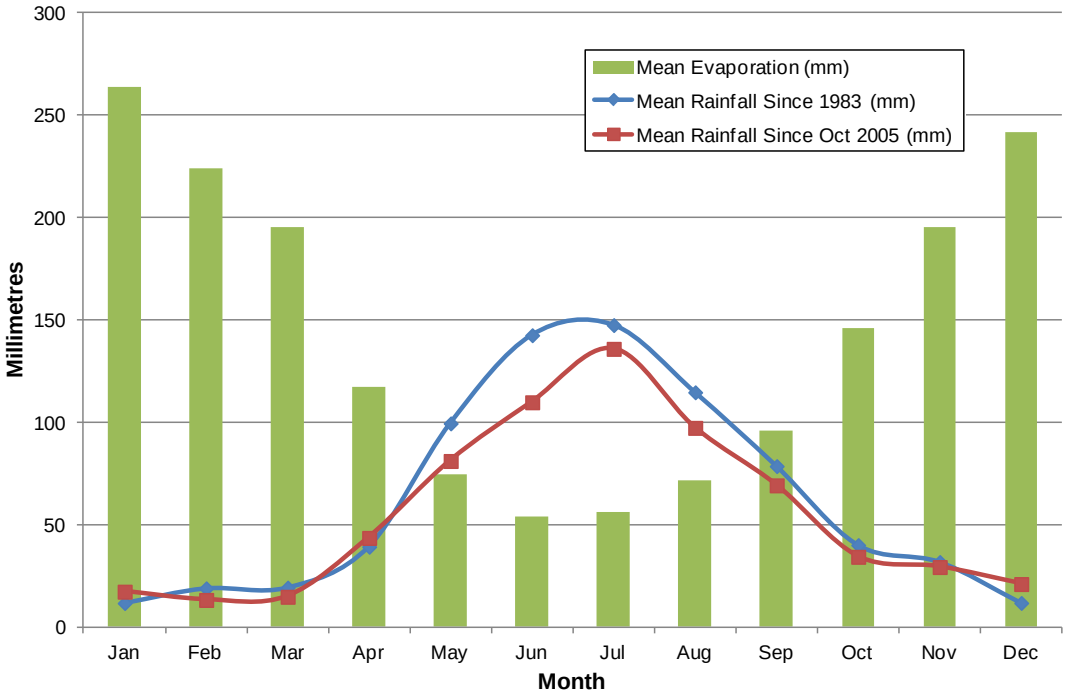
The nearest weather station to the site is the Medina Research Centre (Site 9194), located approximately 7 km to the north-north-west of the site. The area is characterised by a temperate climate, with a distinctly dry and hot summer, and cold and wet winter. The monthly mean maximum temperature since 1983 (when the weather station began operating) is 31.5 °C, recorded in February. The monthly mean minimum temperature is 8 °C recorded in August.

The average annual rainfall since 1983 is 758 mm. The average annual rainfall since October 2005, which is the starting time of the groundwater model and encompasses the time period of most of the local monitoring, is 663 mm. The pan evaporation rate is 1734 mm/yr (1983 to present).

A climate summary is provided in Table 1 and Graph 1.

Table 1: Climate Summary

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall since 1983 (mm)	12	19	19	39	99	143	147	115	79	40	32	12	758
Mean rainfall since Oct 2005 (mm)	17	13	15	44	81	110	136	97	69	34	29	21	667
Mean evaporation (mm)	264	224	195	117	74	54	56	71	96	146	195	242	1734
Mean maximum temperature (°C)	30.6	31.5	29.4	25.6	22.1	19.3	18.3	18.8	20.3	22.6	25.9	28.1	24.4
Mean minimum temperature (°C)	17.0	17.6	15.9	13.3	10.5	9.1	8.2	8.0	9.1	10.3	13.3	15.1	12.3



Graph 1: Rainfall and Evaporation

2.3 Geology

2.3.1 Regional Mapping

Department of Industry and Resources (DoIR) geology mapping (DoIR 1999) indicates the eastern two-thirds of the site is underlain by brown clay of the Guildford Formation. The Bassendean sand is exposed along a north–south ridge near the western edge of the site. It is a light grey, fine to medium-grained sand of eolian origin.

Regionally, the Tamala limestone is exposed at the western part of the model domain and is a hard crème limestone of eolian origin. The Spearwood sand, which is derived from the Tamala limestone, is exposed along the centre and southern areas of the

model domain and it typically overlies the Tamala Limestone at depth. It is a pale yellowish brown, medium to coarse-grained sand. The Bassendean sand is exposed along a thin band through the eastern part of the model domain. Brown clays and silts of the Guildford Formation occupy a north–south band adjacent to the Peel Main Drain. Regional surficial geology mapping is shown on Figure D.

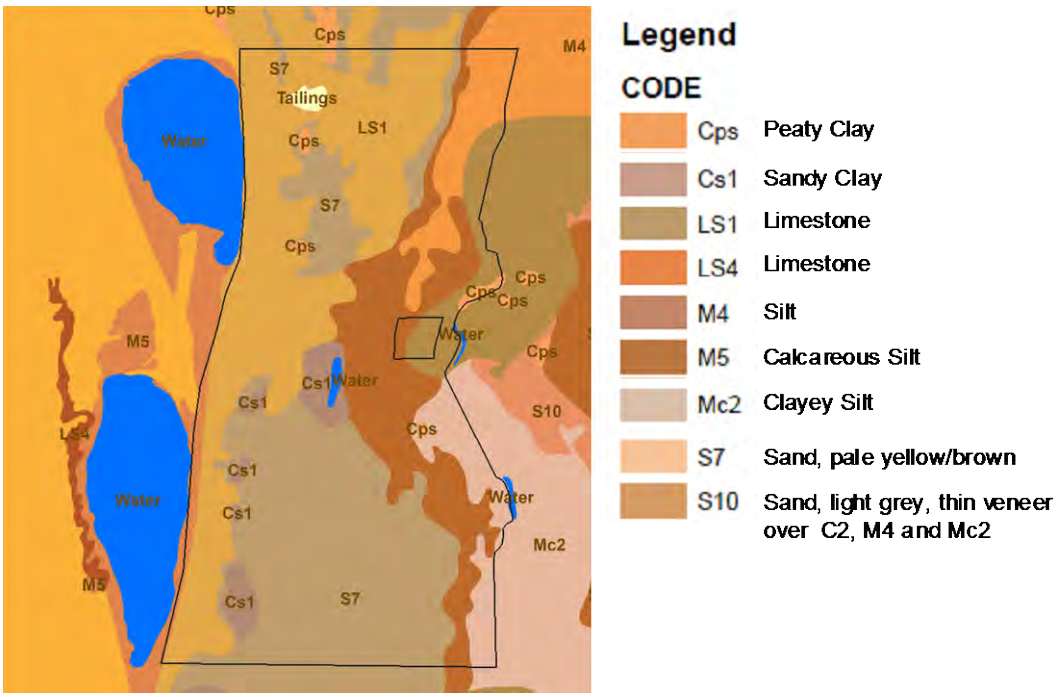


Figure D: Regional Surficial Geology

According to Davidson (1995), the superficial formations across most of the model domain are underlain by the Pinjar Member of the Leederville Formation. The Pinjar Member consists of discontinuous, inter-bedded sandstones, siltstones and shales. The base of the superficial formations ranges from an elevation of approximately -20 mAHD at the western side of the model domain to -10 mAHD at its eastern side (DoW 2014a).

2.3.2 Local Investigations

Structerre (2014) carried out a Geotechnical Investigation across Lots 746 to 750 on 1 and 2 April 2014. The work consisted of:

- six electric friction cone penetrometer tests (EFCPT) to a maximum depth of 6.2 m for material assessment and soil profiling
- 10 excavated test pits to a depth of up to 3.0 m for material assessment and soil profiling

- two dissipation tests to determine the coefficient of permeability and consolidation of the clayey materials

- 10 dynamic cone penetrometer tests (DCPT) to a depth of 3.0 m for evaluation of relative densities of the upper layers.

Local geological information has been obtained from twenty soil borings (C01 to C20) completed as part of acid sulfate soil investigations (RPS 2014). The depths of these soil bores ranged from 5 to 7 metres below ground level (mbgl), and four were converted to groundwater monitoring bores, referred to as MB01 to MB04.

Interpretation of the test pits, soil bores and monitoring bores (30 locations on site) indicates the eastern flood plain is underlain by a thin veneer of sandy silt, which overlies sandy clays of the Guildford Formation. The western ridge is underlain by Bassendean sand to a depth of at least 7 mbgl. Figure E and Figure F show the local geology in plan and oblique view respectively. The curved red line in these figures shows the contact between the Bassendean sand ridge and the Guildford Formation flood plain. Bore logs are provided in Appendix 1.

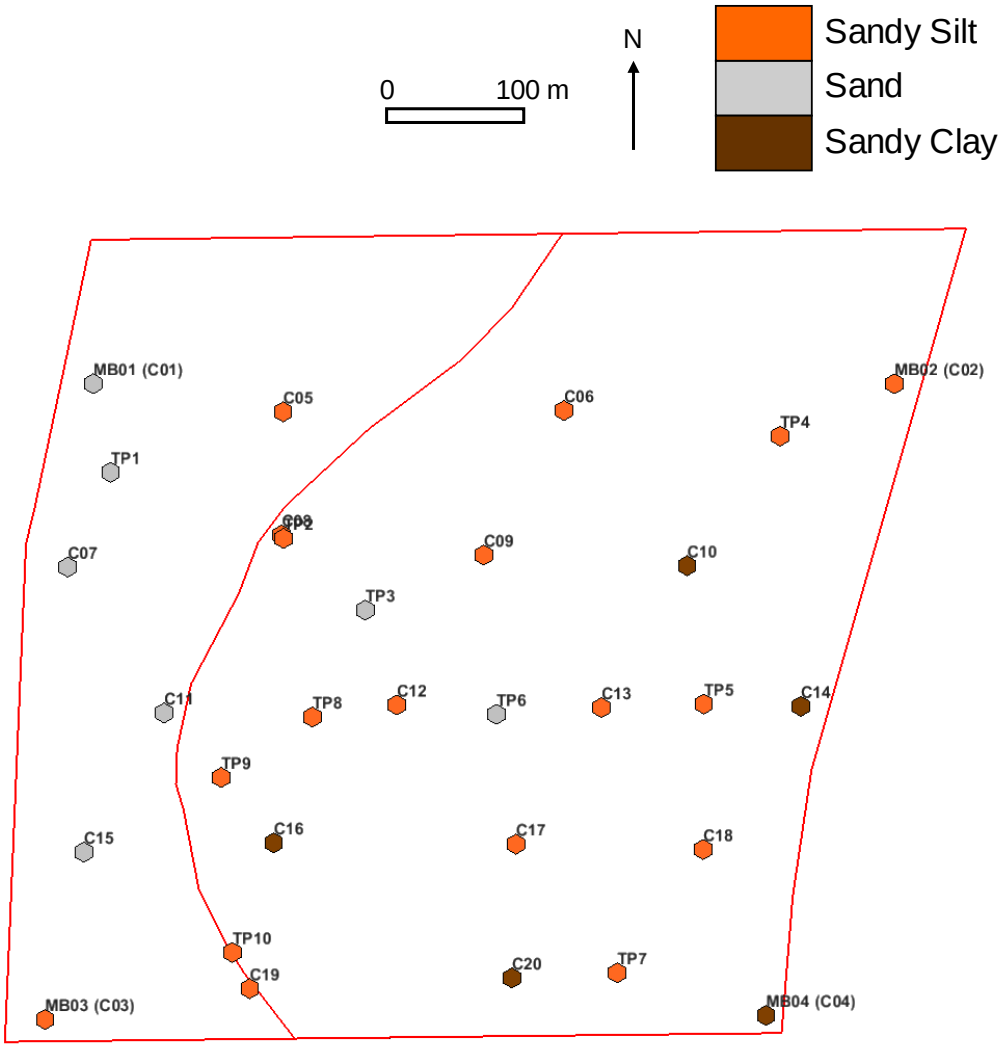


Figure E: Local Surficial Geology – Plan View

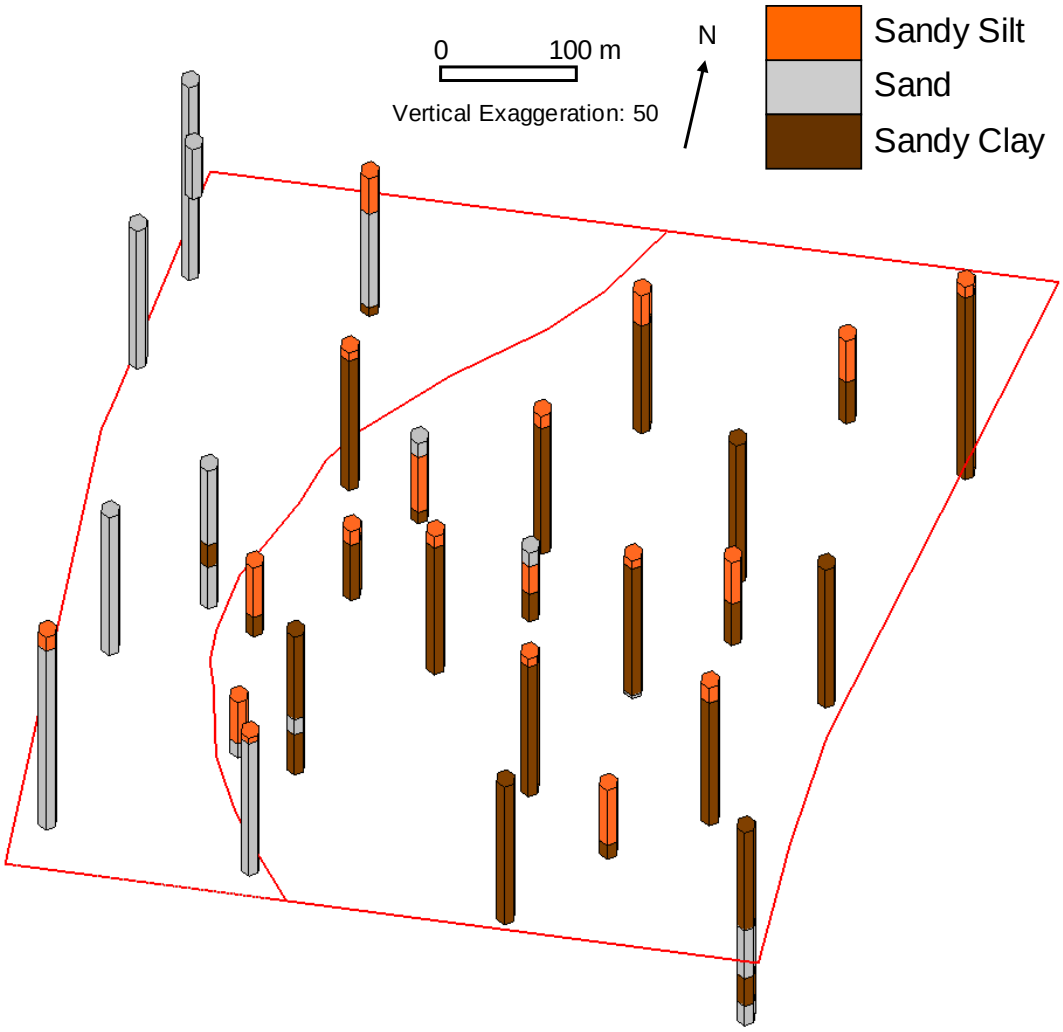


Figure F: Local Surficial Geology – Oblique View

2.4 Hydrogeology

2.4.1 Regional

According to regional information provided by Davidson (1995), the site lies between the Stakehill and Jandakot Mounds. The regional groundwater contours in May 2003 (the end of summer) provided by DoW (2014a) show that groundwater migrates to the west and is at an elevation of approximately 3 mAHD beneath the site.

The site is located within the Stakehill Groundwater Area and more specifically the Tamworth Swamp and Stakehill Confined sub-areas. The aquifers within each respective groundwater sub-area comprise the Superficial Swan (Tamworth Swamp), and the Cattamarra, Leederville and Yarragadee North Aquifers (Stakehill Confined).

The nearest Public Drinking Water Source Protection Area (PDWSA) is the Jandakot Underground Water Pollution Control Area, located approximately 9 km to the north-north-east (DoW 2014a).

2.4.2 Local

2.4.2.1 Monitoring Program

Groundwater levels have been monitored as follows:

- from six bores (WMW1 to WMW6) in the landholding immediately south from May 2012 to April 2013, capturing the 2012 annual high
- from four on-site bores (MB01 to MB04) that were installed as part of the ASS investigations, on April 2013 and July 2014. Monitoring bores MB03 and MB04 were installed in immediate proximity to WMW2 and WMW1 respectively
- from seven bores immediately north (MW25 to MW31) and one bore immediately south (MW32) of the site. Monitoring was undertaken from September 2005 to February 2007, capturing annual high groundwater levels in 2005 in 2006. Sampling was also undertaken from these bores in October 2010
- sampling by DoW from three regional bores; from 1975 to 2013 (two bores) and 1975 to 2008 (one bore)
- Peel Main Drain elevations as interpreted from Folly Pool monitoring data from 2002 to 2013.

Bore locations are shown on Figure G.

2.4.2.2 Pre-development AAMGL

The Maximum Groundwater Level (MGL) and Average Annual Maximum Groundwater Level (AAMGL) have been calculated using July 2014 on-site monitoring, correlated to adjacent bores that have two winter highs of monitoring data.

Groundwater levels from on-site bores (MB03 and MB04) measured in July 2014 were compared with the AAMGL calculated from 2012 and 2014 monitoring at WMW1/MB04 and WMW2/MB03. This is because monitoring bores MB03 and MB04 were installed in immediate proximity to WMW2 and WMW1 respectively. The comparison shows that July 2014 levels at MB03 were 0.08 m higher than the AAMGL measured over two winter peaks, while July 2014 levels at MB04 were 0.06 m lower.

This indicates that July 2014 levels were very similar (< 0.1 m difference) to the AAMGL measured over two winter peaks (2012 and 2014). Consequently, the July 2014 measured levels in the other on site bores (MB01 and MB02) are considered appropriate to use as an AAMGL. Table 2 summarises the AAMGL and MGL information and Figure G shows the monitoring bore locations.

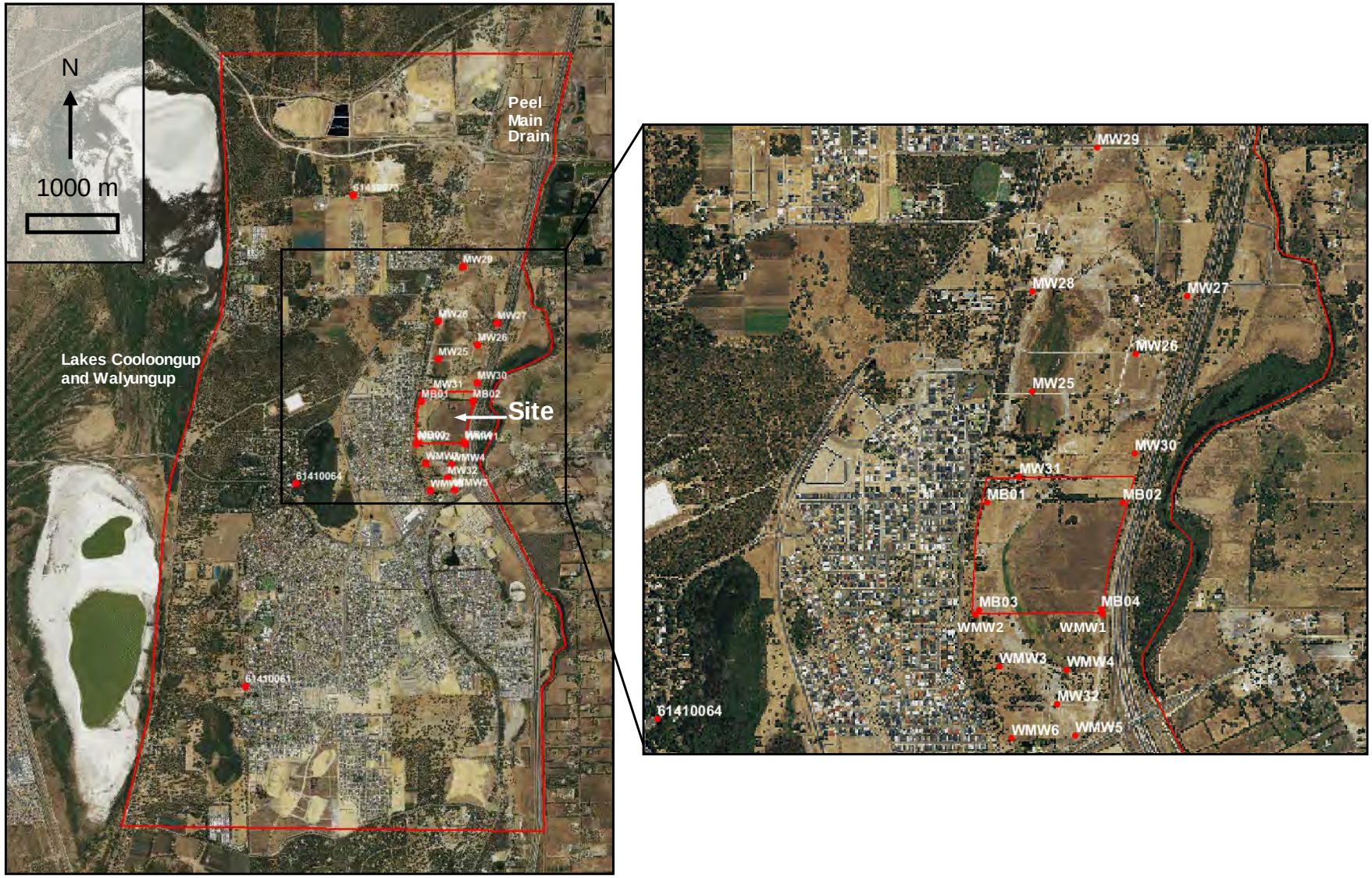


Figure G: Monitoring Bore Locations

Table 2: AAMGL and MGL Calculation

Name	Year of Annual High Monitored	AAMGL (mAHD)	MGL (mAHD)	AAMGL Minus 2014 Site Monitoring (m)
61410061	1975 to 2008	2.43	3.13	
61410064	1975 to 2013	2.54	3.03	
61410073	1975 to 2013	2.04	2.93	
MB01	2014	3.92	3.92	
MB02	2014	3.68	3.68	
MB03	2014	4.56	4.56	
MB04	2014	3.84	3.84	
WMW2/MB03	2012, 2014	4.49	4.56	-0.08
WMW1/MB04	2012, 2014	3.89	3.95	0.06
WMW1	2012	3.95	3.95	
WMW2	2012	4.41	4.41	
WMW3	2012	4.41	4.41	
WMW4	2012	4.42	4.42	
WMW5	2012	4.38	4.38	
WMW6	2012	4.35	4.35	
Folly Pool (Peel Main Drain)	2002 to 2013	2.82	3.54	

Figure H shows the AAMGL calculated from monitoring bores without considering influence from the on-site drains. The AAMGL was calculated by interpolating between monitoring bores using the Kriging method. The lack of smoothness along contour lines is a function of the interpolation method. The lines within the site are the approximate locations of the Sub F and Sub H drains.

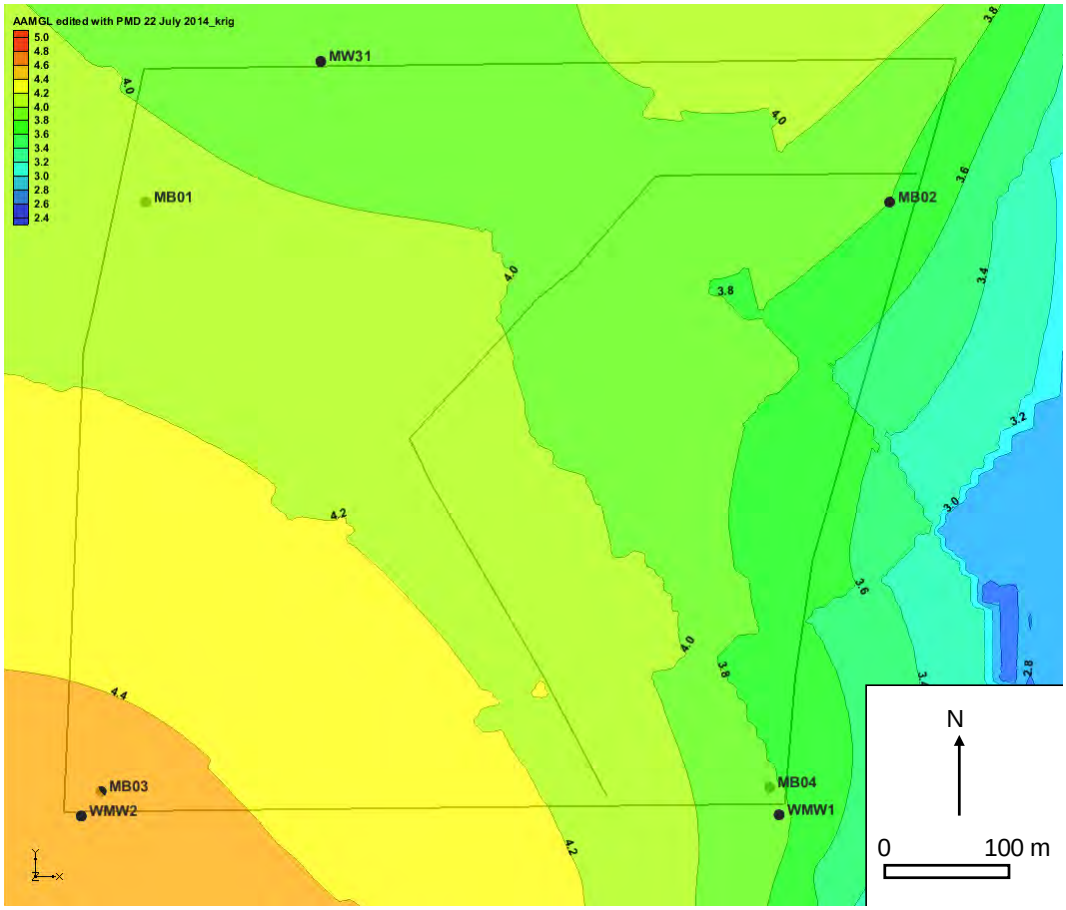


Figure H: Site AAMGL (mAHD)

The AAMGL is calculated to range from approximately 4.5 mAHD at the south-west corner of the site to 3.6 mAHD along the eastern boundary, with groundwater migrating to the east-north-east towards the Peel Main Drain.

The local groundwater elevation is significantly higher than regional monitoring shows and the local flow direction is towards the east, not the west as is indicated in the regional mapping (DoW 2014a). This is due to local groundwater mounding, with discharge being particularly impeded to the east due to the presence of low permeability soils adjacent to the Peel Main Drain.

Based on the AAMGL method of calculation, the AAMGL exceeds the topography over large areas of the site. This is because the AAMGL calculation interpolates directly between monitoring bores, while the site itself is depressed in its central area.

Figure I shows the areas where the calculated AAMGL exceeds the topographic surface. The calculated AAMGL exceeds the topographic surface by up to approximately 0.7 m in the central areas of the site and up to 1.8 m at the base of the Sub H drain.

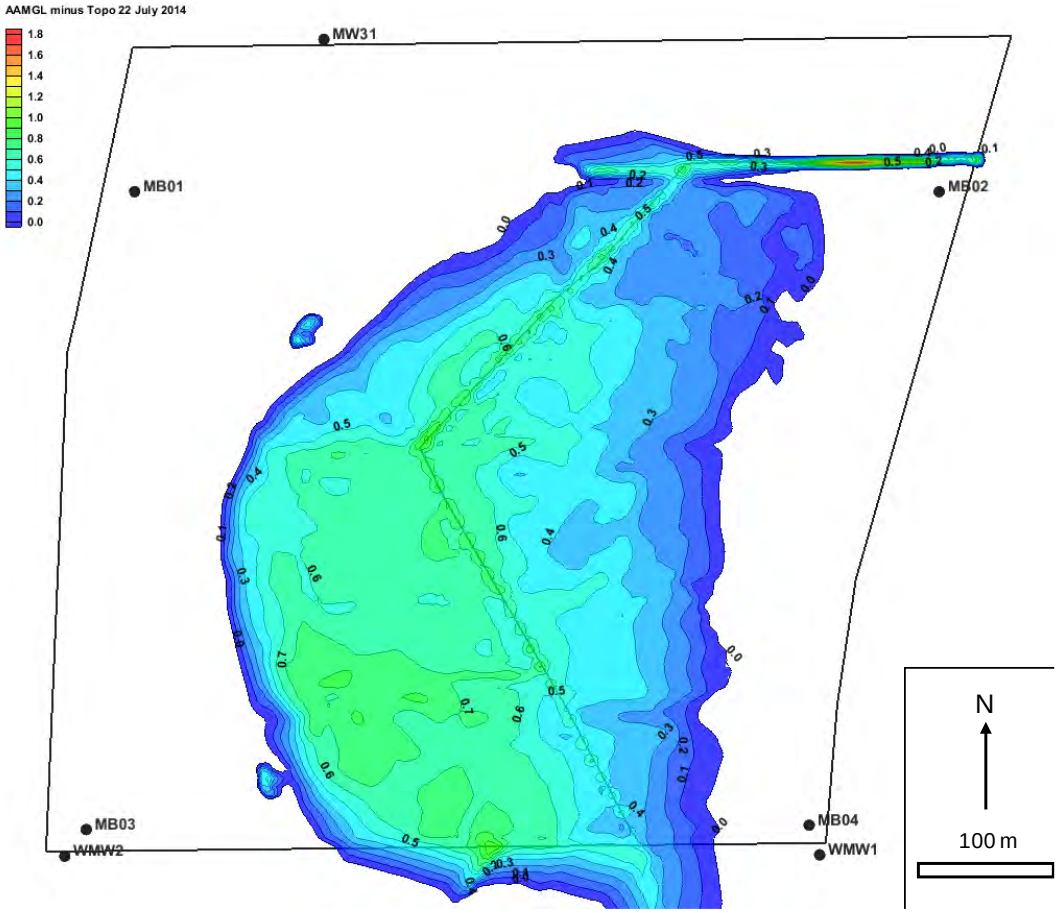


Figure I: AAMGL Minus Topo (m)

It is proposed to set the post-development Controlled Groundwater Level (CGL) at either the AAMGL or the topographic surface (whichever is lower). Figure J shows the minimum of AAMGL or topographic surface and is the proposed CGL for the site. The CGL is the same as the AAMGL over the eastern and western site boundaries, which are adjacent to the Peel Main Drain (east) and the Tramway Reserve (west) respectively.

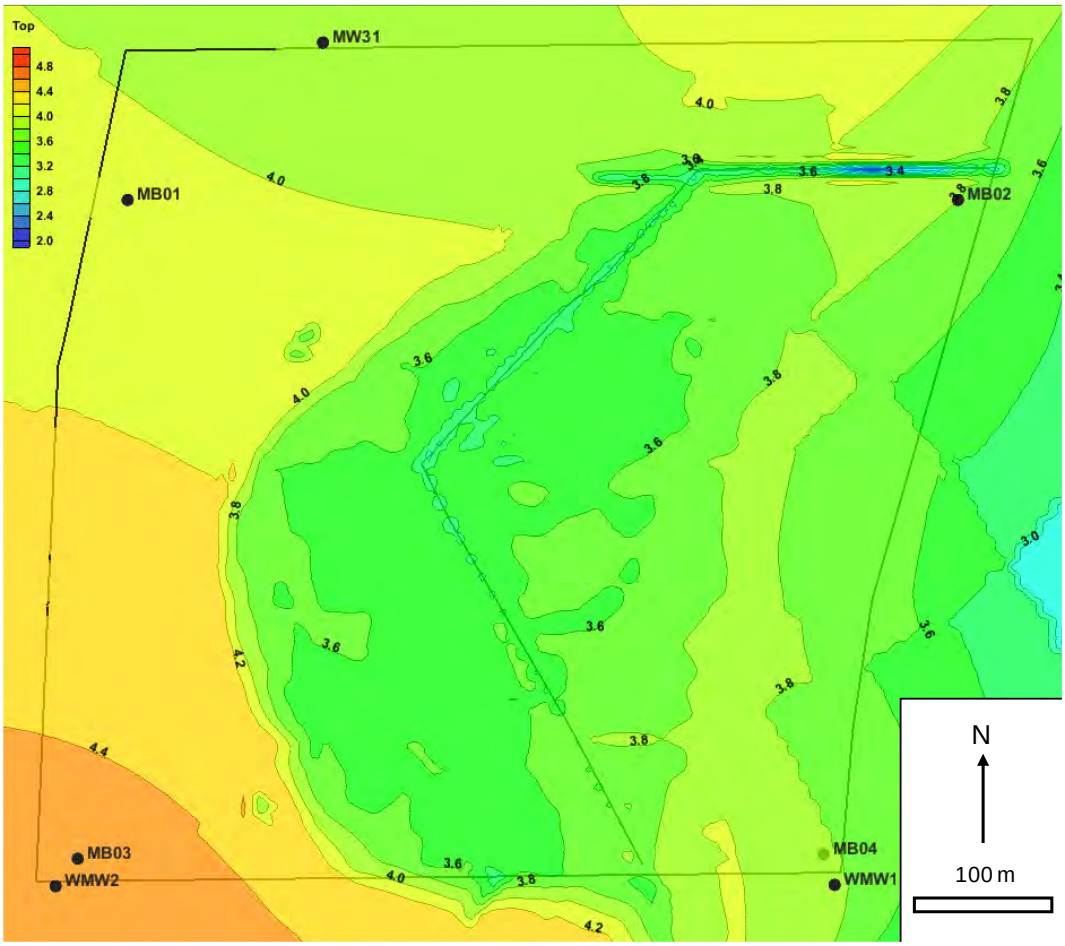


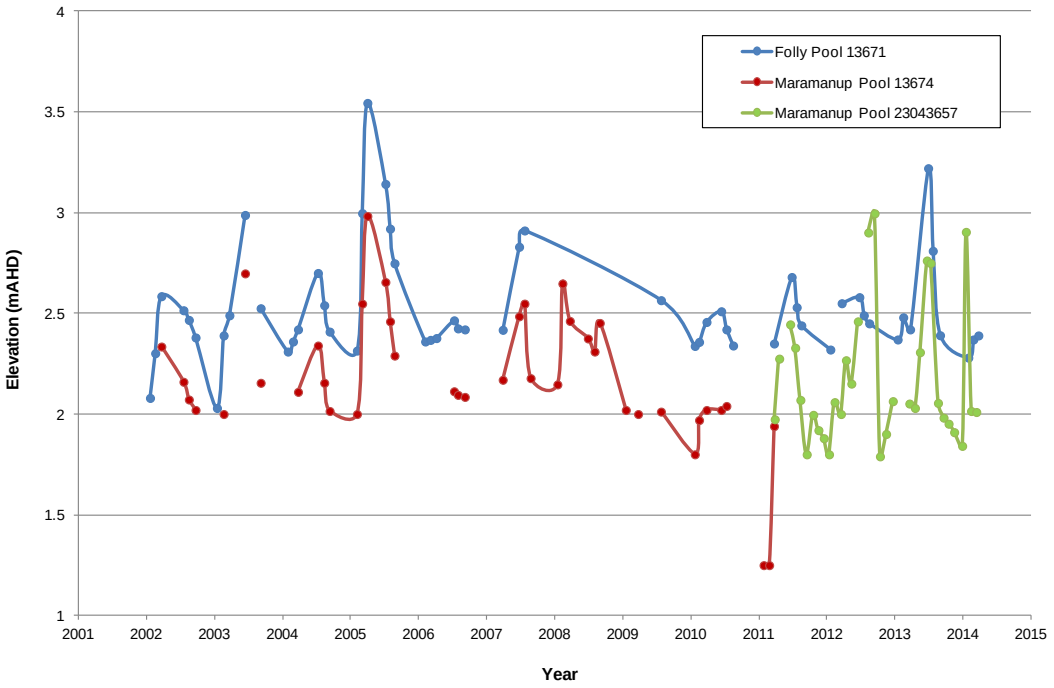
Figure J: Proposed CGL (mAHD)

Despite pre-development depth to groundwater being very low, with inundation of areas of the site, groundwater levels are expected to rise even further with urban development due to the increase in shedding surfaces and higher infiltration rates associated with imported sand fill. On this basis, it is likely that groundwater levels will need to be controlled by a combination of fill material and subsurface drainage.

2.5 Surface Hydrology and Wetlands

2.5.1 Drainage

The site is located within the Peel Estuary–Serpentine River Catchment and Peel Main Drain Sub-catchment. The Peel Main Drain (PMD) is situated east of the site and drains stormwater run-off from the catchment into the Serpentine River and ultimately the Peel–Harvey Inlet. The PMD is a major drainage system that is owned and managed by the Water Corporation. It was constructed in the 1930s to facilitate agricultural development within the surrounding waterlogged land. The PMD currently flows alongside the Kwinana Freeway, into Folly Pool and then re-forms into the PMD after Folly Road. Graph 2 shows hydrographs of Folly Pool located directly east of the site and Maramanup Pool further south.



Graph 2: Peel Main Drain Levels

The drainage on the site is managed through the Sub H and Sub F drains. The Sub H drain traverses the northern Lot 545 and the Sub F drain traverses through the low-lying centre of Lots 748, 749 and 750. Stormwater run-off flows into the Sub H and F drains which then flows out of the site, via a culvert beneath the Kwinana Freeway to Folly Pool and ultimately the PMD.

2.5.2 Flood Mapping

Flood mapping provided by DoW indicates the 100 year ARI flood plain level at the site is approximately 3.75 mAHD. Habitable floor levels will need to provide a minimum separation of 0.5 m AHD above the 100 year flood level. Figure K shows flood levels as provided by DoW (2014b).

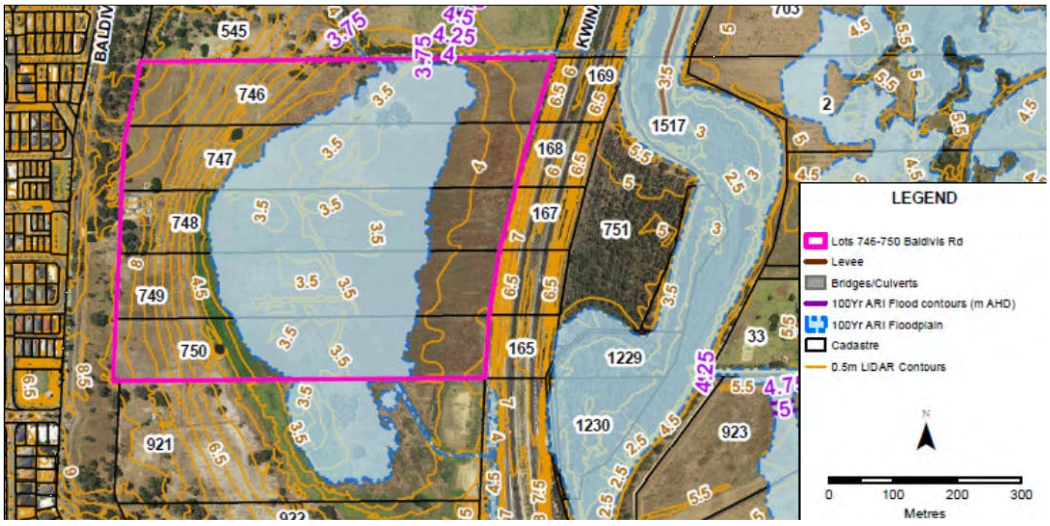


Figure K: Flood Mapping (Source DoW 2014b)

2.5.3 Wetlands

The low-lying areas of the site are part of a larger multiple use management category Palusplain (UFI 15785). The nearest Conservation Category Wetland (CCW) is Folly Pool, located a minimum of 120 m east of the site. Folly Pool is also classed as an Environmental Protection Policy wetland. Currently, stormwater run-off flows from the Sub H and F drains and subsequently into Folly Pool.

2.6 Flora and Vegetation

Because of the historical land uses (particularly agricultural activities), the majority of the site has been cleared. Remnant vegetation exists in the north-eastern corner of the site however the remaining area is degraded with only scattered vegetation throughout.

The Tramway Nature Reserve runs parallel to Baldivis Road and it is situated in the road reserve adjacent to the western boundary of the site. Patches of vegetation in this reserve are in good condition however, there is some evidence of disturbance. No Bush Forever Sites (BFS) are located within the development area, however approximately 35 ha of land that includes Folly Pool to the east of the site is classified as Bush Forever Site (No. 418). Around 15 ha of the BFS consist of bushland and 7 ha of EPP wetland (PB 2007).

3.0 MODEL DEVELOPMENT

3.1 Grid Design

The simulation program used for modelling the groundwater flow field was Modflow NWT (Niswonger, Panday and Ibaraki 2011) coupled with the pre- and post-processor GMS version 9.2 (Aquaveo 2014). Modflow NWT (along with the Upstream Weighting Solver) allows model simulation with the inclusion of drying and rewetting of model cells, which is necessary for this project.

The model domain is shown on Figure L.

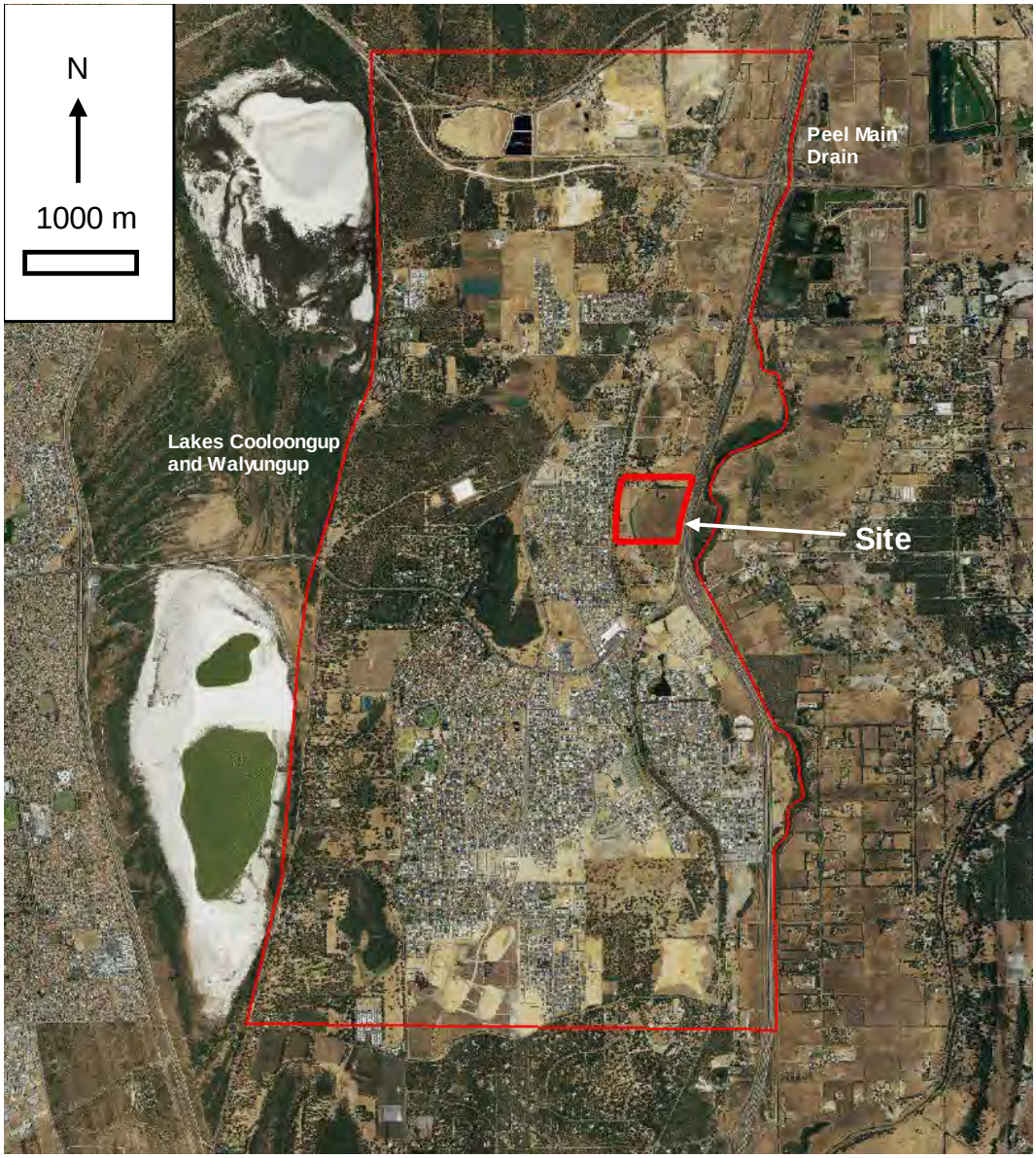


Figure L: Model Domain

The model is considered to be of moderate complexity. It is comprised of three layers, with 189 rows and 157 columns (89,000 cells), covering an area with dimensions approximately 9 km north–south, by 4 km east–west.

The model cell size increases from approximately 7.5 m within the vicinity of the site up to 120 m at the model boundaries. The grid size increases by a factor of 1.2 towards the boundaries, with less than 1.5 recommended by Anderson and Woessner (2002) for solution accuracy. The model grid in plan view is shown on Figure M, with darker areas due to small cell sizes.

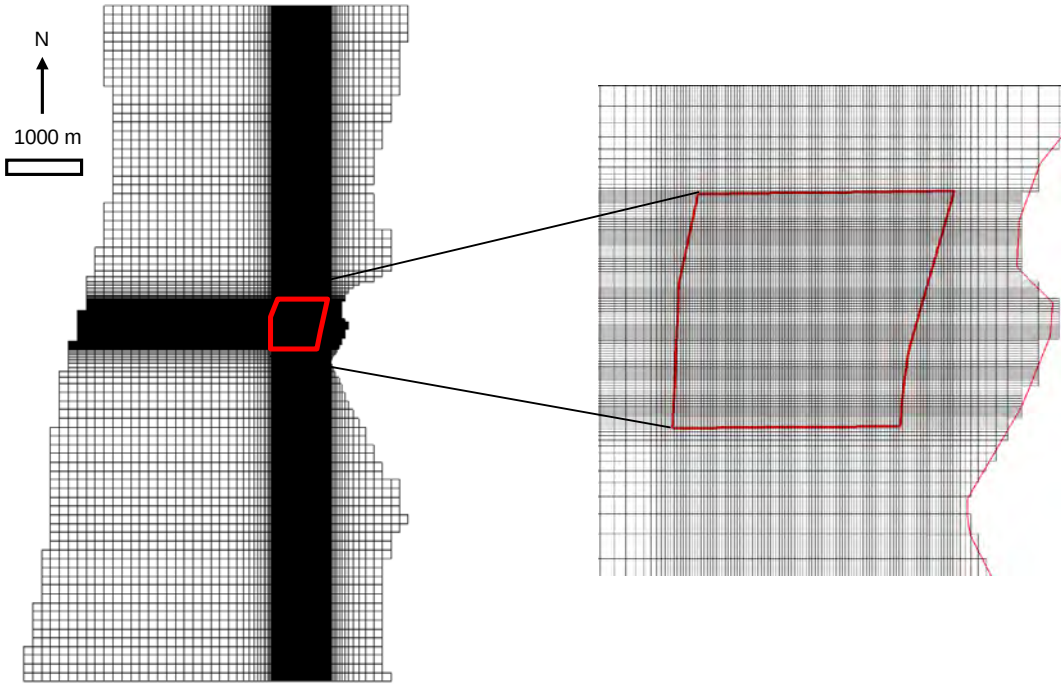


Figure M: Model Grid: Plan View

The model layers are described below and are shown on Figure N.

- Layer 1 – Bassendean sand along western edge of site and Guildford Formation over low-lying eastern area. Spearwood sand is located further west. The topographic surface of Layer 1 was interpolated from LiDAR data within the site and regional contours used over the rest of the model domain.

- Layers 2 and 3 – Bassendean sand and Guildford Formation as above with Tamala limestone further west as determined from regional bore logs.

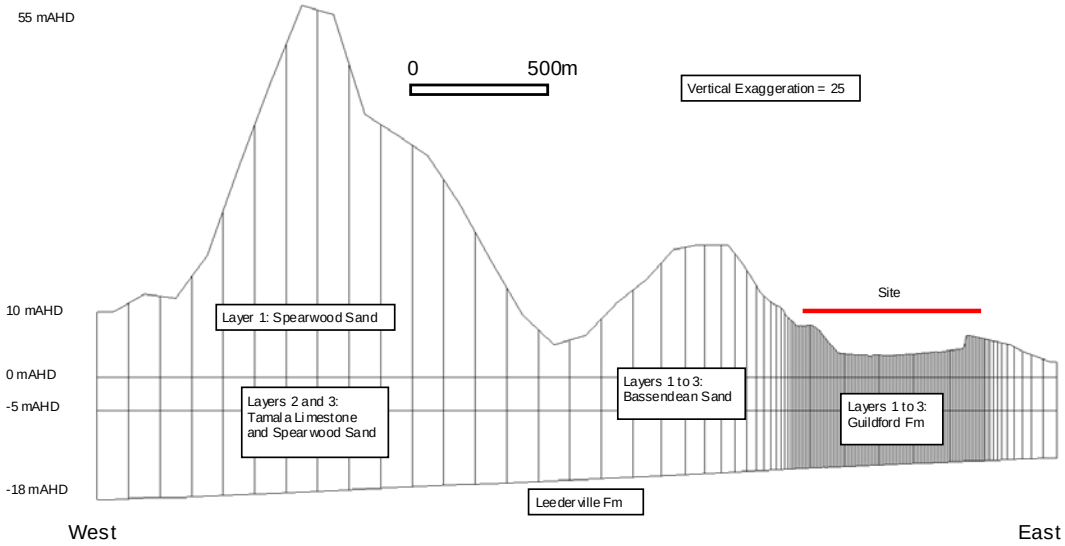


Figure N: Model Grid: West–East Cross-section through Site

3.2 Boundary Conditions

The flow model was developed with the following boundary conditions.

- western boundary – constant hydraulic head along the 1.5 mAHD contour, which corresponds to the eastern edges of Lake Walyungup and Lake Cooloongup
- eastern boundary – the Modflow River Package was used to simulate the PMD as the eastern boundary. The PMD bed elevation was provided by DoW. The assigned stage varied according to measured monthly levels from Folly Pool
- northern and southern boundaries – no flow boundaries estimated to be parallel to groundwater flow
- no-flow boundary at the base of the model coincident with the base of the superficial aquifer
- specified flow as rainfall recharge and evapotranspiration (ET) at the top of the model, with maximum ET coincident with the topographic surface.

3.3 Starting Heads and Time Steps

The base model was run as a transient simulation with monthly stress periods from October 2005 to July 2014. This period is sufficient to establish modelled groundwater trends and fluctuations. Ten time steps were used with each stress period, which is within the range suggested by Anderson and Woessner (2002) and MDBC (2000) for numerical accuracy.

The model was originally run in steady state mode, with the steady state model outputs used as starting heads for the transient simulation (October 2005).

3.4 Conceptual Hydrogeological Model

A conceptual model of the hydrogeological processes that were used as the basis of the groundwater flow model is provided in Figure O. The figure shows that water enters the system via rainfall recharge and leaves the system via groundwater outflow, abstraction and evapotranspiration. Surface run-off has not been directly incorporated in the model but has been indirectly incorporated by varying groundwater recharge rates.

The conceptual model shows the groundwater mound near the contact of the Bassendean sand and Guildford Formation. This is caused by high infiltration into the sand and low infiltration into the clays.

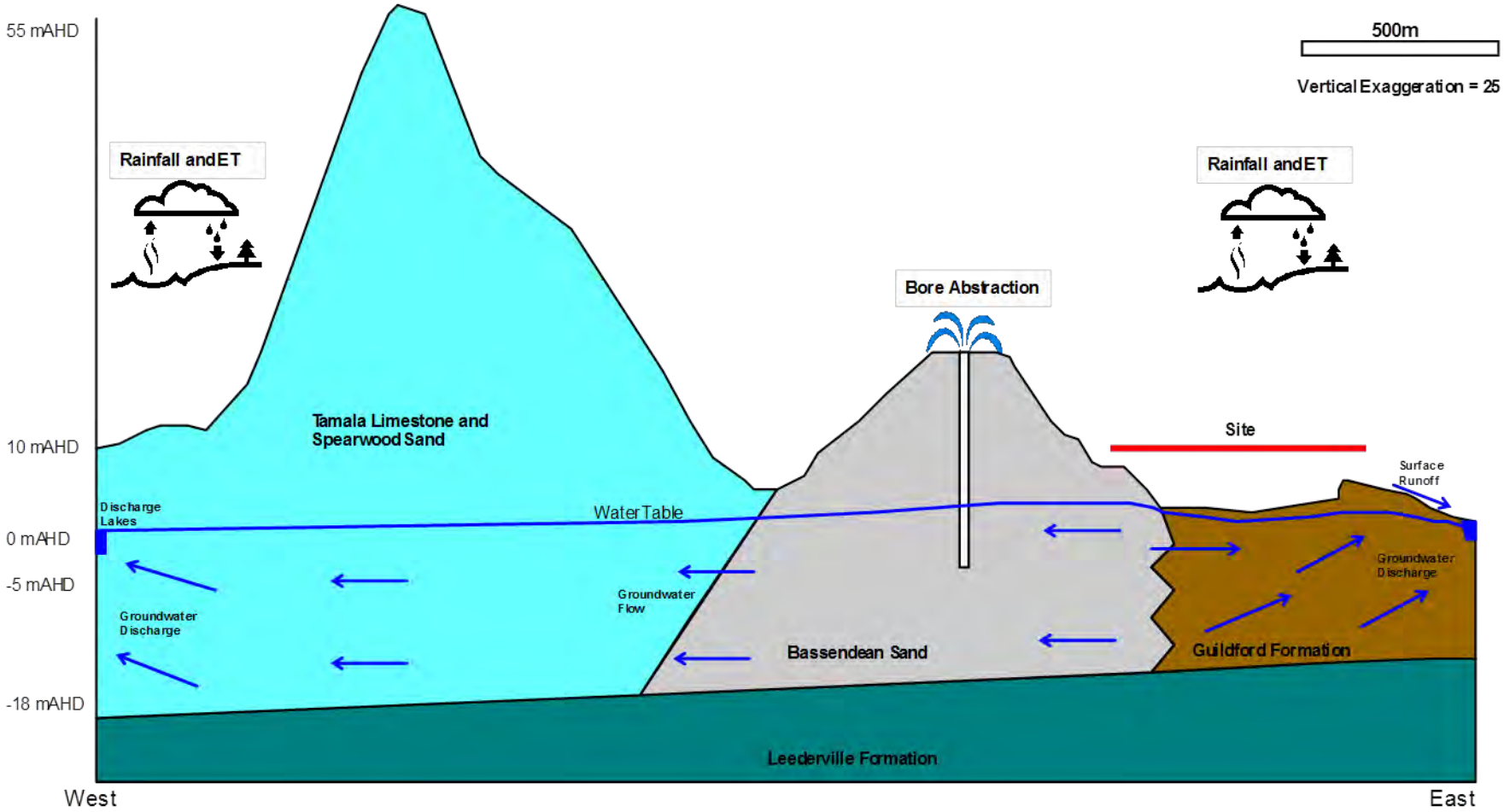


Figure O: Conceptual Hydrogeological Model

4.0 MODEL PARAMETERS

4.1 Aquifer Parameters

4.1.1 Hydraulic Conductivity

The estimated hydraulic conductivities (K) of the geologic units are as follows:

- Bassendean Sand – the estimated average provided by the Perth Regional Groundwater Model (PRAMS, Davidson and Wu 2008) is 15 m/day.
- Spearwood Sand – the K values for the Spearwood Sand used in the PRAMS model in the Mariginiup area range from approximately 7 to 15 m/day.
- Guildford Formation – the estimated range provided by PRAMS (Davidson and Wu 2008) is 0.1 to 1 m/day.
- Tamala Limestone – the estimated range provided by Davidson (1995) is 100 to 1,000 m/day.

4.1.2 Groundwater Recharge

4.1.2.1 Recharge Estimation by Groundwater Area

The site is located between the Stakehill and Jandakot Mounds. Davidson (1995) estimates recharge to the Jandakot Mound is between 0 to 24% of rainfall, with an average of 15%. The variation in recharge rates in the Jandakot Mound is due to the hydraulic conductivity of the soils and the depth to the water table. Shallow water table depths and low K materials typically result in low recharge rates. Davidson (1995) estimates the recharge rate in clayey areas of the Jandakot Mound to be 5% and in sandy areas to be 15%.

4.1.2.2 Urban Areas

Urban land use is located in large areas across the model domain. A recharge rate of 37% of annual rainfall was reported by Appleyard (1995) for (then) new urban areas in Perth. According to Silberstein et al. (2004), recharge beneath residential urban areas with sandy soils and a water table depth of more than 10 m, is estimated to be between 48 to 60% of rainfall.

4.1.2.3 Bushland

Bushland is located across the north-western area of the model domain. Recharge beneath low, medium, and high density Banksia woodland has been estimated to be approximately 38%, 18% and 10% respectively with a deep water table (Silberstein et al.

2004). Sharma and Pionke (1984) estimate 12% of rainfall recharges the superficial aquifer beneath native bushland, while Farrington and Bartle (1991) estimate 22% of rainfall recharges the aquifer beneath Banksia woodland.

4.1.2.4 Cleared Areas

Areas to the north, west and south of the site have been cleared. Recharge rates beneath pasture in the Perth area have been estimated at 45% by Silberstein et al. (2004). Based on a local investigation on pastoral land near Lake Pinjar with a water depth of between four and seven metres, Sharma et al. (1988) estimated between 50 and 60% of rainfall recharges the aquifer. Davidson (1995) states that the maximum recharge rate in the Gnangara Mound (south) is 36% for market gardens, which is due to tillage of the soil increasing recharge. This implies that recharge beneath pasture is less than this rate. Pasture/cleared areas with shallow water tables will typically have lower recharge rates than these literature values due to increased evaporation and run-off.

4.1.3 Specific Yield and Storage

The specific Yield (Sy) is the amount of water that will be drained by gravity from a material. Lower specific yield values will result in higher seasonal groundwater fluctuations and vice versa. Davidson (1995) estimates the Sy of the Bassendean Sand to be 0.2, the Tamala Limestone to be 0.25 and the Guildford Clay is estimated at 0.05. Values provided by Kresic (2007) for medium-grained sand range from 0.15 to 0.32, with an average of 0.26.

The specific storage (Ss) is the amount of water released from storage per unit volume of the aquifer per unit decline in hydraulic head, as a result of mineral skeleton compressibility. Although the superficial aquifer at the model domain is not confined, Ss is required for multilayer Modflow models. A range of 1×10^{-4} 1×10^{-6} 1/m is considered appropriate for soils of the Swan Coastal Plain.

4.1.4 Vertical Anisotropy

The vertical anisotropy (VA) is a measure of the ratio between the horizontal and vertical hydraulic conductivities. The VA can range from <10 for high permeability homogeneous material such as sand to orders of magnitude higher for horizontally layered low permeability material such as shales.

4.1.5 Groundwater Abstraction

Groundwater is abstracted from the superficial aquifer via private bores. According to the DoW (2014c) Water Register, there are approximately 161 private bores within the model domain. Figure P shows the superficial aquifer abstraction bore locations.

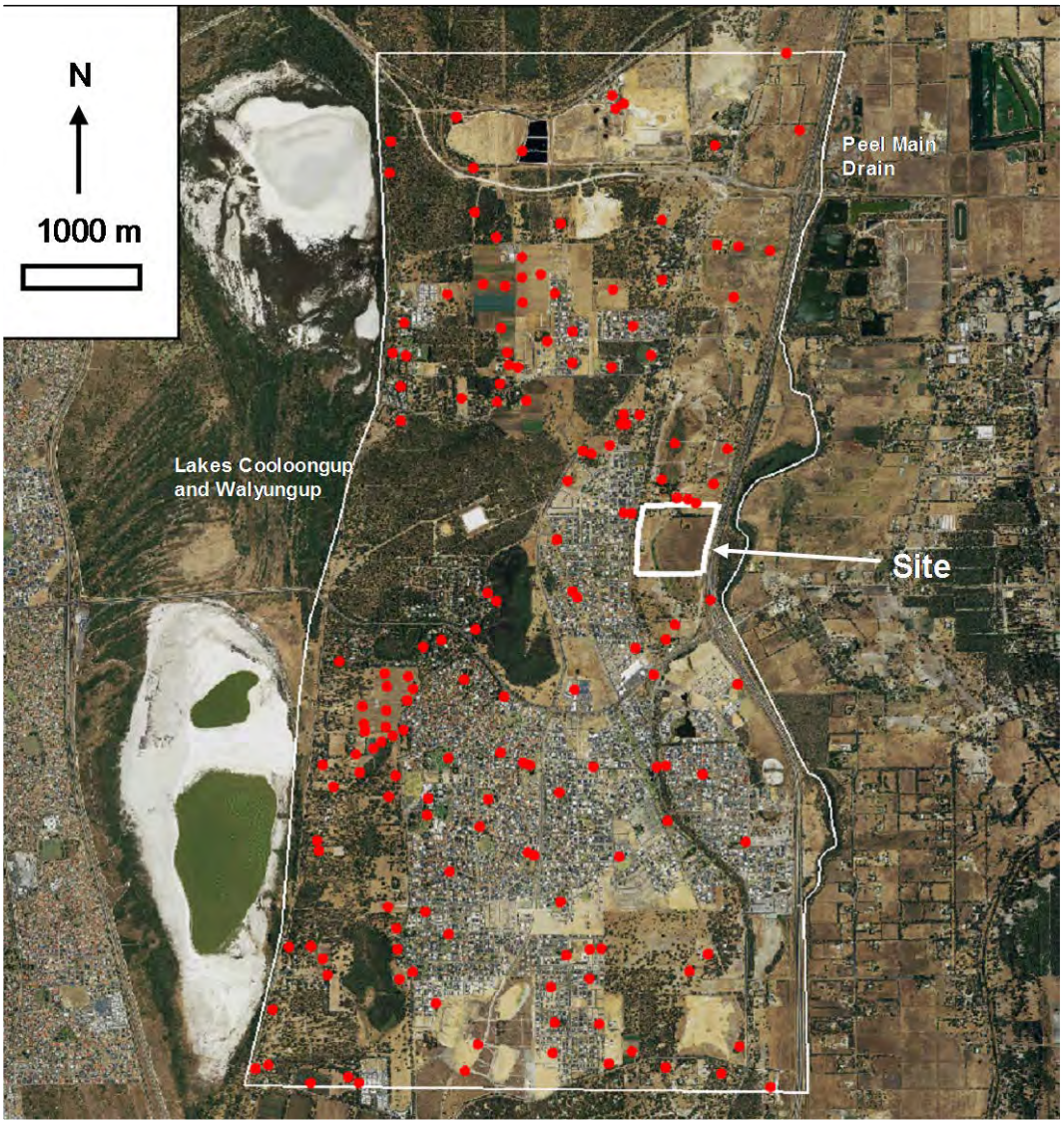


Figure P: Abstraction Locations

The pumping rates of these bores were estimated from the licensed allocation, with averages applied where more than one bore is abstracting from the one licence. Private abstraction was divided into monthly periods in the transient modelling simulation, with more abstraction in drier months, as outlined in Table 3.

Table 3: Private Bore Abstraction Ratios

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abstraction Ratio	2	2	2	1.25	0.75	0	0	0	0.5	1	1	1.5

4.1.6 Evapotranspiration

Evapotranspiration (ET) is an important process, particularly with shallow water tables and vegetated areas. Monthly pan evaporation rates measured from Medina Research Station were used as the basis of ET for the model. The actual evaporation of water

when it reaches the surface is less than the measured pan evaporation. The surface water (lake) evaporation rate is defined as the ratio of evaporation from a lake compared to evaporation from a Class A Pan. The surface water evaporation rate is less than pan evaporation due to factors such as heating of the pan sides. A value of 0.8 pan was used for surface water evaporation, which is similar to values provided by Fetter (1993) and Silberstein et al. (2004).

The Modflow (McDonald and Harbaugh 1988) ET Package was used to simulate ET. In this package, a user defined ET rate and elevation is applied, with the rate decreasing linearly to some extinction depth, at which depth ET is considered zero. Silberstein et al. (2004), estimates the ET extinction depth, or the depth at which ET ceases, to be 3 m beneath lakes. This means that the maximum potential ET rate occurs at the topographic surface and decreases linearly to zero at a depth of 3 m.

5.0 MODEL CALIBRATION

5.1 Calibration Method

The groundwater flow model was calibrated by comparing computed groundwater heads with observed superficial aquifer groundwater heads from 21 observation wells within the model domain. The observation bores are shown on Figure G.

The model was calibrated to groundwater levels and trends by the trial and error approach. The goal for model calibration is good comparison with measured and simulation levels, fluctuations and trends. A statistical calibration is not appropriate due to the low hydraulic head range across the model domain (cf Barnett et al. 2012).

5.2 Groundwater Levels

The calibrated model produced groundwater contours that closely resemble the measured values over most of the domain. The mean absolute residual head (MARH) difference is 0.43 m and the root mean squared (RMS) residual head difference is 0.52 m.

Figure Q shows the simulated groundwater contours in June 2014, which was at the end of the model run. The figure shows the higher groundwater elevations (mounding) along the eastern edge of the model domain, principally due to the low permeability Guildford Formation and urban development in the area.

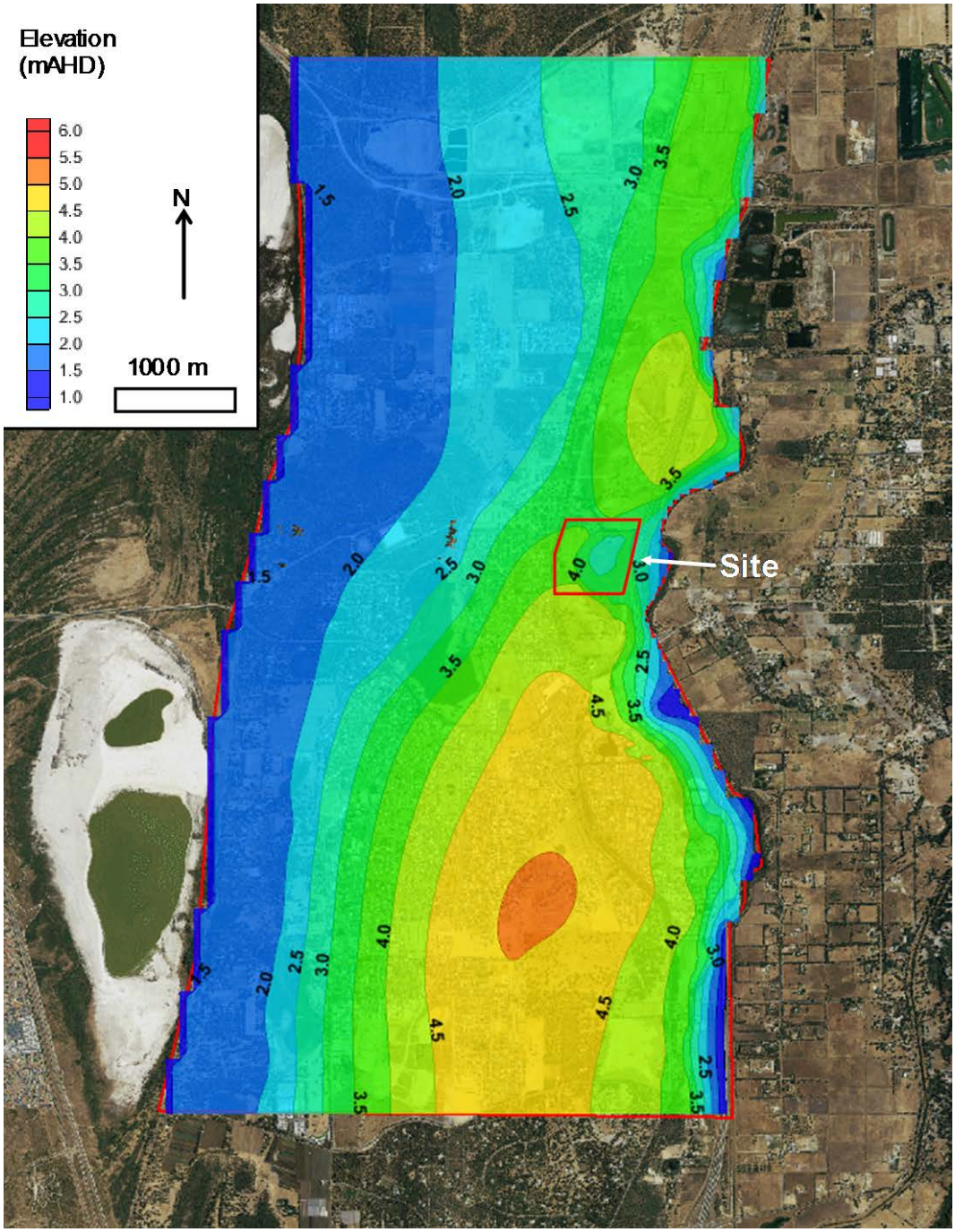


Figure Q: Simulated Groundwater Contours June 2014

Figure R shows comparison between model-predicted and measured groundwater levels for the calibration period (nearly nine years). The model is well calibrated regionally, with the simulated groundwater trends and fluctuations closely resembling the measured trend.

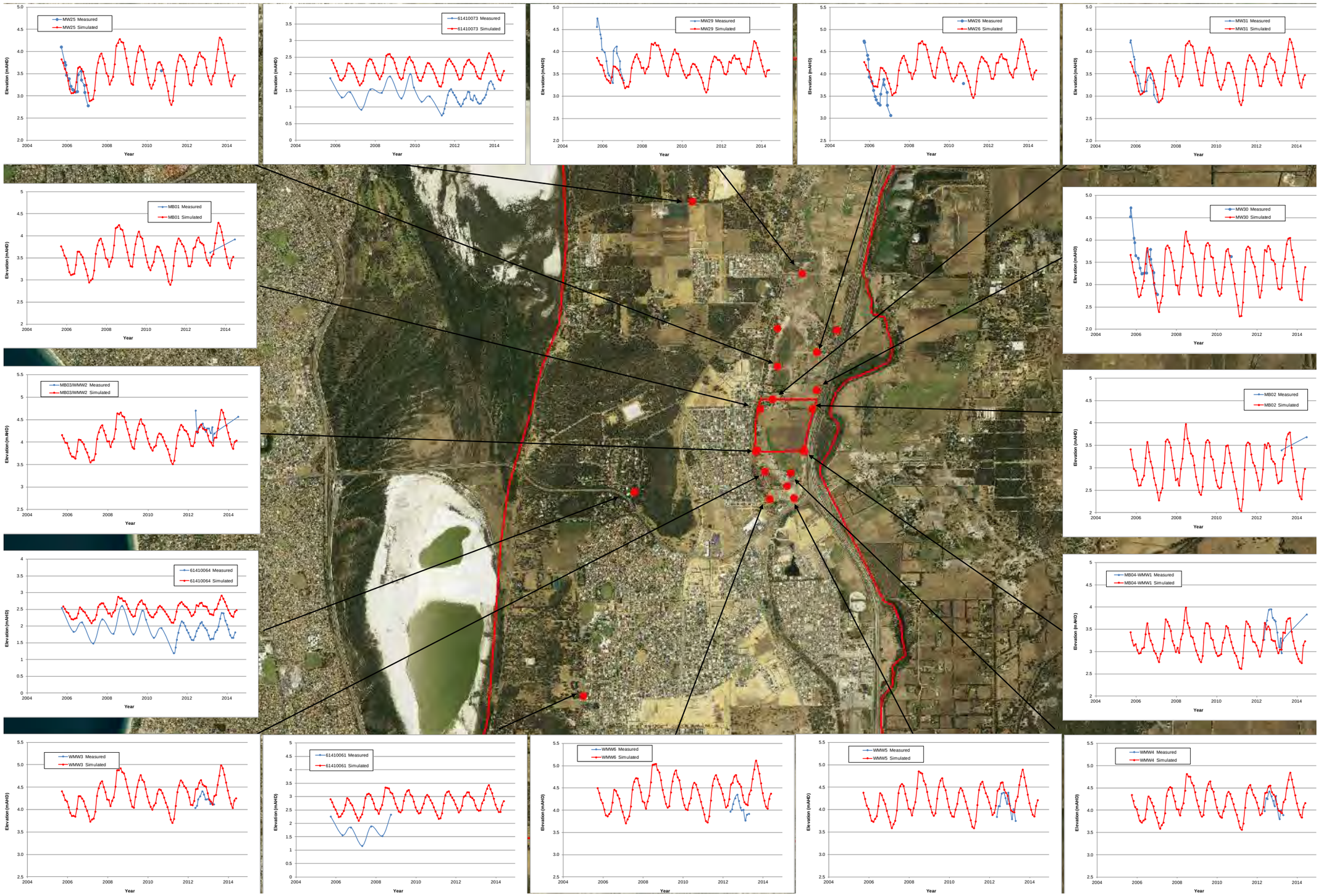


Figure R: Model Calibration Graphs

5.3 Calibrated Parameter Values

5.3.1 Hydraulic Conductivity

The calibrated K values are reasonable based on the literature. Calibrated K values are as follows:

5.3.1.1 Layer 1

- Guildford Formation – 0.1 m/day
- Bassendean Sand – 10 m/day
- Spearwood Sand – 10 to 20 m/day.

Figure S shows the Layer 1 K distribution used for the model.

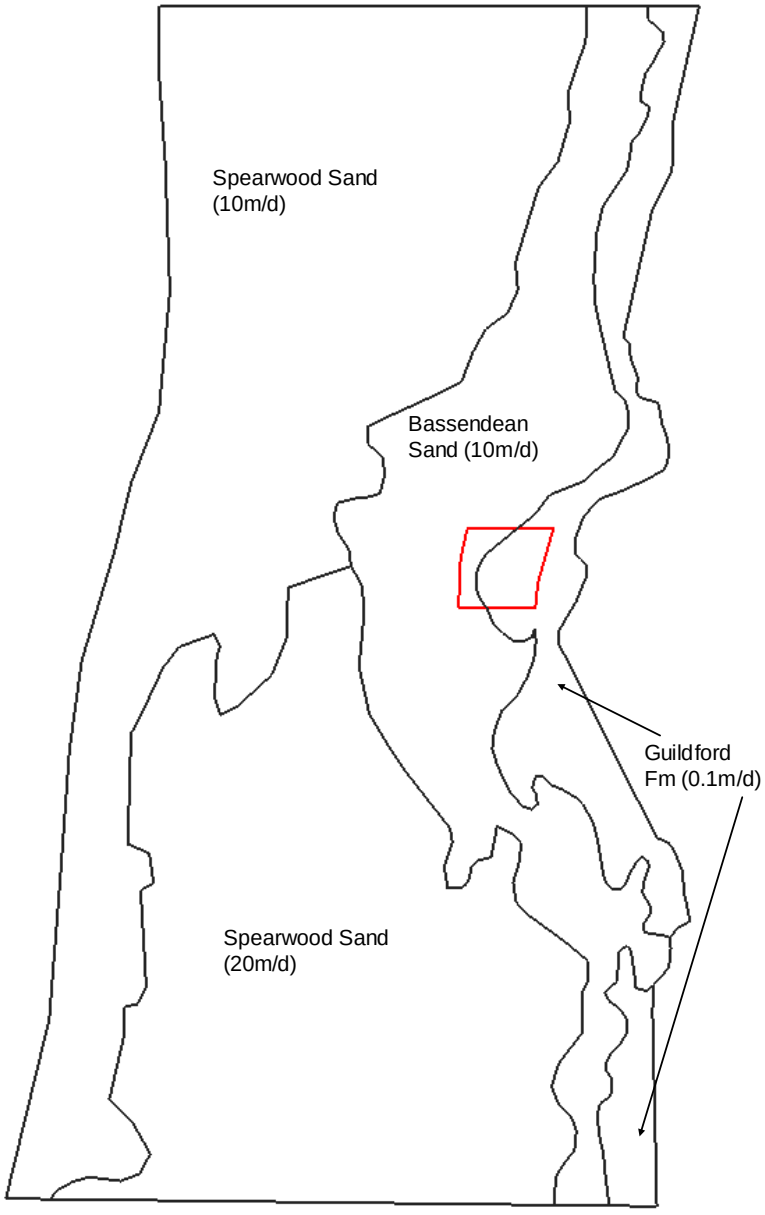


Figure S: Layer 1 Hydraulic Conductivity Coverage

5.3.1.2 Layer 2 and 3

- Guildford Formation – 0.75 m/day
- Tamala Limestone – 100 m/day
- Bassendean Sand – 10 m/day
- Spearwood Sand – 10 m/day.

Figure T shows the Layer 2 and 3 K distribution used for the model.

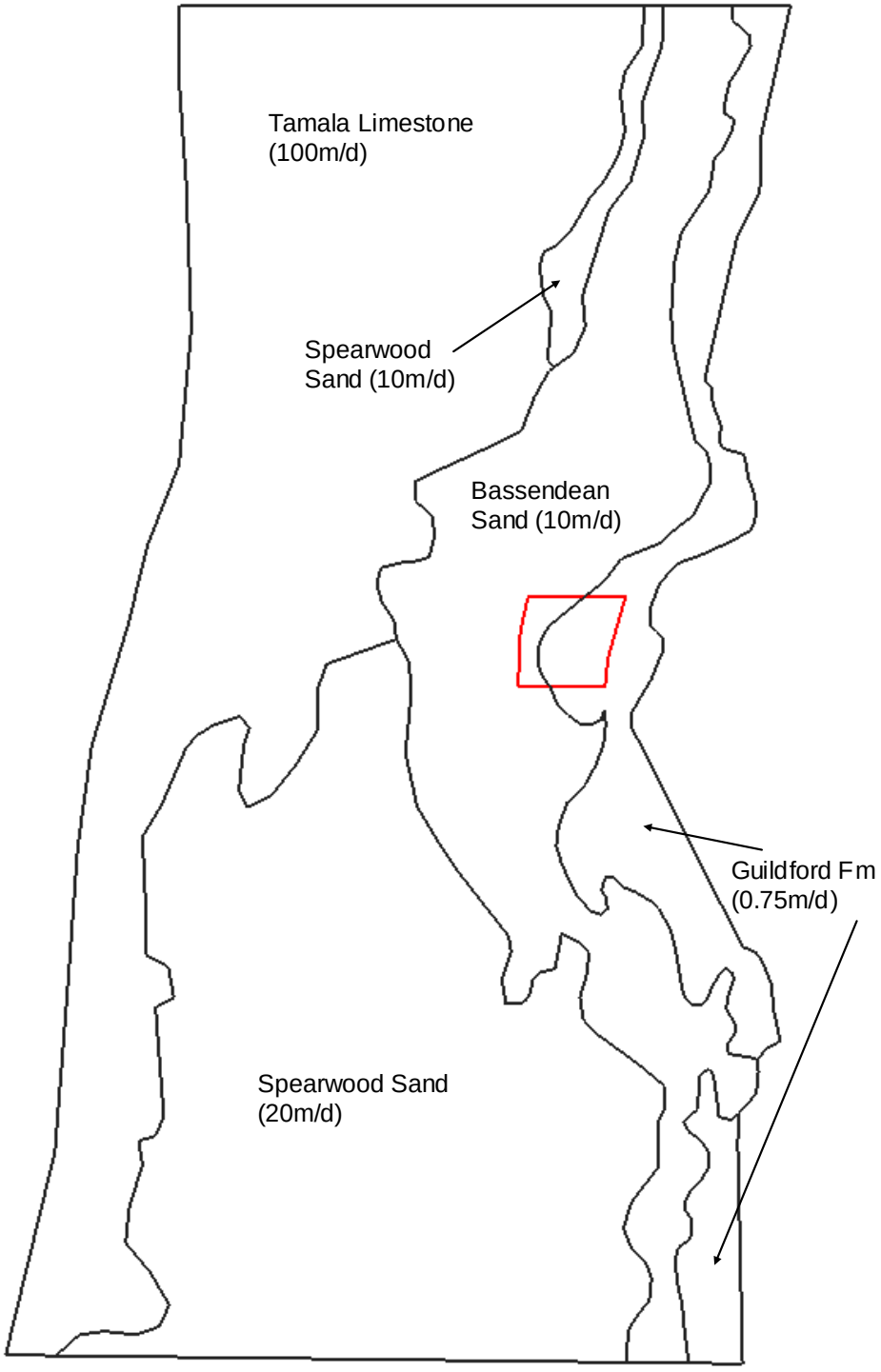


Figure T: Layer 2 and 3 Hydraulic Conductivity Coverage

5.3.1.3 Specific Yield and Specific Storage

The following specific yield values were used in the calibrated model:

- 0.2 – Bassendean Sand and Spearwood Sand
- 0.03 to 0.5 – Guildford Clay
- 0.25 – Tamala Limestone.

A specific storage value of 10^{-4} 1/m was used which is appropriate for soils of the Swan Coastal Plain.

5.3.2 River Package Parameters

A riverbed conductance value of 0.5 (m^2/day)/m was applied to the Peel Main Drain sediments. River stage elevations were interpolated from measured Folly Pool elevations from 2002 to 2014.

5.3.3 Evapotranspiration

An ET extinction depth of 1 m from the topographic surface was applied to the model. The applied ET rate was 0.8 of pan evaporation, calculated from monthly pan evaporation averages.

5.3.4 Vertical Anisotropy

Vertical Anisotropy (VA) values ranged from 3 for the sand and limestone areas and 10 for clay areas.

5.3.5 Recharge

5.3.5.1 Gross Recharge Rate

Recharge rates vary across the model according to land use. The gross recharge value (rainfall entering the groundwater, not including ET) applied across the model domain is 32% of actual rainfall. The following gross recharge rates were used for the calibrated model, input as monthly average values.

- Urban: 45–50%
- Cleared Areas on Sand: 45%
- Mixed Use: 20–25%
- Clay Areas: 15%
- Bushland: 15%.

Figure U shows the Recharge Coverage used for the model.

Figure U: Recharge Coverage

5.3.5.2 Net Recharge Rates

The water balance (Table 4) indicates the net recharge rate (Gross Recharge Rate minus ET) is 28%. Net rainfall recharge rates (% annual rainfall) were calculated for various zones in the model, as shown on Table 4 and Figure U.

Table 4: Net Recharge – Model Zones

Zone ID	Area (hectares)	Zone No.	Gross Recharge (m/yr)	ET (m/yr)	Net Recharge (m/yr)	Gross Recharge (% rainfall)	ET (% rainfall)	Net Recharge (% rainfall)
Site East	25	1	0.1	0.22	-0.12	15	34	-19
Site West	12	2	0.29	0.03	0.25	45	5	40
Mixed	231	3	0.12	0.05	0.07	19	8	12
Guildford Fm	53	4	0.09	0.2	-0.11	13	31	-18
Guildford Fm	263	5	0.09	0.14	-0.05	15	22	-8
Urban	43	6	0.28	0	0.28	44	0	44
Cleared	370	7	0.29	0.01	0.28	46	1	44
Cleared	25	8	0.3	0.01	0.29	47	2	45
Cleared	386	9	0.28	0	0.28	44	0	44
Urban	965	10	0.33	0.02	0.3	51	3	47
Bush	803	11	0.09	0	0.09	14	0	14
Mixed	488	12	0.14	0	0.14	22	0	22
Total	3,664	NA	0.21	0.03	0.18	32	4	28

According the model, rainfall recharge rates were highest in the urban areas (44 to 47% rainfall) and cleared areas on sand, having recharge rates of ~ 45% rainfall. Mixed-use recharge rates ranged from 12 to 22% while the recharge rate for bushland was 14%. Of note is the net recharge rate on clayey areas along the western model boundary of -8% to -19% rainfall. This indicates the clayey areas are discharge regions, with water entering by rainfall and higher groundwater inflow, while water leaves via high ET and lower groundwater outflow.

At the site itself, the net recharge rate is calculated at 40% along the sandy ridge while the low-lying clay area is calculated to have a net recharge rate of -20% (15% gross recharge minus 34% ET).

5.4 Pre-development Water Balance

The water balance for the entire model for all stress periods is provided in Table 5.

Table 5: Water Balance

Water Balance Parameter	Total Volume (m^3)	Per Cent In/Out (with Storage)	Per Cent In/Out (without Storage)	Parameter Rate (M/Yr)
WATER IN				
Storage	33,646,696	33	na	
Groundwater inflow	1,381,260	1	2	0.004
Abstraction	0	0	0	
River leakage (PMD)	548,111	1	1	0.002
Evapotranspiration	0	0	0	
Recharge	66,298,328	65	97	0.21
TOTAL IN	101,874,395	100	100	
WATER OUT				
Storage	32,869,592	32	na	
Groundwater outflow	22,414,014	22	32	0.07
Abstraction	37,446,432	37	54	0.12
River leakage (PMD)	1,007,625	1	1	0.003
Evapotranspiration	8,136,683	8	12	0.03
Recharge	0	0	0	
TOTAL OUT	101,874,346	100	100	
IN–OUT	49			
Per cent discrepancy	0.00			

According to the model results, the water balance error for the entire model domain is 0.00%, which is less than 0.1%, the error specified by Konikow (1978).

The water balance results indicate that most of the water entering the system is via rainfall recharge (97% not including storage) and most of the water is exiting the system by groundwater outflow to the west to Lakes Cooloongup and Walyungup (32%), bore abstraction (54%), ET (12%) with minimal discharge into the Peel Main Drain. The abstraction equates to 0.12 m/yr over the entire model domain, or 1,200 kL/ha/yr.

The aquifer storage change is a low proportion of the water balance (0.09%/yr) indicating the aquifer is not being significantly added to or depleted.

6.0 MODEL PREDICTIONS

6.1 Objective of the Predictions

The calibrated model was used as the basis for predicting the potential impact of the development on groundwater levels. The predictive model simulations were also used to provide an indication of any management that may be required.

6.2 Predictive Model Changes

The post-development ground elevations will be different than the pre-development elevations. As such, the pre-development model was changed as follows.

- Layer 1: Inclusion of fill material. It is proposed to fill the site with Safety Bay Sand. A K of 5 m/d and Sy of 0.15 was applied to the Safety Bay Sand fill material, which is low (conservative) in comparison to literature values (cf. Davidson 1995)
- Layer 2: Top surface coincident with the existing topography at site
- Layers 3 and 4: as for pre-development model Layers 2 and 3
- ET was not applied to the development.

6.3 Starting Heads

Groundwater levels from the base calibrated model were used as the initial starting heads in the predictive model. It is therefore assumed the subsurface drains are installed at this time. The model was run for 10 years until 2023.

6.4 Scenario 1: Development with Fill and without Subsurface Drains

6.4.1 Objective

A model was run to predict groundwater levels at the site if fill material was imported but no subsurface drains were installed. The shallow pre-development depth to groundwater is expected to rise after development, principally because of the decrease in ET resulting from the removal of vegetation and replacing with hard stand.

6.4.2 Assumptions

The predictive scenario was made with the following assumptions:

- The model was run from September 2013 to 2023.

- Average monthly rainfall was incorporated for approximately five years (2013 to 2018), followed by two successive high annual rainfall events (2019 and 2020) using 1991 rainfall data, with the model reverting to average monthly rainfall from 2021 to 2023. The 1991 rainfall was the highest since 1975, with an annual rainfall of 1022 mm, 595 mm of which fell from May to July. Table 6 shows the monthly rainfall for 1991 and the average since 1983.

Table 6: Monthly Rainfall for Model Predictions

Rainfall Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average since 1983	12	20	20	40	99	145	148	114	76	40	33	12	759
1991 rainfall	2	30	8	38	159	251	186	99	108	40	74	27	1022

  It is considered more appropriate to use high rainfall over a longer time period rather than short term ARI rainfall events. This is because groundwater levels, and hence subsurface drain flows, will not respond as quickly as surface water flows to these short term events. Rather, the rainfall is expected to infiltrate into the soil before gradually discharging to the drains.

- A monthly groundwater recharge rate of 70% was assigned to the development, which is higher than the estimate provided in the Perth Vertical Flux Model (Silberstein et al. 2004) for urban areas, however residential density is higher now than when previous recharge estimates have been made. The ET component from the pre-development model was removed.

- The Modflow Drain Package was applied to the topographic surface at the site to simulate run-off.

6.4.3 Results

Figure V shows an east–west cross-section through the centre of the site at the winter period of a high rainfall (1991) year. According to the model, groundwater is predicted to rise to at least the land surface over most of the site, except for a small area at the west. This shows that subsurface drainage is required at the site to control groundwater levels.

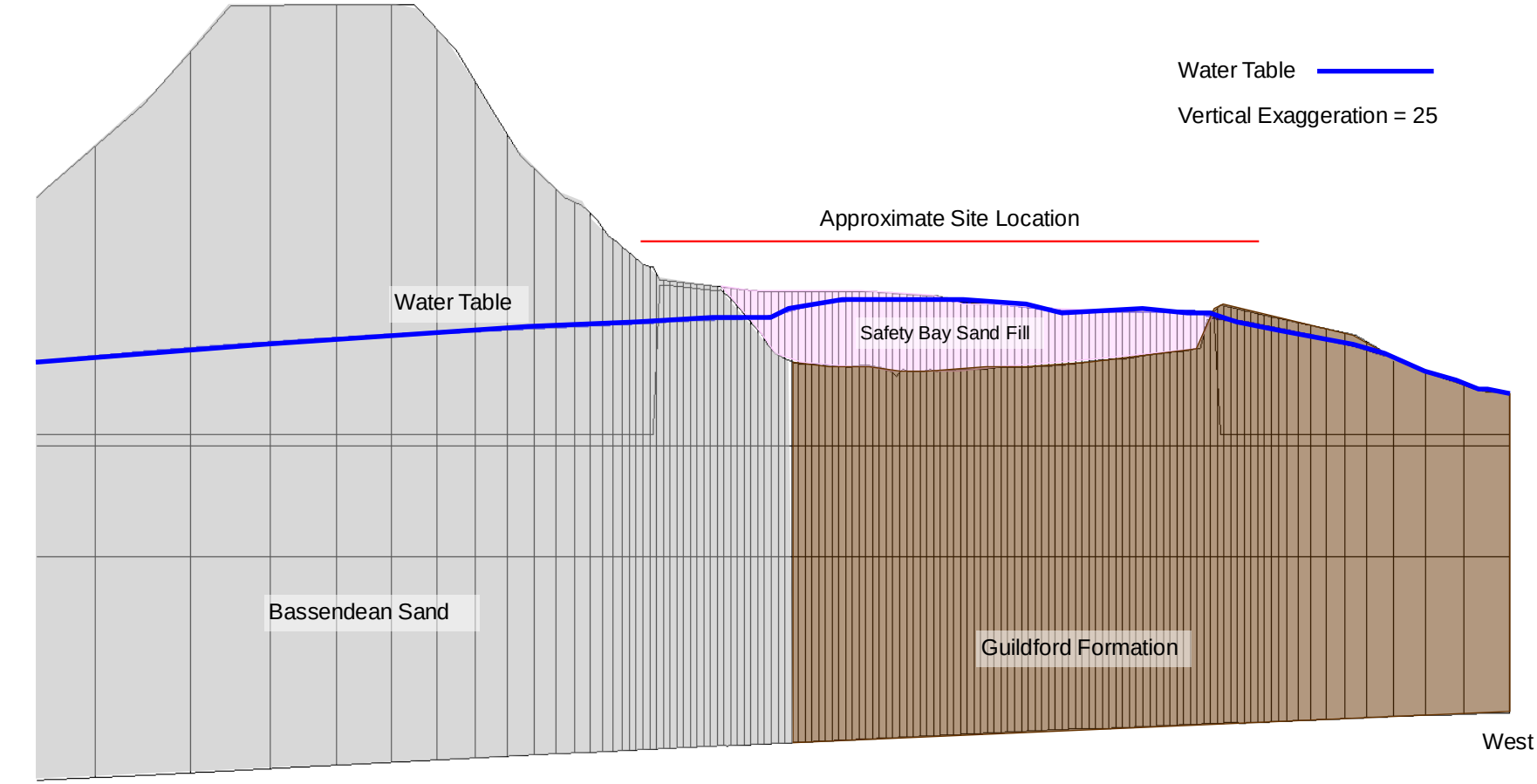


Figure V: Post-development Cross-section

6.5 Scenario 2: Development with Fill and Subsurface Drains

6.5.1 Assumptions

According to Scenario 1, subsurface drains are required to control groundwater levels. As such a simulation was run incorporating subsurface drains. The following assumptions were made for Scenario 2 in addition to those outlined in Scenario 1:

- subsurface drainage as provided by site engineers Development Engineering Consultants (DEC)
- all subsurface drains located within Safety Bay Sand material – some minor trenching into the clay at the eastern part of the site was incorporated into the model
- a drain conductance value of 100 (m^2/day)/day was assigned to the material surrounding drains
- the modelling does not include the proposed subsurface drainage in the location of the existing Sub H drain. Although this subsurface drain is at a relatively low elevation (~2.5 mAHD), it may not be free flowing for extended time periods; hence inclusion of subsurface drainage into the model at this location is not considered appropriate.

6.5.2 Results

Figures W and X show the depth to water for an annual average peak (Figure W) and annual peak for a 1991 rainfall year (Figure X), with contours starting at 0 mbgl. The model predicts no inundation in areas outside of Public Open Space (POS) with the proposed subsurface drainage system.

Figures Y and Z show the depth to water for an annual average peak (Figure Y) and the annual peak for a 1991 rainfall year (Figure Z), with contours starting at 0.8 mbgl. For an average annual peak event, the model predicts groundwater clearance to exceed 0.8 m, except for POS and some areas at the south and north-west of the site. For a 1991 rainfall year peak event, the model predicts groundwater clearance to exceed 0.8 m over most of the site, except for POS and areas at the south, centre and north-west.

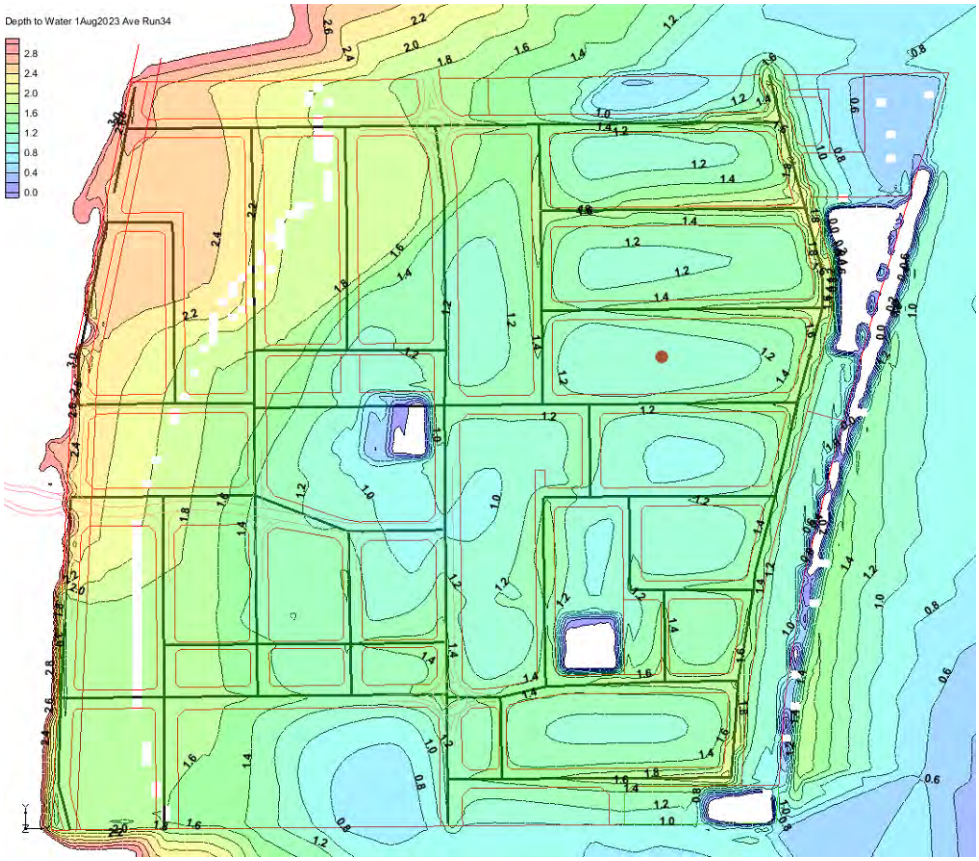


Figure W: Depth to Water Average Annual Peak (Contours from 0 mbgl)

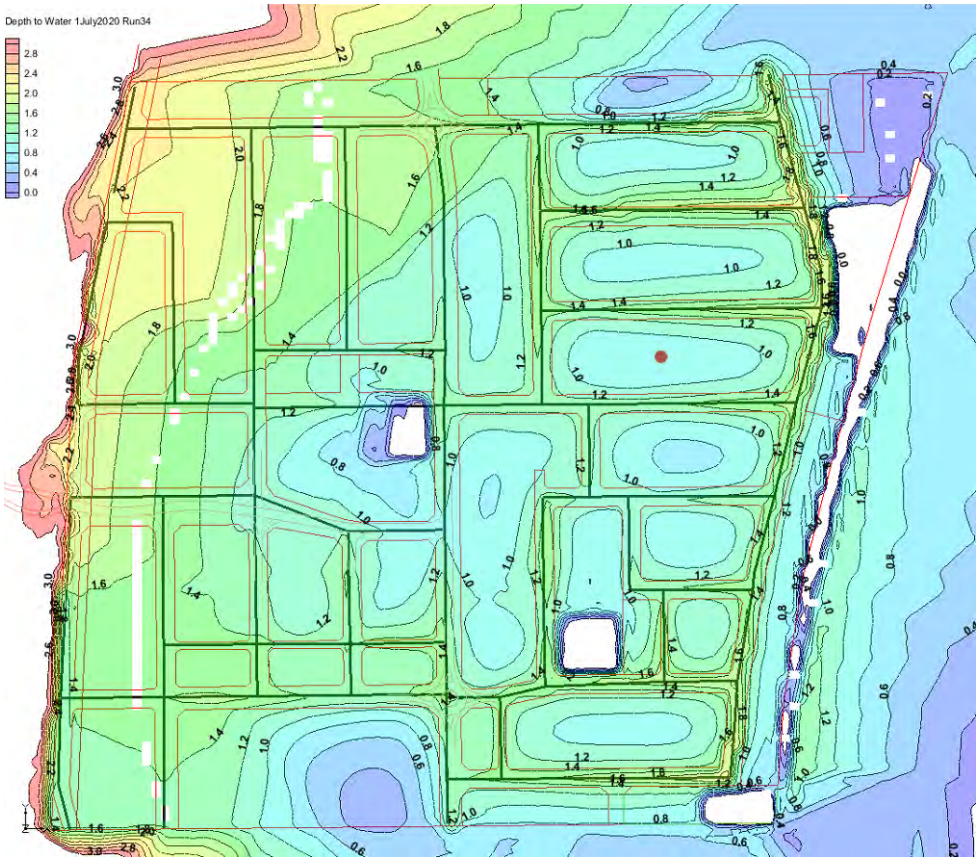


Figure X: Depth to Water 1991 Rainfall Annual Peak (Contours from 0 mbgl)

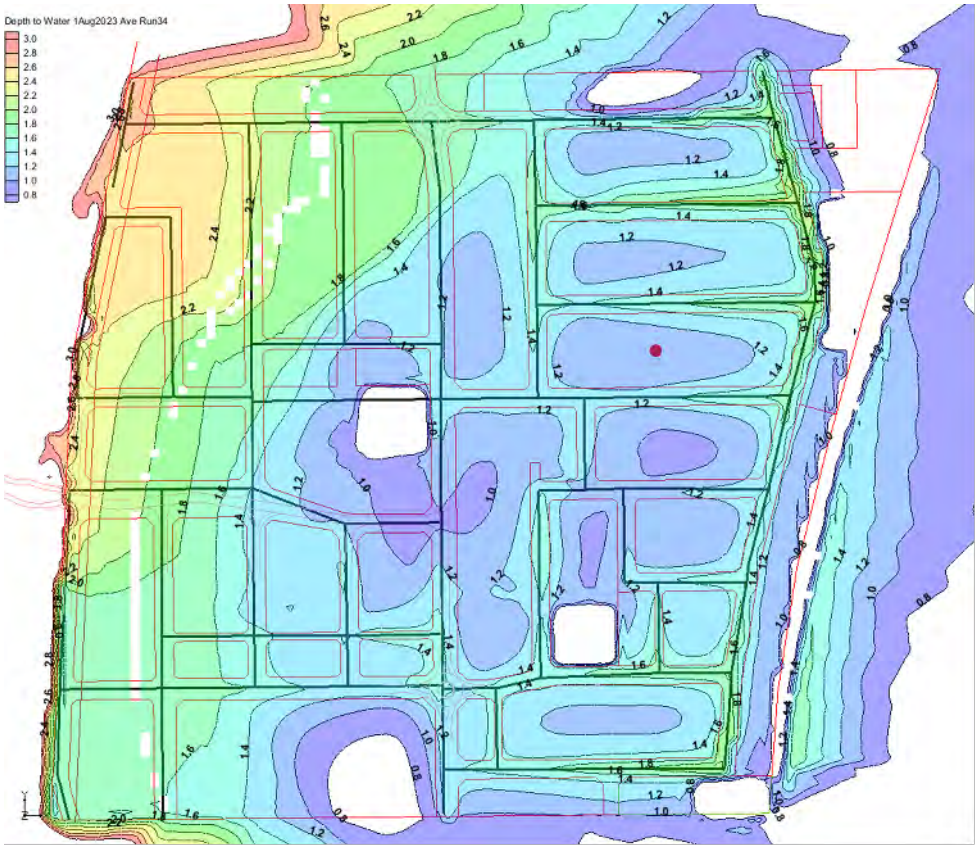


Figure Y: Depth to Water Average Annual Peak (Contours from 0.8 mbgl)

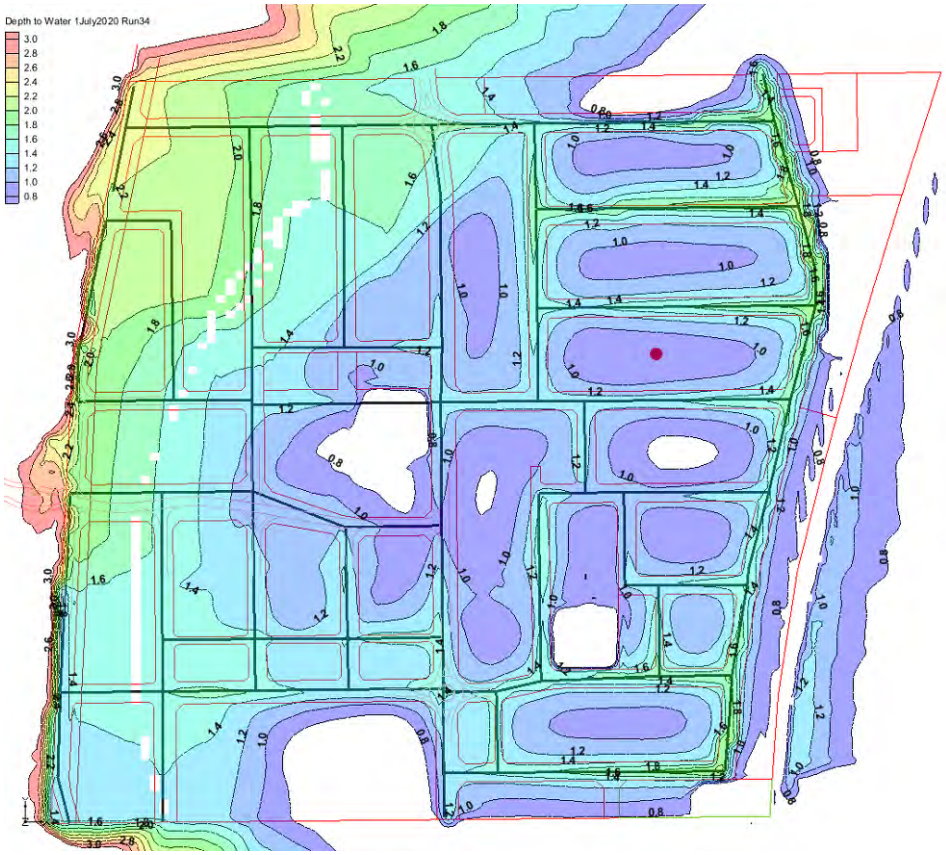
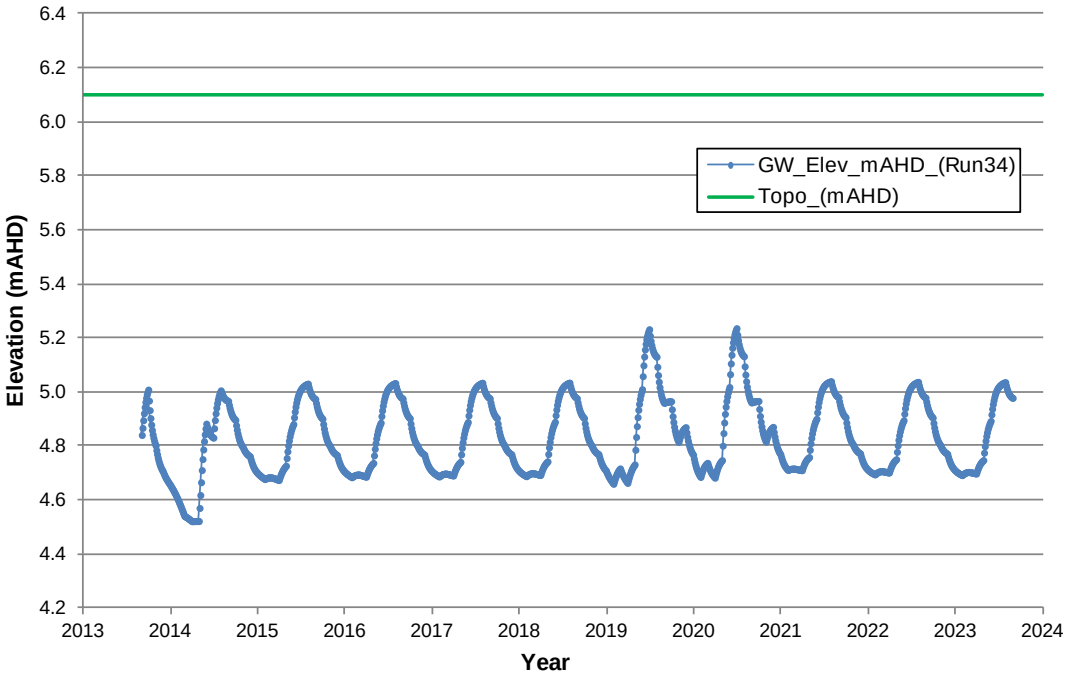


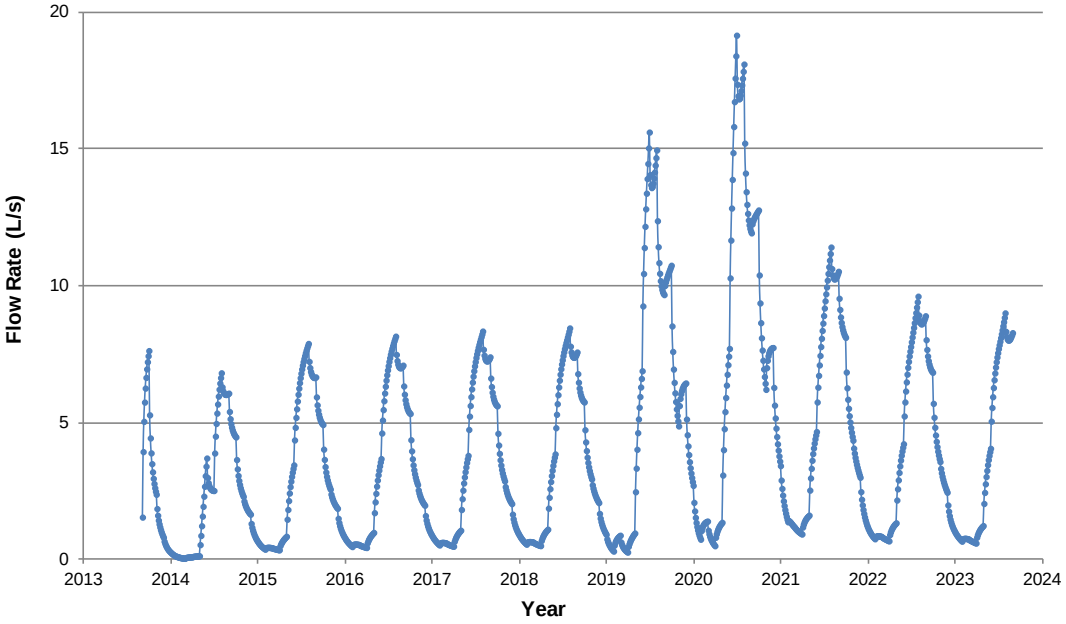
Figure Z: Depth to Water 1991 Rainfall Annual Peak (Contours from 0.8 mbgl)

Graph 3 shows the predicted water levels at a point at the central eastern part of the site (shown as red dot in Figures X to Z). At this point, the model predicts groundwater levels to be approximately 0.2 m higher for a 1991-year peak compared with an average annual peak.



Graph 3: Predicted Groundwater Elevation with Subsurface Drains, North-central Point

Graph 4 shows the predicted subsurface drain ouflows. The flows based on average monthly rainfall are predicted to be up to 10 L/s while flows based on 1991 monthly rainfall are predicted to be up to 20 L/s.



Graph 4: Predicted Subsurface Drain Flows

The post-development model water-balance error is less than 0.1%.

6.6 Model Uncertainty

A level of uncertainty exists with all environmental data collection and modelling. The model parameters included in the base model are considered conservative. These parameters include:

- K value of 5 m/day for the Safety Bay Sand fill which is lower than literature values indicate (Davidson 1995)
- a post-development recharge rate of 70% at the site and high long-term rainfall scenario (1991 rainfall event)
- specific yield value for Safety Bay Sand fill of 0.15, which is considered to be on the lower end based on literature values (Davidson 1995, Kresic 2007).

On this basis, the model is expected to provide conservative predictions.

7.0 CONCLUSIONS AND LIMITATIONS

7.1 Conclusions

The groundwater modelling predicts that urban development will cause groundwater levels to rise. The subsurface drainage system as designed by the site engineers (DEC) is predicted to inhibit inundation in areas outside of POS. For an average annual peak event, the model predicts groundwater clearance to exceed 0.8 m, except for POS and some areas at the south and north-west of the site. For a 1991 rainfall year peak event, the model predicts groundwater clearance to exceed 0.8 m, except for POS and areas at the south, centre and north-west of the site.

The modelling does not include the proposed subsurface drainage in the location of the existing Sub H drain. Although this subsurface drain is at a relatively low elevation (~2.5 mAHD), it may not be free flowing for extended time periods; hence inclusion of subsurface drainage into the model at this location is not considered appropriate.

The model results (Scenario 1 and 2) are sensitive to the presence and functionality of subsurface drains; as such, it is important the drains are constructed properly and are free from significant clogging.

7.2 Limitations

Interpreting the results of a groundwater model requires some caution. There is an inherent compromise between the complexity of the actual hydrogeological system and the relative simplicity of a computer model. This can be particularly important when relatively large cells with homogeneous properties are used to model heterogeneous geological materials. Also, many of the model parameters are not known with detailed accuracy across the model domain, instead the parameters are adjusted during calibration of the model to simulate the observed behaviour. Despite these limitations, groundwater modelling, when properly applied, is a versatile and powerful tool that often provides the best available answer to complex problems.

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APPENDIX I

Bore Logs

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C01**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	388979 NORTHING: 6423378	DEPTH TO WATER: (m):	4
DATE:	26/03/2014	TOTAL DEPTH: (m):	7
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ1 @ C01S18		

(m)	Soil Description
0.5	**LOAMY SAND.** Dark Brown. Dry. Some organics. No Staining. No Odour.
1.0	**SAND.** Orange. Dry. No Staining. No Odour.
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	**SAND.** Grey/Yellow. Saturated. No Staining. No Odour.
5.5	
6.0	
6.5	
7.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C01S01			6.40	4.80	M	
C01S02	0.5		6.80	5.10	L	
C01S03			6.90	5.40	L	
C01S04			7.00	5.00	L	
C01S05	1.0		6.70	5.40	L	<0.02
C01S06			7.00	5.50	L	
C01S07	1.5		7.10	5.40	L	
C01S08			7.10	5.40	L	
C01S09	2.0		7.20	5.40	L	
C01S10			7.20	5.40	L	
C01S11	2.5		7.20	5.40	L	
C01S12			7.00	5.40	L	
C01S13	3.0		6.90	5.30	L	
C01S14			7.00	5.50	L	
C01S15	3.5		7.10	5.30	L	
C01S16			7.40	5.30	L	
C01S17	4.0		7.70	5.90	L	
C01S18			7.80	6.00	L	
C01S19	4.5		7.70	5.70	L	
C01S20			7.80	5.90	L	
C01S21	5.0		7.30	5.40	L	
C01S22			8.00	4.70	L	
C01S23	5.5		6.60	2.40	M	
C01S24			6.40	2.40	H	
C01S25	6.0		6.20	2.20	H	
C01S26			6.00	2.20	H	0.02
C01S27	6.5		6.20	2.20	L	
C01S28			6.90	2.20	M	
	7.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C02**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389586 NORTHING: 6423581	DEPTH TO WATER: (m):	2
DATE:	26/03/2014	TOTAL DEPTH: (m):	7
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ2 @ C02S02		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
	CLAY LOAM. Dark Grey. Abundant organics. No Staining. No Odour.	C02S01			7.70	6.20	L	
		C02S02			8.10	6.60	V	<0.02
0.5	**SANDY CLAY.** Dark Grey. No Staining. No Odour.	C02S03	0.5		8.10	6.80	L	
		C02S04			7.70	6.60	L	
1.0	**SANDY CLAY.** Pale Grey. No Staining. No Odour.	C02S05	1.0		7.80	6.60	L	
		C02S06			7.70	6.50	L	
1.5			1.5					
	SANDY CLAY. Pale Grey/White. Moist. No Staining. No Odour.	C02S07			7.70	6.80	M	
		C02S08			7.60	7.10	M	
2.0		C02S09	2.0		7.70	7.20	M	
	SANDY CLAY. Yellow/Borwn/Grey. Saturated. No Staining. No Odour.	C02S10			8.10	9.10	M	
2.5		C02S11	2.5		8.20	9.60	M	
		C02S12			8.90	9.30	V	
3.0		C02S13	3.0		9.30	8.80	V	
		C02S14			8.80	8.50	V	
3.5		C02S15	3.5		9.40	9.10	V	
		C02S16			9.60	9.30	V	
4.0		C02S17	4.0		8.60	8.40	V	
		C02S18			8.40	8.90	V	
4.5	**CLAYEY SAND.** Grey/Brown. Saturated. No Staining. No Odour.	C02S19	4.5		9.20	7.30	V	
		C02S20			9.20	7.90	V	
5.0		C02S21	5.0		8.80	8.50	V	<0.02
		C02S22			8.90	8.50	V	
5.5		C02S23	5.5		8.80	8.30	V	
		C02S24			8.70	8.30	V	
6.0	**CLAYEY SAND.** Pale Grey. Saturated. No Staining. No Odour.	C02S25	6.0		8.80	8.50	M	
		C02S26			8.80	7.60	M	
6.5		C02S27	6.5		9.00	7.30	M	
		C02S28			9.20	4.10	M	
7.0			7.0					

Further Comments:

Legend:

Green shading denotes inferred Potential Acid Sulphate Soil (PASS)

Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)

Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C03**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	388943 NORTHING: 6423103	DEPTH TO WATER: (m):	3.65
DATE:	26/03/2014	TOTAL DEPTH: (m):	7
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ3 @ C03S12		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
0.5	**SILTY SAND.** Dark Grey/Dark Brown. Medium/Fine grained. Dry. Some organics roots, rootlets and charcoal. No Staining. No Odour.	C03S01	0.5		4.30	3.50	L	
		C03S02			5.10	4.00	M	
1.0	**SAND.** Grey. Medium/Fine grained. Dry. No Staining. No Odour.	C03S03	1.0		4.60	3.30	L	
		C03S04			4.50	3.40	L	
1.5		C03S05	1.5		4.70	4.10	L	
		C03S06			5.00	4.10	L	
2.0		C03S07	2.0		5.20	3.90	L	
		C03S08			5.30	3.70	L	<0.02
	SAND. Brown/Pale Grey. Medium/Fine grained. Dry. No Staining. No Odour.	C03S09			6.30	3.40	L	
2.5	**COFFEE SANDS.** Brown. Medium/Fine grained. Dry. No Staining. No Odour.	C03S10	2.5		4.90	4.10	L	
		C03S11			5.20	4.10	L	
3.0	**COFFEE SANDS.** Dark Brown. Medium/Fine grained. Moist. Some cemented Coffee Rock gravels. No Staining. No Odour.	C03S12	3.0		5.50	4.20	L	<0.02
	COFFEE SANDS. Dark Brown. Medium/Fine grained. Moist. No Staining. No Odour.	C03S13			6.30	4.70	L	
3.5	**SAND.** Pale Brown/Yellow. Medium/Fine grained. Saturated. No Staining. No Odour.	C03S14	3.5		6.30	4.80	L	
		C03S15			6.20	4.90	L	
4.0		C03S16	4.0		5.70	4.70	L	
	COFFEE SANDS. Brown. Medium/Fine grained. Saturated. No Staining. No Odour.	C03S17			5.20	4.40	L	
4.5	**COFFEE SANDS.** Dark Brown/Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C03S18	4.5		5.50	4.50	L	
		C03S19			5.90	4.60	L	
5.0		C03S20	5.0		6.30	4.00	L	
	SAND. Grey/Brown. Medium/Fine grained. Saturated. No Staining. No Odour.	C03S21			6.10	3.80	L	
5.5		C03S22	5.5		6.30	3.50	L	
		C03S23			6.30	3.60	L	
6.0		C03S24	6.0		6.40	3.50	L	
		C03S25			6.40	2.80	M	
6.5		C03S26	6.5		6.50	2.70	M	
		C03S27			6.40	2.50	M	
7.0		C03S28	7.0		6.60	2.50	M	

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C04**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389482 NORTHING: 6423106	DEPTH TO WATER: (m):	
DATE:	26/03/2014	TOTAL DEPTH: (m):	7
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ4 @ C04S12, CZ4A @ C04S15		

(m)	Soil Description
0.5	**SILTY CLAY.** Dark Grey. Medium/Fine grained. Dry. Trace organics roots. Trace sand. No Staining. No Odour.
1.0	**SILTY CLAY.** Dark Grey/Dark Green. Medium/Fine grained. Dry. No Staining. No Odour. **SANDY CLAY.** Pale Brown/Pale Grey. Medium/Fine grained. Moist. No Staining. No Odour.
1.5	**COFFEE ROCK.** Dark Brown. Medium/Fine grained. Moist. Cemented. No Staining. No Odour. **SANDY CLAY.** Pale Brown. Medium/Fine grained. Moist. Some Coffee Rock Gravels. No Staining. No Odour.
2.0	**SANDY CLAY.** Dark Grey. Medium/Fine grained. Moist. No Staining. No Odour.
2.5	**CLAYEY SAND.** Pale Grey. Medium/Fine grained. Moist. No Staining. No Odour.
3.0	
3.5	**SANDY CLAY.** Dark Brown/Dark Grey. Medium/Fine grained. Moist. No Staining. No Odour. **SAND.** Grey. Medium/Fine grained. Saturated. With clayey sand inclusions. No Staining. No Odour.
4.0	
4.5	
5.0	
5.5	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
6.0	
6.5	**SAND.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
7.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C04S01			5.40	3.60	M	
C04S02	0.5		6.10	4.50	M	
C04S03			6.00	4.80	L	
C04S04			6.20	4.70	L	
C04S05			5.90	4.60	L	
C04S06	1.0		6.20	4.80	L	
C04S07			6.30	5.10	L	
C04S08			6.30	5.00	L	
C04S09	1.5		6.20	5.10	L	
C04S10			7.10	6.20	L	
C04S11	2.0		7.20	5.80	M	
C04S12			8.30	6.30	L	
C04S13	2.5		7.30	5.00	L	
C04S14			7.30	4.20	L	
C04S15	3.0		7.40	4.70	V	
C04S16			7.30	1.90	V	
C04S17	3.5		7.00	1.70	V	
C04S18			7.20	2.10	V	
C04S19	4.0		7.30	1.90	X	
C04S20			7.10	1.90	H	
C04S21	4.5		7.00	2.00	X	
C04S22			7.00	1.70	V	
C04S23	5.0		7.00	2.00	V	0.07
C04S24			6.80	1.70	H	
C04S25	5.5		7.10	2.20	V	
C04S26			7.10	2.10	M	
C04S27	6.0		7.00	2.10	V	
C04S28			7.00	2.10	V	
C04S29	6.5		7.10	2.00	X	
C04S30			7.10	1.90	X	
	7.0					

Further Comments:

Legend:
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- Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
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SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C05**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389224 NORTHING: 6423549	DEPTH TO WATER: (m):	1.7
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ5 @ C05S02		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
	SANDY LOAM. Dark Brown. Dry. Some organics and roots. No Staining. No Odour.	C05S01			4.20	2.30	M	
	SANDY CLAY. Dark Grey/Brown. Medium/Fine grained. Moist. Trace organics. No Staining. No Odour.	C05S02			4.00	1.90	M	
0.5		C05S03	0.5		3.60	2.40	M	0.08
		C05S04			3.60	2.80	M	
1.0		C05S05	1.0		3.80	3.00	M	
	SAND. Dark Grey. Medium/Fine grained. Moist. No Staining. Sulphur odour.	C05S06			3.90	2.10	M	
1.5		C05S07	1.5		4.40	1.80	H	
		C05S08			5.00	1.90	H	
2.0		C05S09	2.0		6.20	1.80	V	
		C05S10			5.60	1.80	V	
2.5		C05S11	2.5		6.00	1.90	V	
		C05S12			6.40	1.90	M	0.12
3.0		C05S13	3.0		6.80	2.00	H	
		C05S14			6.80	1.90	V	
3.5		C05S15	3.5		7.10	1.80	H	
	SAND. Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C05S16			7.10	2.00	V	
4.0		C05S17	4.0		7.10	2.10	V	
		C05S18			7.30	1.90	H	
4.5		C05S19	4.5		7.80	2.50	H	
	SANDY CLAY. Grey. Saturated. No Staining. Sulphur odour.	C05S20			7.80	2.20	V	
5.0			5.0					

Further Comments:

Legend:
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Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C06**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389336 NORTHING: 6423568	DEPTH TO WATER: (m):	
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ6 @ C06S02		

(m)	Soil Description
0.5	**CLAY LOAM.** Dark Grey. Some organics. No Staining. No Odour.
1.0	**SAND.** Grey. Medium/Fine grained. No Staining. Slight Sulphur odour.
	SANDY CLAY. Dark Grey. Some organics. No Staining. No Odour.
1.5	**SANDY CLAY.** Dark Grey. No Staining. No Odour.
2.0	**CLAYEY SAND.** Dark Grey. Medium/Fine grained. No Staining. No Odour.
2.5	
	SANDY CLAY. Pale Grey. Medium/Fine grained. No Staining. No Odour.
3.0	
3.5	
4.0	
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C06S01	0.5		7.50	2.50	M	0.37
C06S02			4.40	2.50	M	
C06S03			4.50	2.80	M	
C06S04	1.0		7.50	2.10	V	
C06S05			4.40	2.30	L	
C06S06	1.5		4.80	2.80	L	
C06S07			4.80	2.30	L	
C06S08	2.0		7.10	2.10	V	
C06S09			7.40	2.50	V	
C06S10	2.5		8.10	2.40	V	
C06S11			8.70	2.20	V	
C06S12	3.0		8.40	2.90	H	
C06S13			8.10	2.20	H	
C06S14	3.5		8.80	3.10	H	
C06S15			8.00	7.70	V	
C06S16	4.0		8.60	7.50	V	<0.02
C06S17			8.40	7.00	V	
C06S18	4.5		8.10	5.80	V	
C06S19			8.20	2.40	V	
C06S20	5.0		8.30	2.80	M	

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C07**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389125 NORTHING: 6423552	DEPTH TO WATER: (m):	4.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ7 @ C07S19		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
	SANDY LOAM. Dark Brown. Some organics. No Staining. No Odour.	C07S01			6.60	4.30	H	
	SAND. Dark Brown/Orange. Dry. No Staining. No Odour.							
0.5		C07S02	0.5		7.20	5.00	M	
		C07S03			7.30	5.30	M	
		C07S04			7.20	5.30	L	
1.0		C07S05	1.0		7.30	5.30	L	
		C07S06			7.30	5.00	L	
1.5		C07S07	1.5		7.30	5.30	L	
		C07S08			7.30	5.30	L	
2.0		C07S09	2.0		7.50	5.30	L	
		C07S10			7.60	5.40	L	
2.5		C07S11	2.5		7.50	5.40	L	
		C07S12			7.60	5.50	L	<0.02
3.0		C07S13	3.0		7.80	5.50	L	
		C07S14			7.80	5.50	L	
3.5		C07S15	3.5		7.90	5.40	L	
		C07S16			7.80	5.50	L	
4.0		C07S17	4.0		7.90	5.50	L	
		C07S18			7.70	5.50	L	
4.5		C07S19	4.5		7.70	5.60	L	
		C07S20			7.80	5.90	L	
5.0			5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C08**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389118 NORTHING: 6423462	DEPTH TO WATER: (m):	1.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ8 @ C08S08		

(m)	Soil Description
0.0	**SANDY LOAM.** Dark Brown. Some organics some roots, rootlets and grass litter. No Staining. No Odour.
0.5	**SAND.** Dark Grey/Black. Saturated. Trace organics. No Staining. No Odour.
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	**SAND.** Pale Grey. Saturated. No Staining. Slight Sulphur odour.
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C08S01	0.0		8.30	2.50	H	
C08S02			7.90	2.20	H	
C08S03	0.5		4.80	2.20	H	
C08S04			4.30	1.80	H	
C08S05	1.0		5.20	2.00	H	
C08S06			4.70	3.50	H	
C08S07	1.5		4.40	1.90	H	
C08S08			4.10	1.60	H	0.05
C08S09	2.0		4.80	2.20	V	
C08S10			5.40	1.90	M	
C08S11	2.5		5.80	2.10	V	
C08S12			5.80	1.90	V	
C08S13	3.0		6.50	1.80	V	
C08S14			6.70	1.90	V	
C08S15	3.5		6.80	1.90	V	
C08S16			6.90	1.80	V	
C08S17	4.0		7.00	2.00	V	
C08S18			7.00	2.00	L	
C08S19	4.5		6.90	1.90	M	
C08S20			7.00	1.80	M	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C09**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389282 NORTHING: 6423456	DEPTH TO WATER: (m):	1.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ9 @ C09S17		

(m)	Soil Description
0.5	**PEAT.** Dark Grey/Black. No Staining. No Odour.
1.0	**CLAY.** Black. Some organics. No Staining. No Odour.
1.5	**SANDY CLAY.** Grey. With Peat inclusions of 3-5mm lenses. Staining Slight Sulphur. No Odour.
2.0	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C09S01	0.5		4.40	2.60	V	
C09S02			4.40	2.50	V	
C09S03			4.50	3.10	V	
C09S04			8.10	2.70	V	
C09S05	1.0		7.60	2.50	H	
C09S06			8.40	3.00	H	
C09S07	1.5		6.90	2.40	H	
C09S08			7.70	2.00	M	
C09S09	2.0		7.80	2.50	H	
C09S10			7.20	2.80	M	
C09S11	2.5		7.70	2.20	M	
C09S12			6.90	2.10	H	0.06
C09S13	3.0		7.80	2.10	M	
C09S14			7.80	2.30	M	
C09S15	3.5		7.50	2.20	H	
C09S16			7.90	2.00	M	
C09S17	4.0		8.00	2.20	H	
C09S18			8.00	4.40	M	
C09S19	4.5		8.00	2.30	H	
C09S20			8.10	2.70	M	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C10**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389423 NORTHING: 6423442	DEPTH TO WATER: (m):	1.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ10 @ C10S07		

(m)	Soil Description
0.5	**CLAYEY SAND.** Brown. Some organics. No Staining. No Odour.
1.0	
1.5	**SANDY CLAY.** Orange/Brown. No Staining. No Odour.
2.0	**CLAYEY SAND.** Orange/Brown. Medium grained. Saturated. No Staining. No Odour.
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C10S01	0.5		8.10	3.00	V	
C10S02			4.40	2.60	V	
C10S03			5.40	2.80	V	
C10S04	1.0		4.10	2.10	M	
C10S05			4.10	1.80	M	
C10S06	1.5		3.80	2.30	V	0.06
C10S07			8.00	2.90	H	
C10S08	2.0		9.10	2.60	M	
C10S09			8.50	2.40	H	
C10S10	2.5		7.90	2.50	M	
C10S11			8.30	2.70	M	
C10S12	3.0		8.30	2.70	H	
C10S13			8.20	2.30	H	
C10S14	3.5		7.00	2.40	V	
C10S15			7.90	2.40	H	
C10S16	4.0		8.10	2.20	H	0.04
C10S17			8.20	2.50	H	
C10S18	4.5		8.10	4.90	H	
C10S19			8.00	2.60	H	
C10S20	5.0		8.00	2.50	H	

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C11**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389035 NORTHING: 642336	DEPTH TO WATER: (m):	1.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ11 @ C11S12		

(m)	Soil Description
0.5	Humic matter/grass litter. No Staining. No Odour.
	SAND. Black. Medium/Fine grained. Dry. No Staining. No Odour.
1.0	**SAND.** Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
1.5	
2.0	
2.5	
3.0	**CLAY.** Dark Blue/Grey. Medium/Fine grained. No Staining. No Odour.
3.5	**SAND.** Pale Grey. Medium grained. Saturated. No Staining. Slight Sulphur odour.
4.0	**SAND.** Dark grey. Medium/Fine grained. Saturated. No Staining. Slight Sulphur odour.
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C11S01	0.5		5.60	4.20	H	
C11S02			5.80	4.40	H	
C11S03			5.90	4.20	H	
C11S04	1.0		5.80	4.30	H	
C11S05			5.60	4.10	M	
C11S06	1.5		7.80	3.80	M	
C11S07			5.50	3.80	M	
C11S08	2.0		6.50	1.80	M	0.10
C11S09			6.40	1.70	M	
C11S10	2.5		6.80	2.10	H	
C11S11			6.50	1.70	H	
C11S12	3.0		7.00	7.20	H	
C11S13			7.00	7.70	H	0.03
C11S14	3.5		7.00	7.60	H	
C11S15			6.40	1.70	M	
C11S16	4.0		6.80	2.40	M	
C11S17			6.90	1.90	M	
C11S18	4.5		6.90	1.70	M	
C11S19			6.60	1.60	M	
C11S20	5.0		6.80	1.50	M	

Further Comments:

Legend:
- Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
- Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
- Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Overcast
SAMPLING LOCATION ID:	**C12**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389225 NORTHING: 642336	DEPTH TO WATER: (m):	1.5
DATE:	26/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	KK	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ12 @ C12S08		

(m)	Soil Description
0.5	**CLAY LOAM.** Dark Brown. Some organics. No Staining. No Odour.
1.0	**PEATY CLAY.** Black. Moist. Some organics. No Staining. No Odour.
1.5	
2.0	
2.5	
3.0	**SANDY CLAY.** Dark Grey. Saturated. With Limestone gravels. No Staining. No Odour.
3.5	
4.0	**CLAYEY SAND.** Dark Grey. No Staining. No Odour.
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C12S01			4.20	5.50	M	
C12S02			4.00	1.80	V	0.99
C12S03	0.5		4.00	2.60	V	
C12S04			4.10	2.30	V	
C12S05	1.0		4.30	2.10	V	
C12S06			4.60	2.30	V	
C12S07	1.5		4.40	2.10	V	
C12S08			7.70	2.60	H	
C12S09	2.0		7.80	2.40	H	
C12S10			8.00	5.10	H	
C12S11	2.5		8.40	7.40	M	
C12S12			8.10	7.90	H	
C12S13	3.0		8.70	8.00	H	
C12S14			8.50	8.00	H	0.06
C12S15	3.5		8.20	4.50	H	
C12S16			8.70	8.20	H	
C12S17	4.0		8.20	6.30	H	
C12S18			8.20	2.40	V	
C12S19	4.5		8.30	7.60	H	
C12S20			7.90	6.80	H	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C13**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389359 NORTHING: 6423336	DEPTH TO WATER: (m):	1.5
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ13 @ C13S08		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
	SILT LOAM. Dark Brown. Some organics Roots/rootlets. No Staining. No Odour.	C13S01			4.50	1.90	H	
	SILTY CLAY. Dark Brown/Dark Grey. Moist. Sand fraction. No Staining. No Odour.	C13S02			4.30	1.60	H	
0.5		C13S03	0.5		4.40	1.10	M	0.61
		C13S04			4.50	2.10	H	
1.0		C13S05	1.0		4.60	1.60	M	
		C13S06			8.00	1.50	M	
1.5	**SANDY CLAY.** Brown/Grey. Medium/Fine grained. Moist. No Staining. No Odour.	C13S07	1.5		7.70	2.20	L	
	SANDY CLAY. Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C13S08			8.80	2.40	M	
2.0		C13S09	2.0		8.70	3.10	M	
		C13S10			8.90	2.80	M	
2.5		C13S11	2.5		9.20	2.60	X	0.02
	CLAYEY SAND. Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C13S12			8.90	2.40	M	
3.0		C13S13	3.0		8.50	2.60	M	
		C13S14			8.30	2.10	M	
3.5		C13S15	3.5		8.10	2.50	H	
		C13S16			8.40	4.30	M	
4.0		C13S17	4.0		8.10	2.50	X	
		C13S18			8.00	2.50	X	
4.5		C13S19	4.5		8.10	2.40	M	
		C13S20			7.90	2.20	M	
5.0	**SAND.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C13S21	5.0		7.50	1.80	V	

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C14**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389508 NORTHING: 3423337	DEPTH TO WATER: (m):	1.5
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ14 @ C14S10		

(m)	Soil Description
0.5	**SILTY CLAY.** Dark Grey. Medium/Fine grained. Dry. Trace sand fraction. No Staining. No Odour.
1.0	**SANDY CLAY.** Dark Grey/Dark Green. Medium/Fine grained. Dry. No Staining. No Odour.
1.5	**CLAYEY SAND.** Brown/Grey. Medium/Fine grained. Moist. No Staining. No Odour.
2.0	**SANDY CLAY.** Dark Grey/Brown/Pale Brown. Medium/Fine grained. Moist. Trace sand lenses. No Staining. No Odour.
2.5	**CLAYEY SAND.** Dark Grey/Black. Medium/Fine grained. Saturated. Some silty clay inclusions. No Staining. No Odour.
3.0	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
3.5	**SANDY CLAY.** Grey. Medium/Fine grained. Moist. No Staining. No Odour.
4.0	**SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
4.5	**SANDY CLAY.** Pale Grey/Dark Grey/Brown. Medium/Fine grained. Moist. No Staining. No Odour.
5.0	**CLAYEY SAND.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C14S01			6.30	4.40	L	
C14S02			6.20	5.00	L	
C14S03	0.5		6.30	5.00	L	
C14S04			6.60	5.50	L	
C14S05	1.0		6.80	5.60	L	
C14S06			6.60	5.50	L	
C14S07	1.5		6.80	5.60	L	
C14S08			7.40	7.40	X	0.02
C14S09	2.0		6.80	6.00	M	
C14S10			6.90	4.50	M	
C14S11	2.5		8.20	6.20	L	
C14S12			8.20	5.20	M	
C14S13	3.0		8.50	3.90	M	
C14S14			8.10	2.90	M	
C14S15	3.5		7.80	4.80	M	
C14S16			7.70	3.30	L	
C14S17	4.0		7.80	3.30	M	
C14S18			8.00	2.40	V	0.06
C14S19	4.5		7.90	2.70	M	
C14S20			7.90	2.50	M	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C15**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	388972 NORTHING: 6423228	DEPTH TO WATER: (m):	3.4
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ15 @ C15S19		

(m)	Soil Description
0.5	**SAND.** Pale Grey. Medium/Fine grained. Dry. No Staining. No Odour.
1.0	**SAND.** Grey. Medium/Fine grained. Dry. Trace charcoal fragments. No Staining. No Odour.
1.5	**SAND.** Pale Grey/White. Medium/Fine grained. Dry. No Staining. No Odour.
2.0	**SAND.** Pale Brown. Medium/Fine grained. Dry. No Staining. No Odour.
2.5	**SAND.** Pale Grey/White. Medium/Fine grained. Saturated. No Staining. No Odour.
3.0	**COFFEE SANDS.** Dark Brown. Medium/Fine grained. Saturated. No Staining. No Odour.
3.5	**SAND.** Pale Grey/Brown. Medium/Fine grained. Saturated. No Staining. No Odour.
4.0	**COFFEE SANDS.** Dark Brown/Brown. Medium/Fine grained. Saturated. No Staining. No Odour.
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C15S01			5.30	3.50	L	
C15S02	0.5		5.40	3.70	L	<0.02
C15S03			5.30	3.60	L	
C15S04			5.20	3.40	L	
C15S05	1.0		5.40	3.80	L	
C15S06			5.60	3.90	L	
C15S07	1.5		5.80	4.50	L	
C15S08			5.90	4.30	L	
C15S09	2.0		5.70	4.00	L	
C15S10			5.70	3.90	L	
C15S11	2.5		5.80	3.90	L	
C15S12			6.00	4.60	L	
C15S13	3.0		6.10	4.40	L	
C15S14			6.40	4.00	L	
C15S15	3.5		6.30	2.70	M	
C15S16			6.10	3.50	M	
C15S17	4.0		6.50	3.30	L	
C15S18			6.50	3.40	L	
C15S19	4.5		6.50	2.80	M	
C15S20			6.50	1.80	X	<0.02
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C16**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389114 NORTHING: 6423235	DEPTH TO WATER: (m):	0.6
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ16 @ C16S17		

(m)	Soil Description
0.5	**SILT LOAM.** Dark Brown/Black. Medium/Fine grained. Dry. Some Silty Clay inclusing. No Staining. No Odour.
	SILTY CLAY. Black/Dark Grey. Medium/Fine grained. Moist. Trace sand fraction. No Staining. No Odour.
	SANDY CLAY. Dark Brown/Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
2.5	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
3.0	**SAND.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
	SANDY CLAY. Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
3.5	**SAND.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
	CLAYEY SAND. Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C16S01			4.80	2.20	X	
C16S02			4.70	2.50	H	
C16S03	0.5		4.90	2.30	M	0.29
C16S04			6.80	3.50	M	
C16S05	1.0		7.40	2.40	M	
C16S06			7.90	2.20	H	
C16S07	1.5		8.80	2.90	M	
C16S08			9.00	2.70	H	
C16S09	2.0		8.50	2.40	V	
C16S10			8.50	2.30	V	
C16S11	2.5		8.80	2.20	V	
C16S12			9.10	2.30	X	0.06
C16S13	3.0		8.60	1.90	M	
C16S14			8.90	2.20	X	
C16S15	3.5		8.60	3.20	M	
C16S16			8.60	4.20	M	
C16S17	4.0		8.60	3.00	M	
C16S18			8.60	2.80	L	
C16S19	4.5		8.30	6.70	M	
C16S20			8.30	4.50	M	
C16S21	5.0		8.30	2.30	M	

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C17**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389295 NORTHING: 6423234	DEPTH TO WATER: (m):	1.6
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ17 @ C17S05		

(m)	Soil Description
0.5	**SILTY SAND.** Dark Brown. Medium/Fine grained. Dry. Trace Clay inclusions. No Staining. No Odour.
1.0	**SILTY CLAY.** Black/Dark Brown. Medium/Fine grained. Dry. trace sand fraction. No Staining. No Odour.
1.5	**SANDY CLAY.** Dark Brown/Dark Grey. Medium/Fine grained. Dry. No Staining. No Odour.
2.0	**SANDY CLAY.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
2.5	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
3.0	
3.5	
4.0	
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C17S01			4.40	2.20	H	
C17S02			4.30	2.30	M	
C17S03	0.5		4.40	2.10	H	
C17S04			4.30	2.20	H	0.58
C17S05	1.0		4.80	2.00	M	
C17S06			5.70	2.20	M	
C17S07	1.5		8.10	2.30	X	
C17S08			8.50	4.40	M	
C17S09	2.0		7.80	2.30	H	
C17S10			8.10	2.30	X	
C17S11	2.5		8.60	2.90	M	
C17S12			8.40	2.40	M	
C17S13	3.0		8.20	2.80	M	
C17S14			8.30	2.90	X	
C17S15	3.5		8.00	2.30	X	
C17S16			7.90	2.30	X	0.05
C17S17	4.0		7.80	2.10	M	
C17S18			8.40	3.90	M	
C17S19	4.5		8.20	2.10	H	
C17S20			7.50	2.50	X	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C18**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389435 NORTHING: 6423230	DEPTH TO WATER: (m):	1.5
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ18 @ C18S01		

(m)	Soil Description
0.5	**CLAY LOAM.** Dark Grey/Dark Brown. Medium/Fine grained. Dry. Some organics roots/rootlets. No Staining. No Odour.
1.0	**SANDY CLAY.** Dark Grey/Green. Medium/Fine grained. Dry. Trace organics roots/rootlets. Trace charcoal. No Staining. No Odour.
1.5	**CLAYEY SAND.** Brown/Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
2.0	**SANDY CLAY.** Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.
2.5	
3.0	**SANDY CLAY.** Grey/Brown. Medium/Fine grained. Moist. No Staining. Sulphur odour.
3.5	**CLAYEY SAND.** Pale Grey. Medium/Fine grained. Moist. No Staining. No Odour.
4.0	**CLAYEY SAND.** Grey. Medium/Fine grained. Saturated. Clay inclusions. No Staining. No Odour.
4.5	
5.0	

Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
C18S01			4.40	2.20	M	
C18S02			4.30	2.70	M	
C18S03	0.5		4.10	2.80	M	
C18S04			4.80	2.40	M	
C18S05	1.0		4.50	2.30	M	
C18S06			4.50	2.60	L	
C18S07	1.5		6.50	2.80	L	0.04
C18S08			9.00	2.20	X	
C18S09	2.0		8.40	2.50	L	
C18S10			8.50	2.20	L	
C18S11	2.5		9.00	3.20	L	
C18S12			7.60	3.20	H	
C18S13	3.0		7.80	4.50	L	
C18S14			7.30	2.10	H	
C18S15	3.5		7.70	2.40	X	
C18S16			8.00	2.10	M	
C18S17	4.0		7.90	2.20	M	
C18S18			7.70	2.10	L	
C18S19	4.5		7.60	2.00	L	0.10
C18S20			6.80	2.30	M	
	5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C19**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389096 NORTHING: 6423126	DEPTH TO WATER: (m):	0.8
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ19 @ C19S04		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
	SILTY SAND. Dark Grey. Medium/Fine grained. Some organics roots/rootlets. No Staining. No Odour.	C19S01			4.80	3.30	L	
	SAND. Grey. Medium/Fine grained. Saturated. Slightly silty. No Staining. No Odour.	C19S02			4.30	2.40	M	
0.5		C19S03	0.5		4.70	2.20	M	
		C19S04			4.00	1.90	M	
1.0		C19S05	1.0		4.80	1.50	M	0.07
		C19S06			4.80	1.50	M	
1.5		C19S07	1.5		6.20	1.80	L	
		C19S08			6.60	1.90	H	
2.0		C19S09	2.0		6.90	2.00	M	
		C19S10			7.10	1.90	V	
2.5		C19S11	2.5		7.30	1.70	H	
		C19S12			7.10	1.70	H	
3.0		C19S13	3.0		6.80	1.80	H	
		C19S14			6.40	2.00	M	
3.5		C19S15	3.5		6.10	1.90	M	
		C19S16			6.10	2.00	L	
4.0	**SAND.** Grey/Pale Grey. Medium/Fine grained. Saturated. No Staining. Slight Sulphur odour.	C19S17	4.0		7.50	1.90	L	0.07
		C19S18			7.30	1.90	M	
4.5		C19S19	4.5		6.80	1.80	M	
		C19S20			7.00	1.80	M	
5.0			5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

SHEET: 1 of 1

Low
Medium
High
EX**t**reme
Volcanic

ACID SULFATE SOIL FIELD TESTING LOG

PROJECT NUMBER:	**C1323403**	WEATHER:	Fine
SAMPLING LOCATION ID:	**C20**	METHOD:	Push Corer
SITE NAME:	East Baldivis	REFUSAL:	No
SAMPLING AREA:	Lot 742	FILL PRESENT:	
EASTING:	389292 NORTHING: 6423134	DEPTH TO WATER: (m):	1.5
DATE:	27/03/2014	TOTAL DEPTH: (m):	5
SCIENTIST(S):	SMW	STORAGE:	Ice and Eskie
QA/QC SAMPLE IDs:	CZ20 @ C20S03		

(m)	Soil Description	Sample IDs	(m)	Test No.	pHf	pHfox	Vigour	Net Acidity (%S)
0	**SILT LOAM.** Dark Brown/Dark Grey. Medium/Fine grained. Dry. Abundant organics roots/rootlets. No Staining. No Odour.	C20S01	0		4.40	1.60	H	
	SILTY CLAY. Black/Dark Grey. Medium/Fine grained. Dry. Trace organics roots. Trace clay fraction. No Staining. No Odour.	C20S02			4.20	2.10	X	
0.5		C20S03	0.5		4.10	2.30	X	
	SANDY CLAY. Dark Grey/Dark Brown. Medium/Fine grained. Dry. No Staining. No Odour.	C20S04			4.20	2.40	H	
1.0		C20S05	1.0		4.30	2.50	M	
	SANDY CLAY. Dark Grey. Medium/Fine grained. Moist. No Staining. No Odour.	C20S06			3.60	2.10	H	0.15
1.5		C20S07	1.5		7.60	2.20	H	
		C20S08			7.90	1.80	X	0.12
2.0	**SANDY CLAY.** Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C20S09	2.0		7.40	1.90	X	
		C20S10			8.20	2.00	X	
2.5		C20S11	2.5		8.00	1.90	X	
	CLAYEY SAND. Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C20S12			8.60	2.40	M	
3.0		C20S13	3.0		8.90	2.50	M	
	SANDY CLAY. Grey/Dark Green. Medium/Fine grained. Moist. No Staining. No Odour.	C20S14			8.10	2.20	X	
	CLAYEY SAND. Dark Grey. Medium/Fine grained. Saturated. No Staining. No Odour.	C20S15			8.10	2.30	X	
3.5		C20S16	3.5		8.40	2.30	H	
4.0		C20S17	4.0		8.30	3.30	M	
		C20S18			8.00	2.10	M	
4.5		C20S19	4.5		7.80	2.00	M	
		C20S20			8.60	2.80	M	
5.0			5.0					

Further Comments:

Legend:
Green shading denotes inferred Potential Acid Sulphate Soil (PASS)
Orange shading denotes inferred Actual Acid Sulphate Soil (AASS)
Dark Orange shading denotes value exceeds DoE action criteria of 0.03% S

Low
Medium
High
EX**t**reme
Volcanic

BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: C1323403				WEATHER: Overcast	
BOREHOLE ID: MB01				DRILLING METHOD: Push Corer	
SITE: East Baldivis		LOCATION: Lot 742		TOTAL DEPTH: 7 m	
EAST:	388979	NORTH:	6423378	TOP of COLLAR RL: mAHD	
DATE BEGUN:	26/03/2014	DATE COMPLETED:	26/03/2014	STATIC WATER LEVEL: 4 mbgl	
SCIENTIST: KK				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: John Metcalf				SHEET: 1 of 1	

LITHOLOGY DESCRIPTION

-0.5

0.0 **LOAMY SAND.** Dark Brown. Dry. Some organics. No Staining. No Odour.

SAND. Orange. Dry. No Staining. No Odour.

0.5

1.0

1.5

2.0

2.5

3.0

3.5

4.0

4.5

5.0 **SAND.** Grey/Yellow. Saturated. No Staining. No Odour.

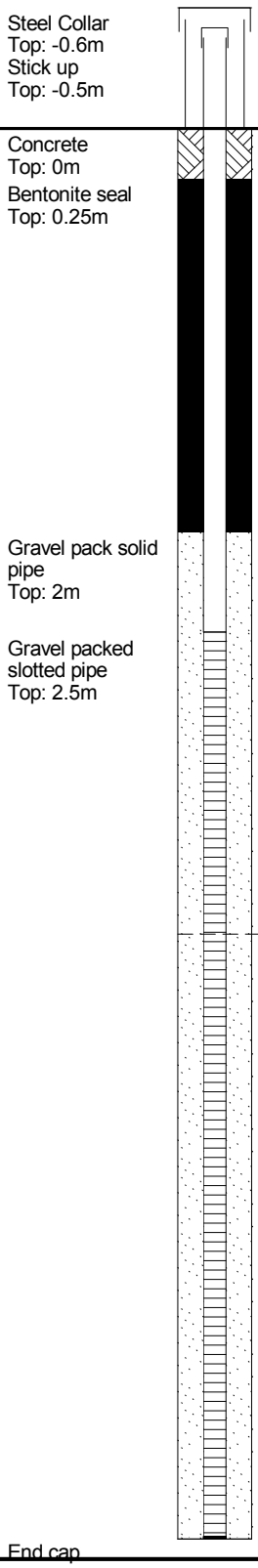
5.5

6.0

6.5

7.0

BORE INSTALLATION



BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: C1323403				WEATHER: Overcast	
BOREHOLE ID: MB02				DRILLING METHOD: Push Corer	
SITE: East Baldivis		LOCATION: Lot 742		TOTAL DEPTH: 7 m	
EAST:	389586	NORTH:	6423581	TOP of COLLAR RL: mAHD	
DATE BEGUN:	26/03/2014	DATE COMPLETED:	26/03/2014	STATIC WATER LEVEL: 2 mbgl	
SCIENTIST: KK				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: John Metcalf				SHEET: 1 of 1	

LITHOLOGY DESCRIPTION

-0.5

0.0 **CLAY LOAM.** Dark Grey. Abundant organics. No Staining. No Odour.

0.5 **SANDY CLAY.** Dark Grey. No Staining. No Odour.

1.0 **SANDY CLAY.** Pale Grey. No Staining. No Odour.

1.5 **SANDY CLAY.** Pale Grey/White. Moist. No Staining. No Odour.

2.0 **SANDY CLAY.** Yellow/Borwn/Grey. Saturated. No Staining. No Odour.

2.5

3.0

3.5

4.0

4.5 **CLAYEY SAND.** Grey/Brown. Saturated. No Staining. No Odour.

5.0

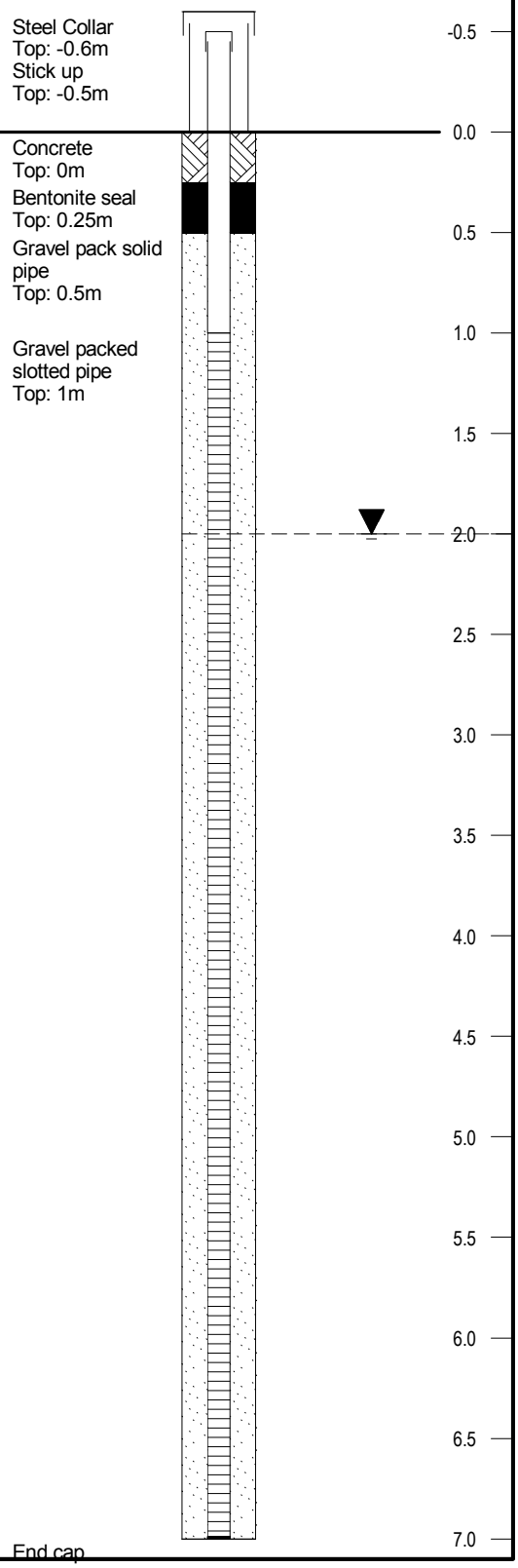
5.5

6.0 **CLAYEY SAND.** Pale Grey. Saturated. No Staining. No Odour.

6.5

7.0

BORE INSTALLATION



BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: C1323403				WEATHER: Fine	
BOREHOLE ID: MB03				DRILLING METHOD: Push Corer	
SITE: East Baldivis		LOCATION: Lot 742		TOTAL DEPTH: 7 m	
EAST:	388943	NORTH:	6423103	TOP of COLLAR RL: mAHD	
DATE BEGUN:	27/03/2014	DATE COMPLETED:	27/03/2014	STATIC WATER LEVEL: 3.65 mbgl	
SCIENTIST: SMW				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: John Metcalf				SHEET: 1 of 1	

LITHOLOGY DESCRIPTION

-0.5

0.0 **SILTY SAND.** Dark Grey/Dark Brown. Medium/Fine grained. Dry. Some organics roots, rootlets and charcoal. No Staining. No Odour.

0.5 **SAND.** Grey. Medium/Fine grained. Dry. No Staining. No Odour.

1.0

1.5

2.0 **SAND.** Brown/Pale Grey. Medium/Fine grained. Dry. No Staining. No Odour.

2.5 **COFFEE SANDS.** Brown. Medium/Fine grained. Dry. No Staining. No Odour.

COFFEE SANDS. Dark Brown. Medium/Fine grained. Moist. Some cemented Coffee Rock gravels. No Staining. No Odour.

3.0 **COFFEE SANDS.** Dark Brown. Medium/Fine grained. Moist. No Staining. No Odour.

3.5 **SAND.** Pale Brown/Yellow. Medium/Fine grained. Saturated. No Staining. No Odour.

4.0 **COFFEE SANDS.** Brown. Medium/Fine grained. Saturated. No Staining. No Odour.

COFFEE SANDS. Dark Brown/Grey. Medium/Fine grained. Saturated. No Staining. No Odour.

4.5

5.0 **SAND.** Grey/Brown. Medium/Fine grained. Saturated. No Staining. No Odour.

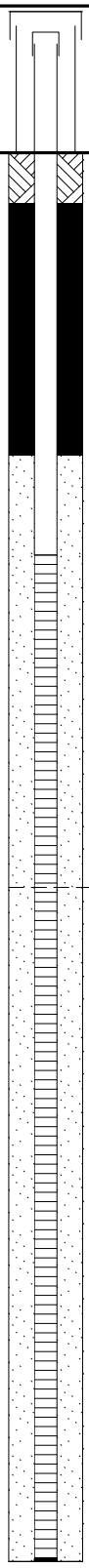
5.5

6.0

6.5

7.0

BORE INSTALLATION



Steel Collar
Top: -0.7m
Stick up
Top: -0.6m

Concrete
Top: 0m

Bentonite seal
Top: 0.25m

Gravel pack solid pipe
Top: 1.5m

Gravel packed slotted pipe
Top: 2m

End cap

-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0

BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: C1323403				WEATHER: Fine	
BOREHOLE ID: MB04				DRILLING METHOD: Push Corer	
SITE: East Baldivis		LOCATION: Lot 742		TOTAL DEPTH: 7 m	
EAST:	389482	NORTH:	6423106	TOP of COLLAR RL: mAHD	
DATE BEGUN:	27/03/2014	DATE COMPLETED:	27/03/2014	STATIC WATER LEVEL: 1.5 mbgl	
SCIENTIST: SMW				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: John Metcalf				SHEET: 1 of 1	

LITHOLOGY DESCRIPTION

-0.5

0.0 **SILTY CLAY.** Dark Grey. Medium/Fine grained. Dry. Trace organics roots. Trace sand. No Staining. No Odour.

0.5 **SILTY CLAY.** Dark Grey/Dark Green. Medium/Fine grained. Dry. No Staining. No Odour.

SANDY CLAY. Pale Brown/Pale Grey. Medium/Fine grained. Moist. No Staining. No Odour.

1.0

COFFEE ROCK. Dark Brown. Medium/Fine grained. Moist. Cemented. No Staining. No Odour.

1.5 **SANDY CLAY.** Pale Brown. Medium/Fine grained. Moist. Some Coffee Rock Gravels. No Staining. No Odour.

2.0 **SANDY CLAY.** Dark Grey. Medium/Fine grained. Moist. No Staining. No Odour.

CLAYEY SAND. Pale Grey. Medium/Fine grained. Moist. No Staining. No Odour.

2.5

3.0

3.5 **SANDY CLAY.** Dark Brown/Dark Grey. Medium/Fine grained. Moist. No Staining. No Odour.

SAND. Grey. Medium/Fine grained. Saturated. With clayey sand inclusions. No Staining. No Odour.

4.0

4.5

5.0

CLAYEY SAND. Grey. Medium/Fine grained. Saturated. No Staining. No Odour.

5.5

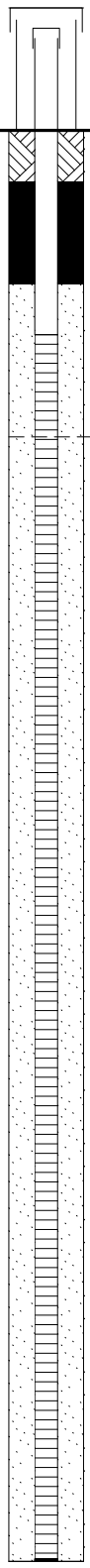
6.0

SAND. Pale Grey. Medium/Fine grained. Saturated. No Staining. No Odour.

6.5

7.0

BORE INSTALLATION



Steel Collar
Top: -0.6m
Stick up
Top: -0.5m

Concrete
Top: 0m

Bentonite seal
Top: 0.25m

Gravel pack solid pipe
Top: 0.75m
Gravel packed slotted pipe
Top: 1m

End cap

-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0

APPENDIX 2

Geotechnical Investigation Lot
746–750 Baldivis Road

GEOTECHNICAL INVESTIGATION

For: Mirvac WA Pty Ltd

Project Address: Lot 746 – 750 Baldivis Road, Baldivis

Project Number: D65859

Job Number: J142676

Revision Number: 0

Author: Tong Chen

Date: 5 May 2014

STRUCterre consulting engineers

Residential Geotechnical Commercial & Infrastructure

Inspect & Investigate Energy Assessment Environmental

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1. PROJECT DETAILS

1.1. Introduction

At the request of Priya Correia of Mirvac WA Pty Ltd, Structerre Consulting Engineers (Structerre) have conducted a geotechnical investigation at Lot 746 – 750 Baldivis Road, Baldivis. The purpose of the investigation was to provide:

- An assessment of the site classification in accordance with AS2870: 2011 “Residential Slabs and Footings”;
- An assessment of the sub-surface soil profile and groundwater conditions across the proposed area;
- The measurement of the depth of groundwater, if encountered;
- Recommendations on suitable foundation systems;
- Recommendations on earthworks and site preparation;
- Allowable ground bearing capacity and associated settlements for strip and pad footings.

This report details the scope of the geotechnical investigation, presents an interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks.

Interpretation of site conditions is based on the sub-surface lithology revealed during the investigation programme, visual assessments of the in situ materials, the results of in situ field tests, and the results of laboratory testing carried out on selected representative samples.

Structerre was provided a geotechnical investigation report done by Douglas Partners (Project No. 82160, dated 21 October 2013).

1.2. Site Description & Proposed Development

The site is located at Lot 746 – 750 Baldivis Road, Baldivis, City of Rockingham. Baldivis Road lies to the west of the site with Kwinana Freeway to the east and existing farm to the south and north. Structerre were provided with a site plan showing the site location with respect to boundaries and the surrounding development.

The site has a total area of approximately 30Ha and is generally flat and level, as is the surrounding topography. At the time of the field investigation the site was mostly vacant, with an existing house and sheds near the western boundary.

We understand that the site is proposed for residential development with internal roads.

1.3. Field Investigation – Scope of Works

The field investigation was carried out on 1 and 2 April 2014 and consisted of:

- 6 x Electric Friction Cone Penetrometer Tests (EFCPT) to a maximum depth of 6.2m for material assessment and soil profiling;
- 10 x excavated test pits to a depth of up to 3.0m over the site for material assessment and soil profiling;
- 2 x dissipation tests to determine the coefficient of permeability and consolidation of the clayey materials and;
- 10 x Dynamic Cone Penetrometer Tests (DCP) in accordance with AS1289.6.3.2 (1997) to a depth of 3.0m for evaluation of relative densities of the upper layers.

A geotechnical engineer from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-1993 Geotechnical Site Investigation.

The EFCPT testing was conducted using a track rig from Structerre and the test pits were excavated with a 5T excavator, owned and operated by Executive Plant Hire.

The EFCPT, test pit, and DCP test locations are shown on the attached site plan (Appendix 1).

2. DESK STUDY

2.1. Geological Setting

The *Rockingham 1: 50,000 Environmental Geology Series* (Part Sheets 2033 II and 2033 III, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layers underlie the site:

- SAND – very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin
- CLAY – strong brown and dark grey clay, plastic in places, soft when wet, variable silt content in matrix, of alluvial origin

2.2. Groundwater and Ground Surface Level

The Perth Groundwater Atlas (Waters & Rivers Commission Website 2nd Edition) indicates the ground surface level is approximately less than 10.0m Australian Height Datum (AHD), which corresponds to the surveyed site levels (3.4m – 9.78m AHD), as provided by The Client.

No groundwater information is available for this area. However, a previous report indicates groundwater to be approximately 1.0m below existing ground level.

2.3. Earthquake Coefficient

In accordance with AS1170.4-2007, the site is located with an earthquake acceleration coefficient of less than 0.09.

3. RESULTS OF THE INVESTIGATION

3.1. Subsurface Soil Profile

The subsurface soil profile was determined from the ground conditions encountered within the test pits and through the interpretation of the DCP and EFCPT results. Based on the site investigation findings, the site can be separated into two zones. The western area of site is defined as Area A and the eastern area of the site is defined as Area B. The approximate boundary line for Area A and Area B is shown in the site plan within Appendix 1. The subsurface soil profiles for the two areas are summaries below:

Table 1 – Subsurface Soil Profile

Zone	Depth to Base of Strata (m)	Material Description
Area A	0.1 (Ave 0.1)	TOPSOIL
	1.8 – 2.0 (Ave 1.9)	SAND / Silty SAND, trace organic material, loose to medium dense
	Not Penetrated (>6.5)	SAND, medium dense
Area B	0.1 (Ave 0.1)	TOPSOIL
	0.5 – 1.8 (Ave 0.9)	SAND / Silty SAND, trace organic material, loose
	1.5 – 2.5 (Ave 1.8)	SILT / SAND, organic material, soft / loose
	2.5 – 3.0 (Ave 2.7)	Clayey SAND, loose to medium dense
	Not Penetrated (>6.5)	SAND, medium dense to dense

The soils encountered are consistent with the expected site conditions as predicted from the Environmental Geology Map and the previous geotechnical investigation. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. EFCPT reports are presented in Appendix 2, with detailed descriptions of the subsurface soil conditions encountered presented in Appendix 3.

3.2. Groundwater

Groundwater was encountered within TP10 at a depth of 1.4m below the existing ground level. However, based on a previous geotechnical investigation report, shallow groundwater was encountered across the site from the surface to a depth of 4.6m. Therefore, it is recommended that earthwork should be carried during the dry season.

3.3. Laboratory Test Results

Laboratory testing was carried out on the natural soil samples to determine soil classification, plasticity, organic content and consolidation rate. The laboratory test results are summarised in tables below, with the test certification enclosed in Appendix 5.

Table 2 – Soil Classification Test Results

Sample	Test Hole	Depth (m)	Soil Description	Liquid Limit % AS1289 3.1.2	Plastic Limit % AS1289 3.2.1	Plasticity index % AS1289 3.3.1	Linear Shrinkage % AS1289 3.4.1	Organic Content (%)
1	TP3	0.5 – 1.0	Sandy SILT trace gravel	67	34	33	17	10.4
2	TP3	2.5 – 3.0	Clayey SAND trace gravel	47	18	29	15	N/S
3	TP4	0.1 – 0.5	Silty SAND trace gravel	52	38	14	10	10.7
4	TP7	1.0 – 1.5	Clayey SAND trace gravel	52	26	26	13	6.6
5	TP7	2.0 – 2.5	Clayey SAND trace gravel	38	15	23	11	N/S
6	TP9	0.5 – 1.0	Silty SAND	44	35	9	5	5.3

Notes:
N/S – Not Scheduled

Table 3 – Consolidation Test Results

Sample	Test Hole	Depth (m)	Coefficient of Consolidation, Cv m^2/year			Coefficient of Compressibility, mv m^2/kN			Coefficient of Permeability, k m/s		
			Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
1	TP3	1.5 – 2.0	52	98	67	2.9×10^{-5}	4.1×10^{-4}	1.9×10^{-4}	4.7×10^{-10}	8.3×10^{-9}	3.4×10^{-9}
2	TP4	0.5 – 1.0	83	140	105	1.5×10^{-5}	2.1×10^{-4}	1.0×10^{-4}	5.7×10^{-10}	6.4×10^{-9}	2.74×10^{-9}
3	CPT3	1.8 – 2.3	38	67	47	2.3×10^{-5}	2.5×10^{-4}	1.3×10^{-4}	3.3×10^{-10}	3.9×10^{-9}	1.7×10^{-9}
4	CPT4	2.0 – 2.5	1.6	8.0	4.0	1.1×10^{-4}	1.9×10^{-4}	1.5×10^{-4}	7.8×10^{-11}	3.8×10^{-10}	2×10^{-10}

3.4. Dissipation Testing

Dissipation testing was carried out at the locations of CPT2 and CPT3. The results of the tests showed that the natural material has a low permeability (7×10^{-10}m/s) and a coefficient of consolidation of between 21 and 35m^2/year.

3.5. Time of Consolidation

Based on the consolidation and dissipation test results, it is estimated that the consolidation period would be less than 6 months.

4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

4.1. Site Classification

AS2870: 2011 "*Residential Slabs and Footings - Construction*" provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

Based on the findings of the investigation, the west of the site (Area A) can be classified as Class "A" and the east of the site (Area B) is classified as Class "P" in accordance with *AS2870* due to the presence of loose sand at depth. The site classification for the eastern part of the site could be upgraded to an equivalent Class "S", provided that the earthworks are undertaken in accordance with the recommendations outlined in Section 4.3 of this report.

Foundations for the development should be designed by a structural engineer, taking into consideration the recommendations outlined in Section 4.3 of this report, ground bearing capacities and the acceptable total and differential settlements of the proposed foundation system.

4.2. Drainage

The site is potentially suitable for on site disposal of stormwater runoff subject to the proposed development and the design of the drainage system, which is unknown at this time, but may include:

- Soakwells;
- Overland flow paths; and
- Compensation Basin.

Based on the investigation results the silty SAND fill materials would be classed as poor drainage medium and would have a permeability characteristic of approximately $1x10^{-6}$ m/s. It is recommended that following the placement of fill materials to achieve final level and the development of a preliminary drainage design, in situ permeability test be undertaken.

4.3. Earthworks

It is considered that the site is suitable for residential development, subject to the appropriate earthworks and foundation design being undertaken. All earthworks shall be undertaken in accordance with AS3798-2007 “Earthworks for Residential and Commercial developments”. The following earthwork options should be considered for the site.

4.3.1. Area A

- The topsoil and vegetation is to be stripped / grubbed and removed from the site.
- Excavate and compact: The area is to be excavated to the final level. The base level is to be proof compacted with a compactor. The compaction requirements are set out in the table below, as per AS 3798:2007:

Table 3 – Compaction Requirements

Item	Application	Minimum relative compaction, %	
		Minimum density ratio Standard Compactive Effort (Cohesive soils)	Minimum density index (Cohesionless soils)
1	Residential - lot, fill, house, sites	95	70
2	Commercial – fills to support minor loadings, including floor loadings of up to 20kPa and isolated pad or strip footings to 100kPa	98	75
3	Fill to support pavements a) General fill b) Subgrade (to a depth of 0.3m)	 95 98	 70 75

4.3.2. Area B

Option 1:

- The topsoil and vegetation is to be stripped / grubbed and removed from the site.
- The base level is to be compacted as per compaction requirement in Table 3.
- The area is to be filled in thin layers (no more than 300mm) to the required finished level with imported fill or materials cut from Area A.

Option 2:

- The topsoil and vegetation is to be stripped / grubbed and removed from the site.
- The base level is to be compacted by dynamic / impact compaction method (i.e. HIEDYC). The density of upper 3.0m of soil may be improved by this method of compaction, subject to verification by field trial.
- The area is to be filled in thin layers (no more than 300mm) to the required finished level with imported fill or materials cut from Area A.

Option 3:

- The topsoil and vegetation is to be stripped / grubbed and removed from the site.
- Excavate the top 1.0m of silty sand and stockpile for reuse on site.

- The underlying sandy silt / silty sand layer is to be compacted by dynamic / impact compaction method (i.e. HIEDYC). The density of the upper 2.5m of soil may be improved by this method of compaction, subject to verification by field trial.

- The 1.0m excavated silty sand is to be replaced and compacted, followed by the placement of imported fill or materials cut from Area A in thin layers (no more than 300mm) to the required finish level.

Option 4 (pre-loading)

- The topsoil and vegetation is to be stripped / grubbed and removed from the site.

- The base level is to be compacted as per compaction requirement in Table 3.

- The area is to be filled in thin layers (no more than 300mm) to the required finished level with imported fill or materials cut from Area A. The settlements generated by the placement of fill should be monitored to enable geotechnical parameters to be back analysed and the surcharging strategy amended, if necessary.

- The area is to be surcharged within between 1m and 3m of sand fill for a period of approximate 6 months.

The previous geotechnical investigation indicated that high groundwater level across the site. However, high level of groundwater was not presented during this investigation. Therefore, in our opinion, both dynamic compaction and pre-loading are considered as appropriate methodologies for site preparation. However, the dynamic compaction should be conducted in dry season (mid summer to beginning of winter) and pre-loading conducted in wet season (mid winter to beginning of summer). It is recommended the client to conduct a dynamic compaction (i.e. HIEDYC) trial as soon as possible.

4.4. Shallow Footings – Allowable Soil Bearing Pressures

Based on the findings of the investigation, shallow pad and strip footings are considered appropriate foundation systems for potential light residential (i.e. one storey) development.

Allowable bearing pressures for shallow footings at this site have been calculated under the assumption that the site preparation procedures specified in Section 4.3 (i.e. Area A and option 1 for Area B) have been carried out, the specified level of compaction has been achieved below the base of each footing and settlement due to the fill has ceased, which is estimated to be approximately 75mm.

Tables 4 and 5 present the allowable bearing pressures for a range of footing sizes for pad and strip footings respectively. The bearing pressures should be designed with consideration of potential settlements. The tables provide allowable pressures for embedment depth of 0.5m.

Table 4 – Allowable Bearing Pressures for Pad Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa) / Settlement (mm) with No Surcharge	Allowable Bearing Capacities (kPa) for Settlement (mm) with 1m Surcharge	Allowable Bearing Capacities (kPa) for Settlement (mm) with 2m Surcharge
0.5	0.5	195 / <5	195 / <5	195 / <5
	1.0	230 / <15	230 / <15	230 / <10
	1.5	180 / <20	180 / <20	180 / <15
	2.0	120 / <20	120 / <20	120 / <15

Table 5 – Allowable Bearing Pressure for Strip Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa) for Settlement (mm) with No Surcharge	Allowable Bearing Capacities (kPa) for Settlement (mm) with 1m Surcharge	Allowable Bearing Capacities (kPa) for Settlement (mm) with 2m Surcharge
0.5	0.5	155 / <10	155 / <5	155 / <5
	1.0	100 / <20	100 / <15	100 / <15
	1.5	65 / <20	65 / <15	65 / <10

The recommended allowable bearing capacities are dependent on the site being dry and well drained, so that the foundation material does not become saturated. Additionally, the earthworks for Area A and in accordance with option 1 for Area B have been completed.

The actual allowable bearing capacity of a particular foundation will be dependent on its location, geometry and founding depth, as well as the founding horizon. Therefore, once specific foundation geometries and the ground improvements from the placement of fill and surcharging have been determined, it is recommended that the allowable bearing capacity and associated settlements be verified.

5. CONCLUSIONS

A site investigation has been carried out at the site of the proposed development to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The subsurface soil encountered in Area A comprised topsoil underlain by sand to 6.5m while in Area B comprised sand / silty sand (organic) to a depth of 1.0m underlain by sandy silt / silty sand to 2.0m, underlain by clayey sand to 3.0m and sand to the investigation depth of 6.8m.

- In the previous geotechnical investigation, water was encountered at various depths across the site from the surface to a depth of 4.6m. However during this investigation water was only found in one test pit at a depth of 1.4m.

- Area A can be classified as Class “A” and Area B can be classified as an equivalent Class “S” in accordance to *AS2870: 2011.*

- Potential suitable earthwork methodologies include stripping and filling, dynamic compaction (i.e.HIEDYC), and surcharging. The recommended earthworks strategy is a combination of techniques and is presented in Section 6, below.

- Allowable bearing capacity for pad footings ranged from 120kPa to 230kPa and from 70kPa to 155kPa for strip footings. The estimation of settlement of the footings ranges between 5 and 20mm depending on earthworks undertaken.

6. RECOMMENDATIONS

Four earthwork options are considered appropriate for the site. However, based on the analysis and the finding of the investigation, it is recommended a combination of these options be undertaken. The site has been divided into three zones as shown in Figure 1 below. The proposed earthwork strategy would be as follows:

Figure 1 – Earthwork Recommendation Zoning

- Topsoil and vegetation in Zone 1 and Zone 3 should be stripped and removed from the site.
- The sand in Zone 1 is to be excavated to 2.5m below finished ground level and the base compacted.
- Zone 3 should be compacted and the excavated sand from Zone 1 placed on Zone 3. Based on the preliminary assessment of the contour levels, the excavated sand from Zone 1 should fill Zone 3 to final level. Settlements induced by the placement of the sand should be monitored to enable the geotechnical properties to be back analysed and the surcharging strategy amended, if necessary.

- The topsoil should be stripping from Zone 2 and removed off site. The organic silty sand in zone 2 should be excavated (approximate 1.0m) and mixed with clean sand in a ratio of 1:1. The mixed soil is to be placed at the base of Zone 1 and compacted.

- The base of zone 2 (sandy silt over clayey sand) should be compact by dynamic / impact compaction method (i.e. HIEDYC) and the improvement of the underlain materials assessed.

- Fill sand shall be imported to site and placed on Zone 3 as surcharge. The approximate imported sand fill is estimated to be 313,000m^3. Note that the imported amount of fill is a preliminary estimation only. The earthworks contractor should determine the actual amount of imported sand. Zone 3 should be surcharged with a minimum 2.0m above finish level. The remaining fill sand is to be placed in Zone 1 and 2, to ensure surface water drainage of the site is maintained.

- The surcharge duration for Zone 3 is estimated to be less than 6 months based on the rate of consolidation of the underlying material.

- Once the surcharging process has been completed the fill sand in Zone 3 is to be transferred to Zone 1 and Zone 2 to bring these areas to final level. The fill should be placed in thin layers (not more than 300mm) with compaction in accordance with Table 3 in this report.

During the surcharging period of Zone 3, a surface water management plan should be done to ensure the surface water drains towards the northeast of the site.

During the earthworks monitoring is required to ensure the earthworks have been undertaken in accordance with the specified standards. Monitoring of the earthworks should include the following:

- For areas with dynamic compaction (i.e. HIEDYC), surveying, dynamic cone penetrometer (DCP) tests and electric friction cone penetrometer tests (EFCPTs) should be undertaken to ensure adequate compaction / improvement of underlying soil has been achieved.

- For areas with surcharging, piezometers and settlement marker will be placed and checked in a regular base to monitor the progress of the settlements induced by the surcharge. Additionally, monitoring of settlement during the placement of fill will enable the geotechnical parameters to be back analysed and the surcharge strategy amended, if necessary.

7. LIMITATION OF FIELD INVESTIGATIONS

This report has been prepared in accordance with generally accepted consulting practice for Mirvac WA Pty Ltd using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

For and behalf of
STRUCTERRE CONSULTING ENGINEERS

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Job #	Revision	Authored	Checked	Authorised
J142676	0	TC	RG	MC

8. REFERENCES

- WRC (2004) Perth Ground Water Atlas Perth – Western Australia
- AS 1726-1993 Geotechnical Site Investigations
- AS 2870-2011 Residential Slabs and Footings
- AS 3798-2007 Earthworks for residential and commercial developments
- AS 1170-4-2007 Earthquake Actions in Australia
- AS 1289.6.3.3-1997 Soil strength and consolidation tests
- AS 4055-2006 Wind loads for housing
- Geological survey of Western Australia 1:50,000 Environmental geology series

APPENDIX 1 – SITE LOCATION MAP

LEGEND

- CPT: Cone Penetration Test
- DIS: Dissipation Test
- TP: Excavated Test Pit
- DCP: Dynamic Cone Penetrometer Test

Note: Showing approximate test locations only

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PROJECT #:	D65859
JOB #:	J142676
CLIENT:	**Mirvac WA Pty Ltd**
SCALE:	NTS
TITLE:	Geotechnical Investigation
DATE:	01/04/2014
DRAWN BY:	TCH
CHECKED BY:	RG

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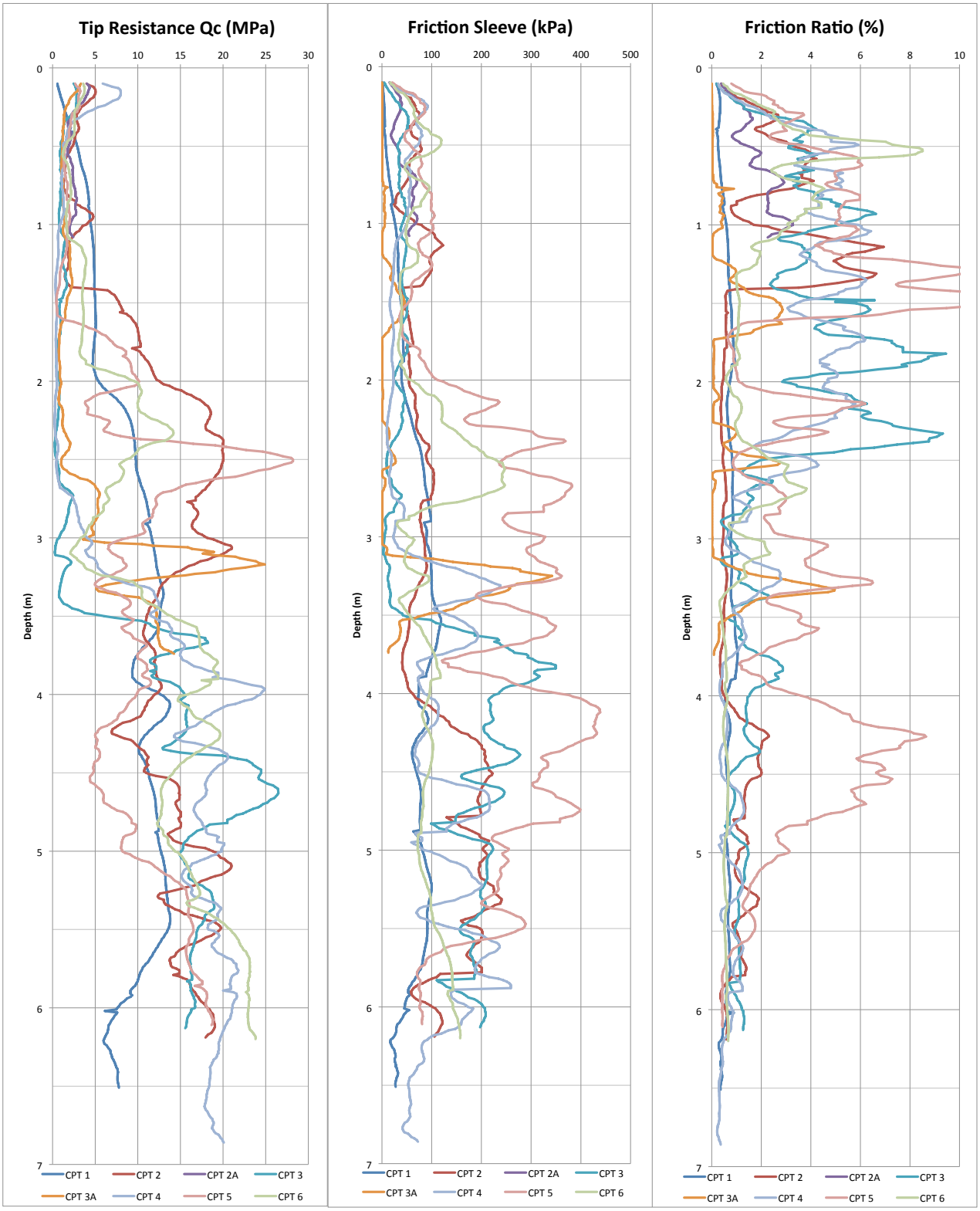
APPENDIX 2 – EFCPT RESULTS

Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	
Probe No:	ALL DATA	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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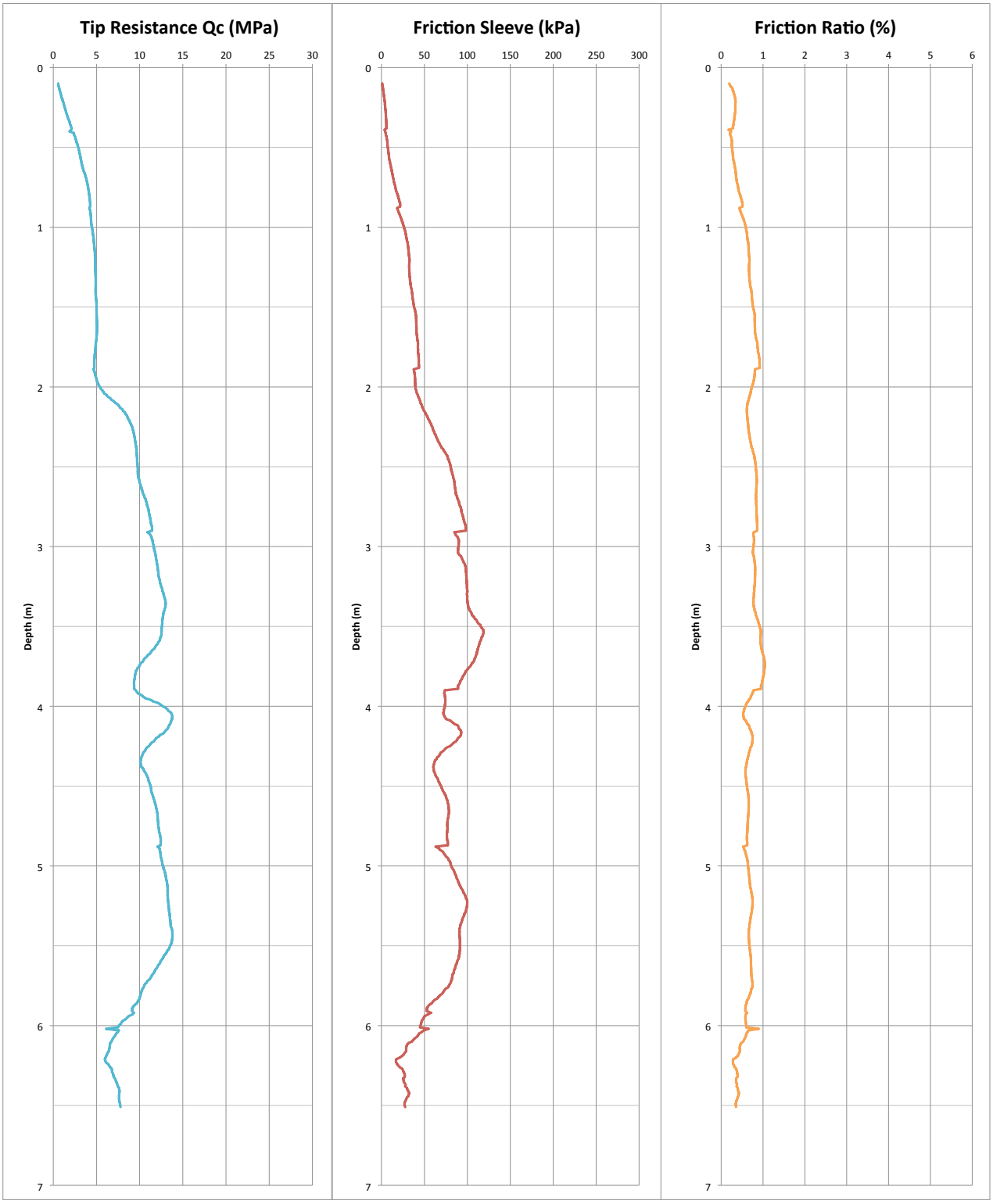
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.2932S 11549.2278E
Probe No:	CPT1	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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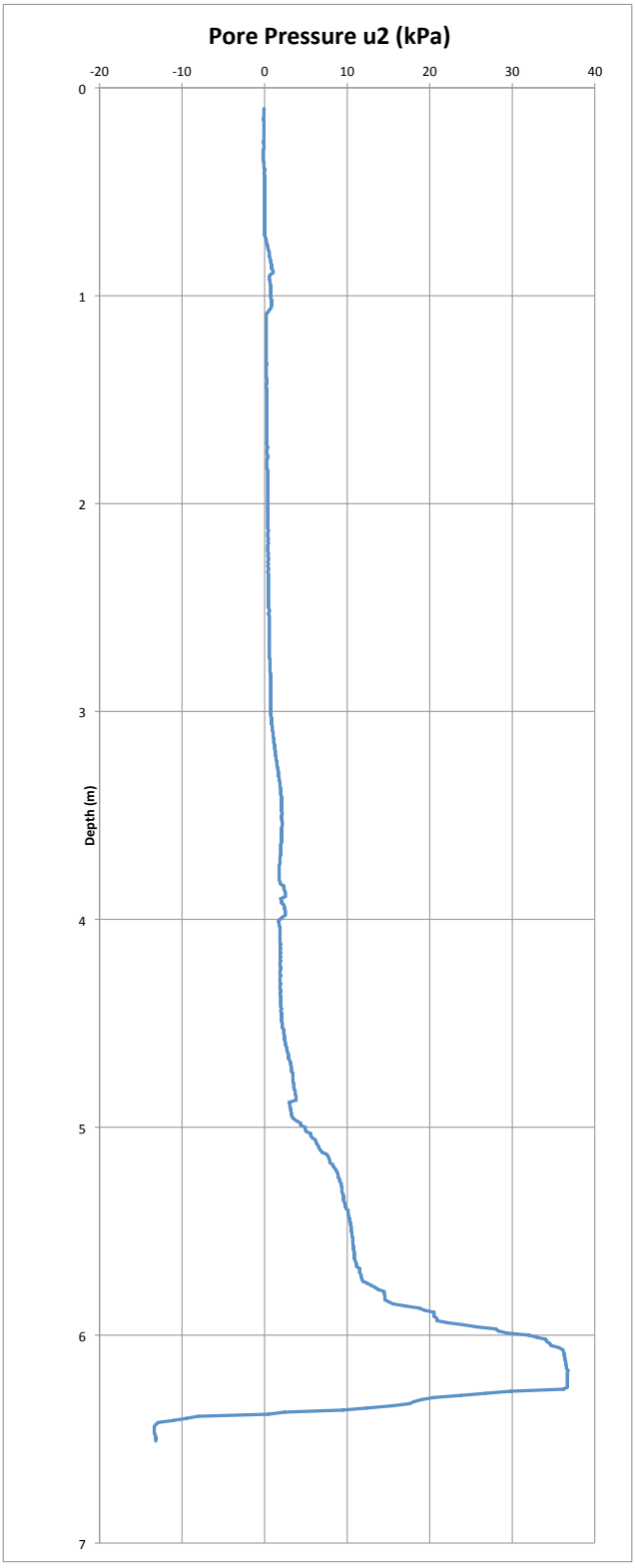
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.2932S 11549.2278E
Probe No:	CPT1	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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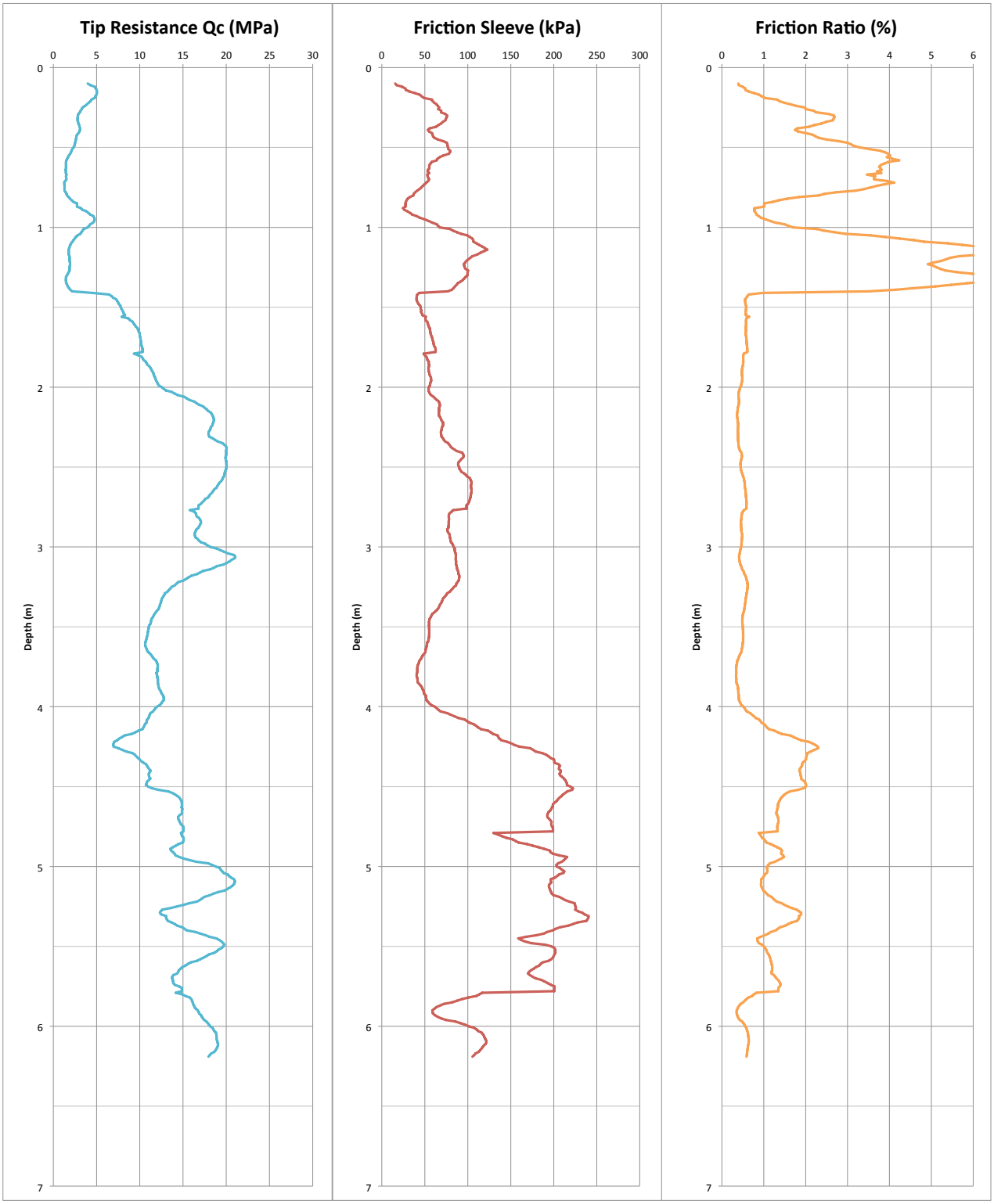
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.1721S 11549.4048E
Probe No:	CPT2	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	Pull- Out

Perth | Brisbane | Sydney | Bunbury | Geraldton | Gold Coast | Albany | Karratha

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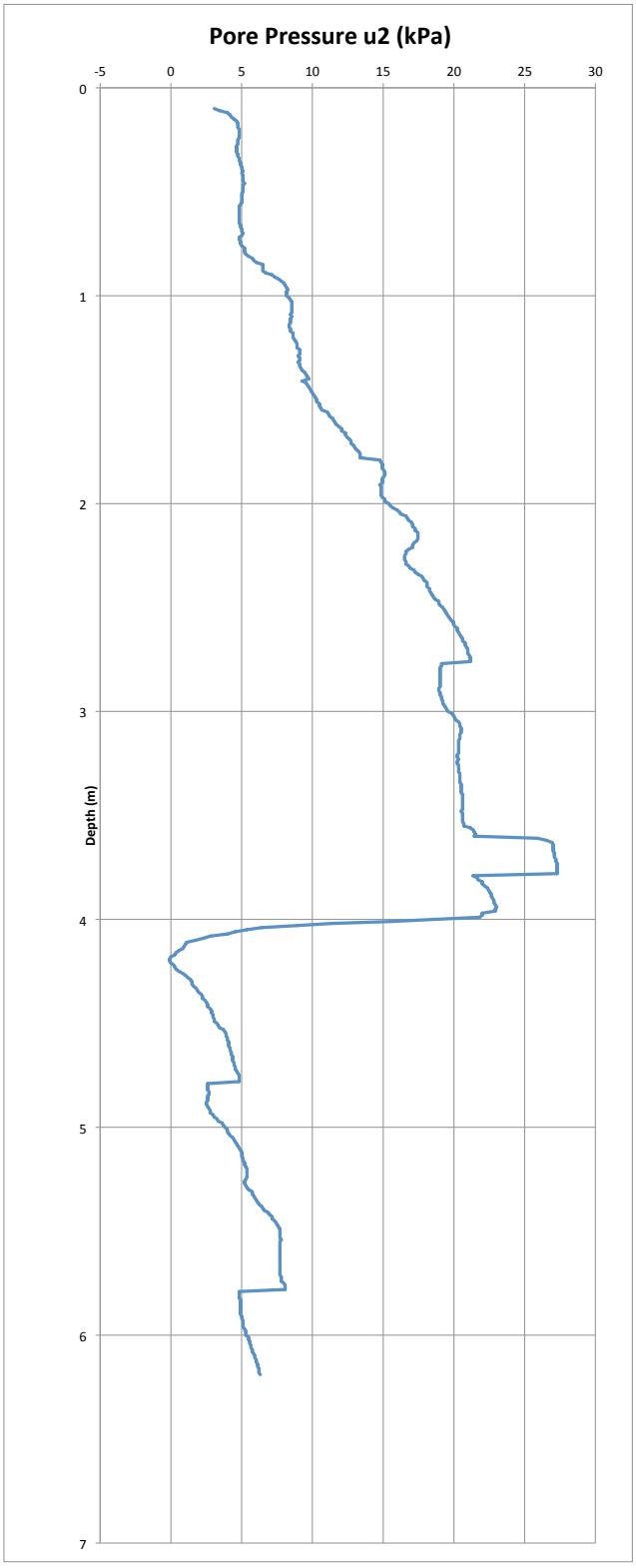
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.1721S 11549.4048E
Probe No:	CPT2	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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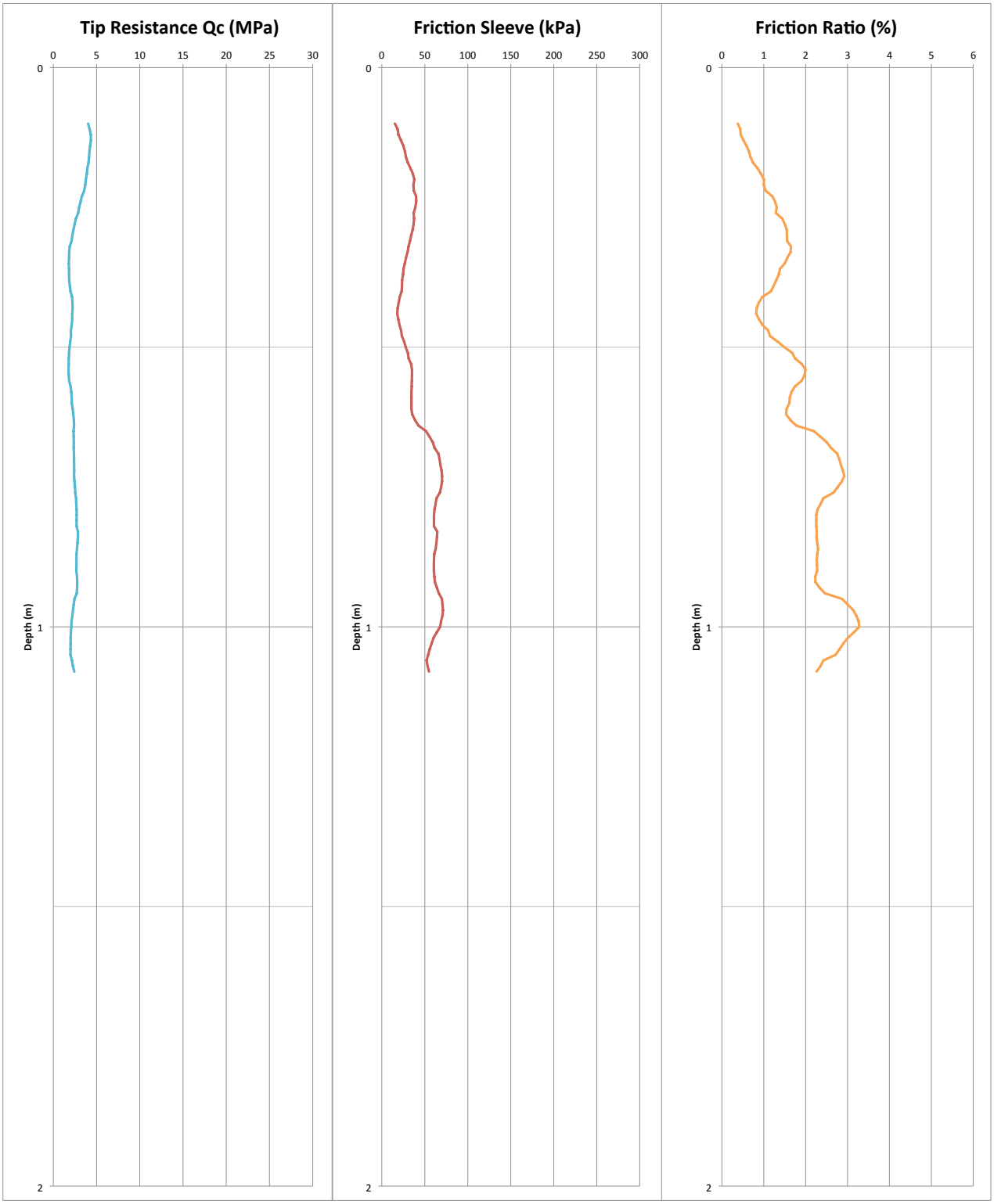
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.1748S 11549.4038E
Probe No:	CPT2A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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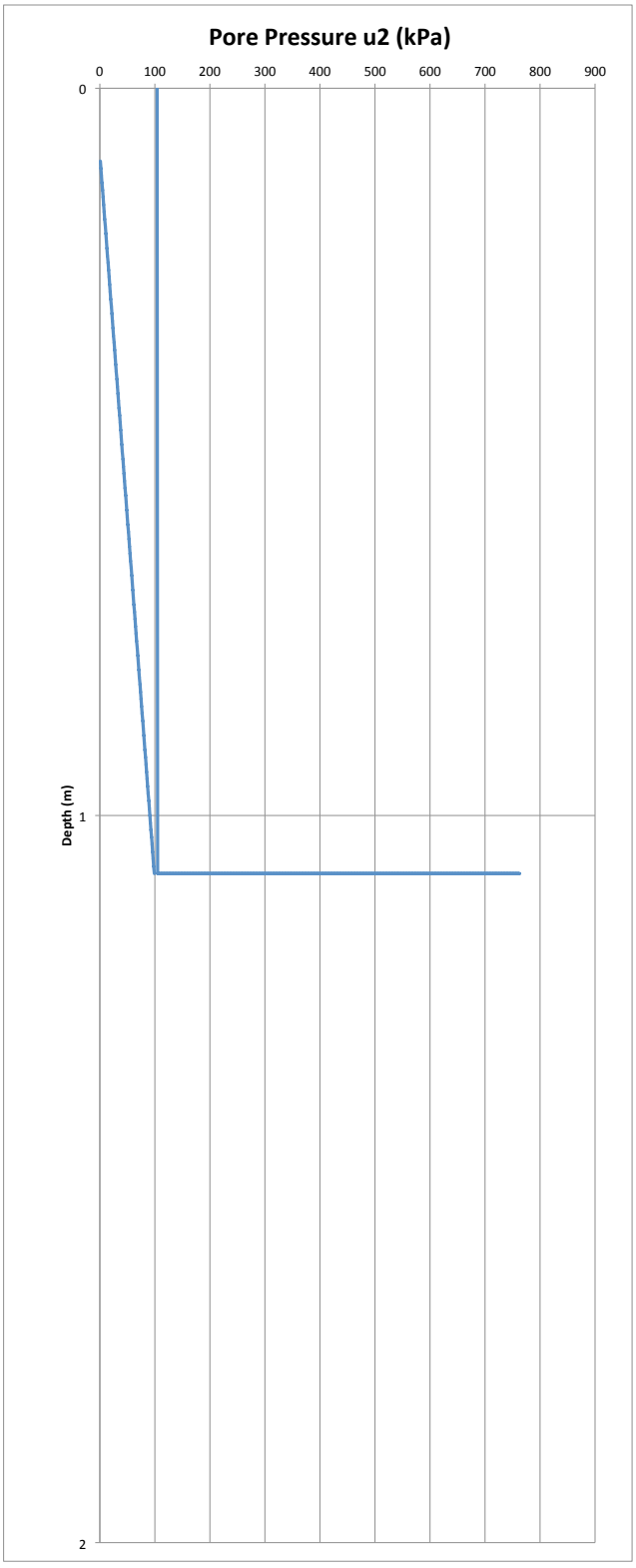
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.1748S 11549.4038E
Probe No:	CPT2A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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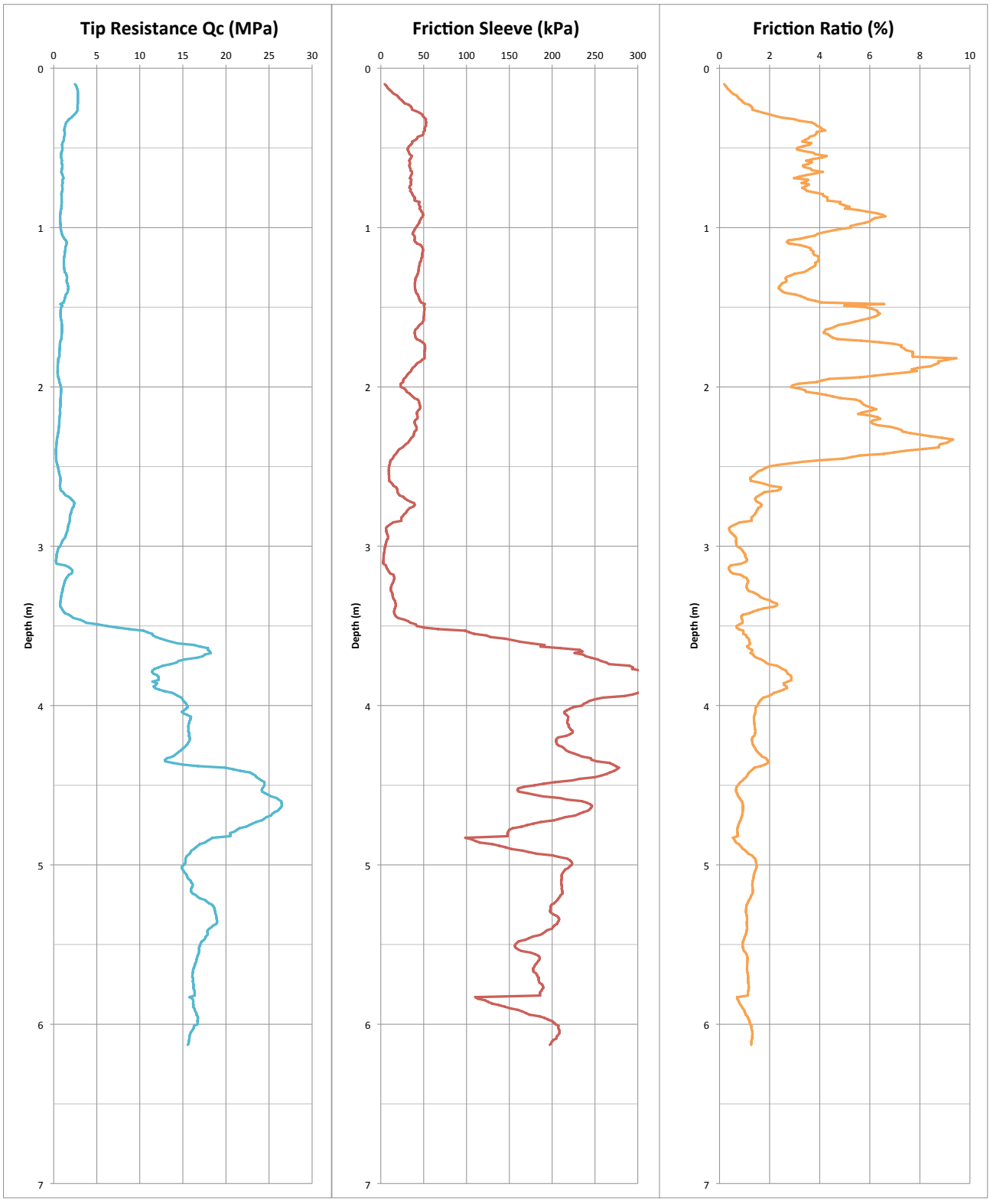
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3131S 11549.3776E
Probe No:	CPT3	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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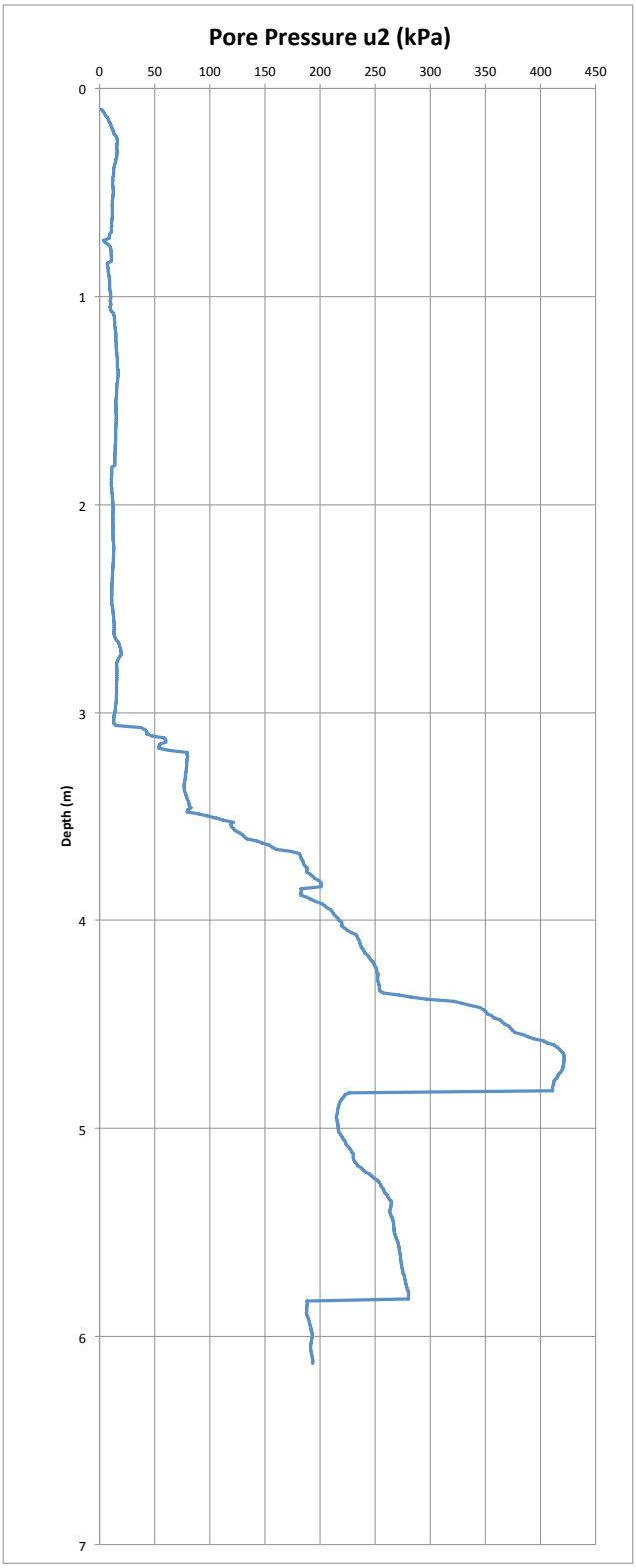
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3131S 11549.3776E
Probe No:	CPT3	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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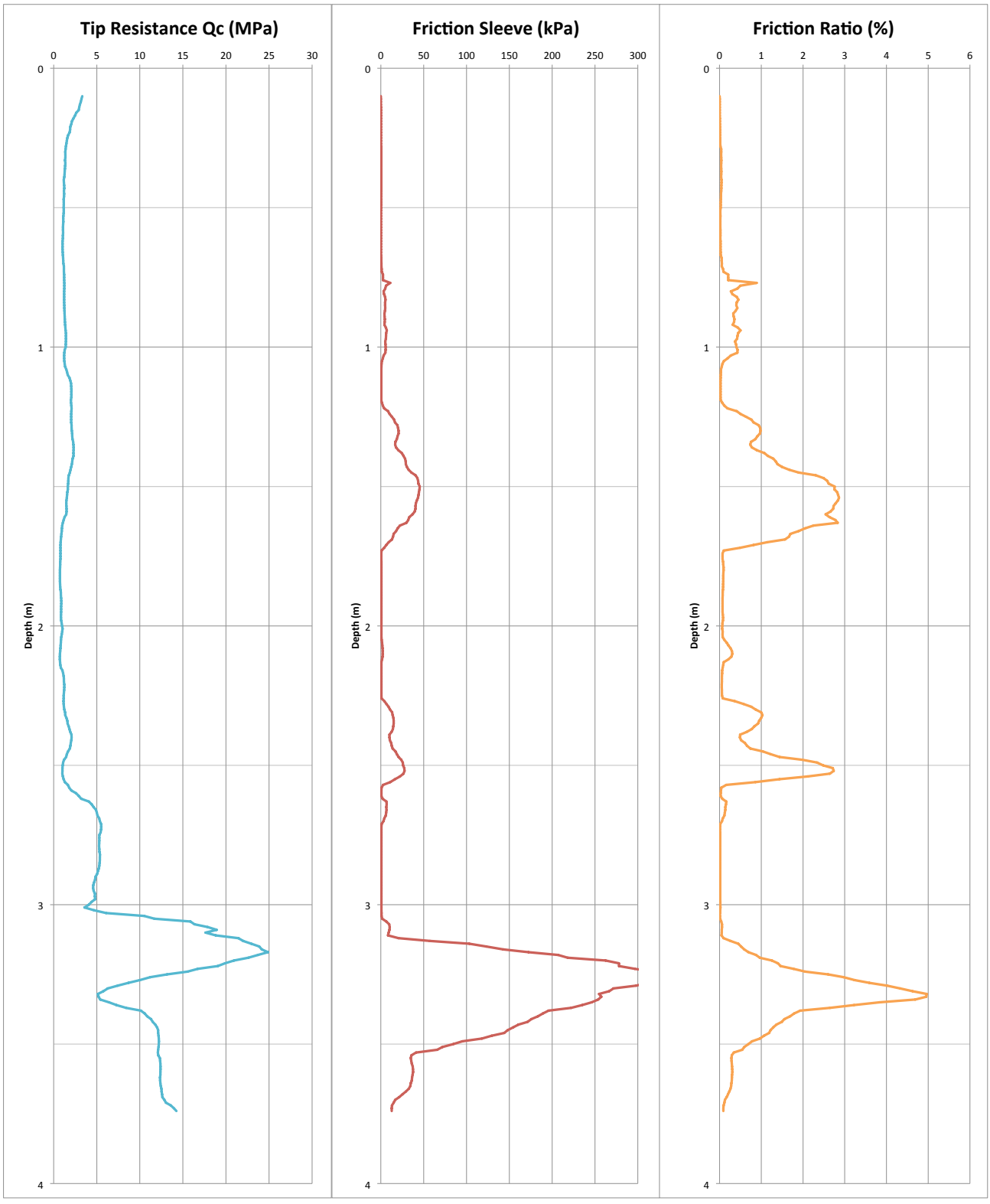
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3135S 11549.3776E
Probe No:	CPT3A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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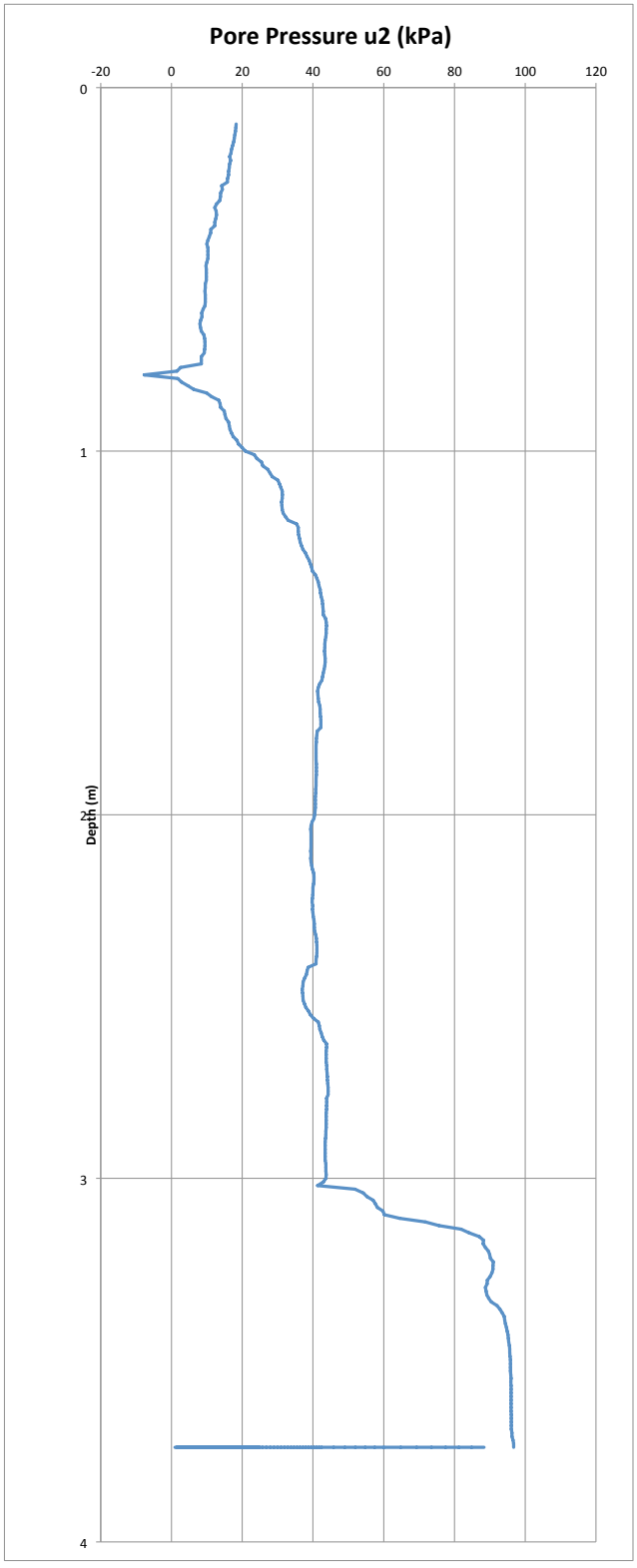
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3135S 11549.3776E
Probe No:	CPT3A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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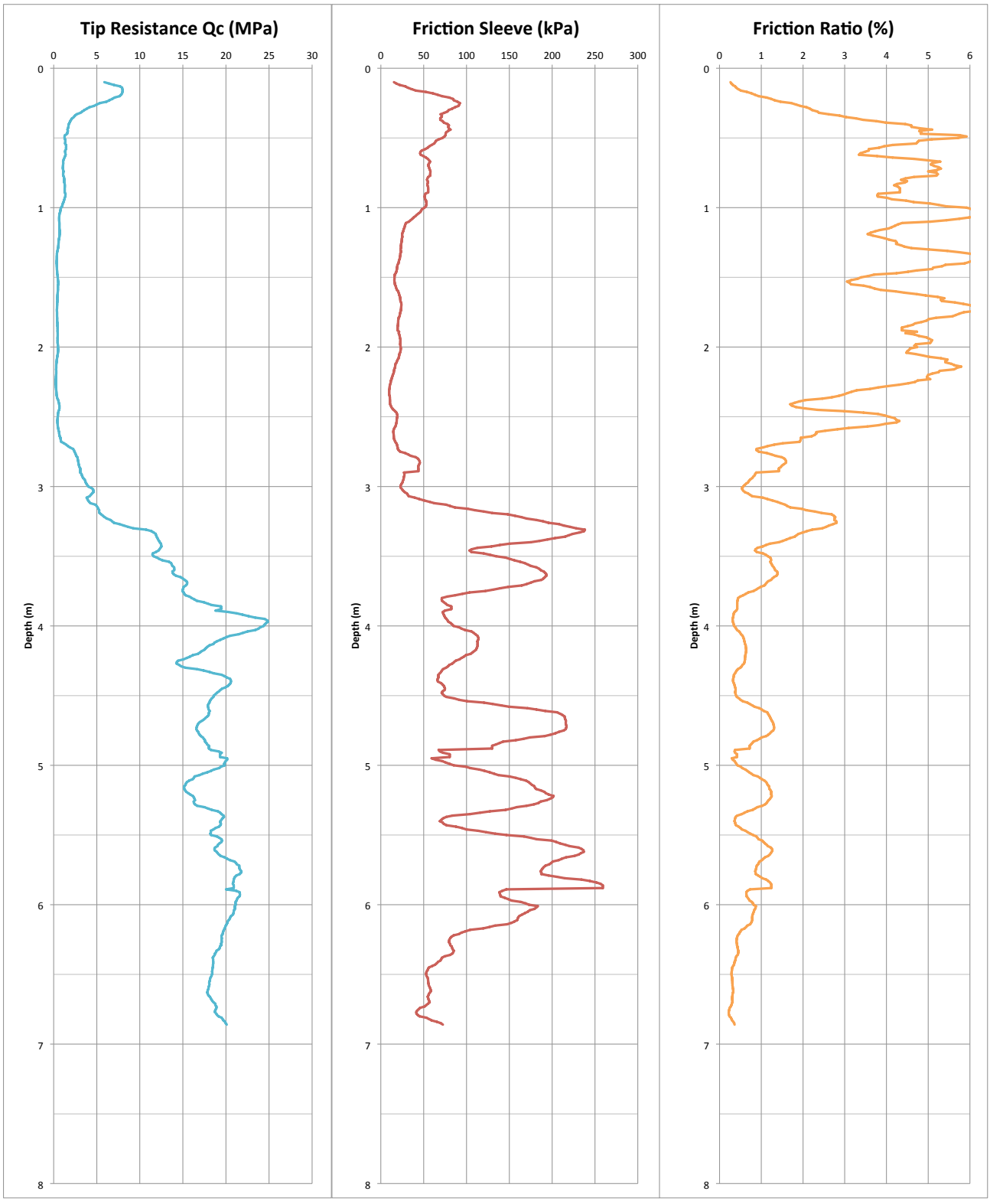
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3662S 11549.3556E
Probe No:	CPT4	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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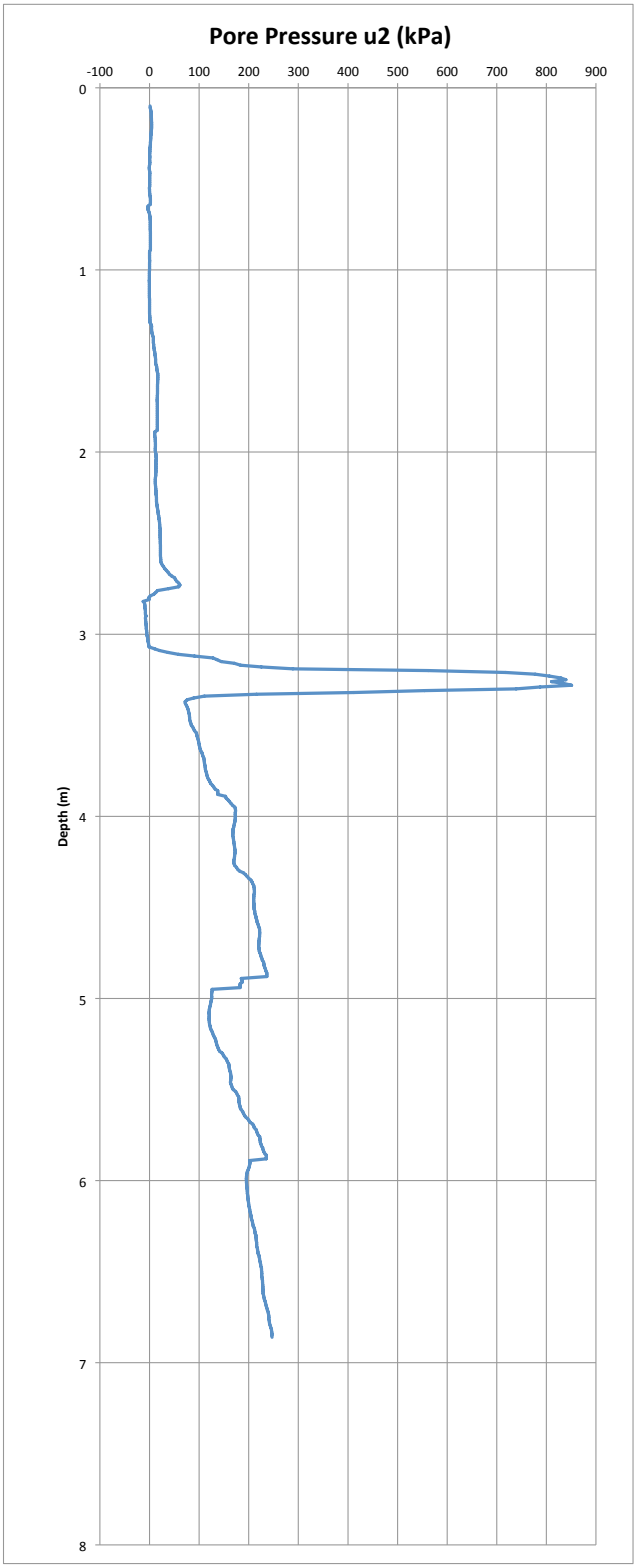
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3662S 11549.3556E
Probe No:	CPT4	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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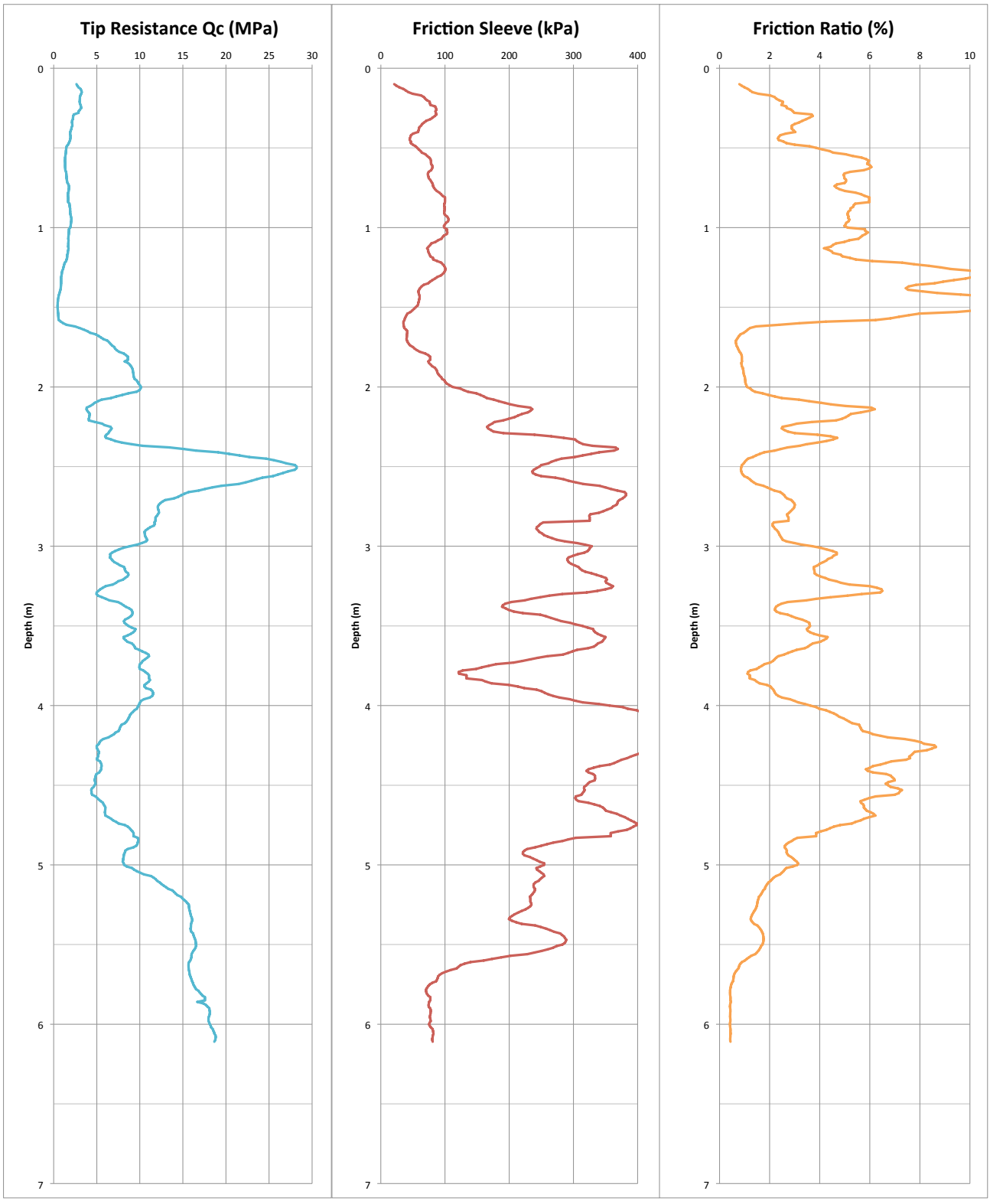
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.2311S 11549.5395E
Probe No:	CPT5	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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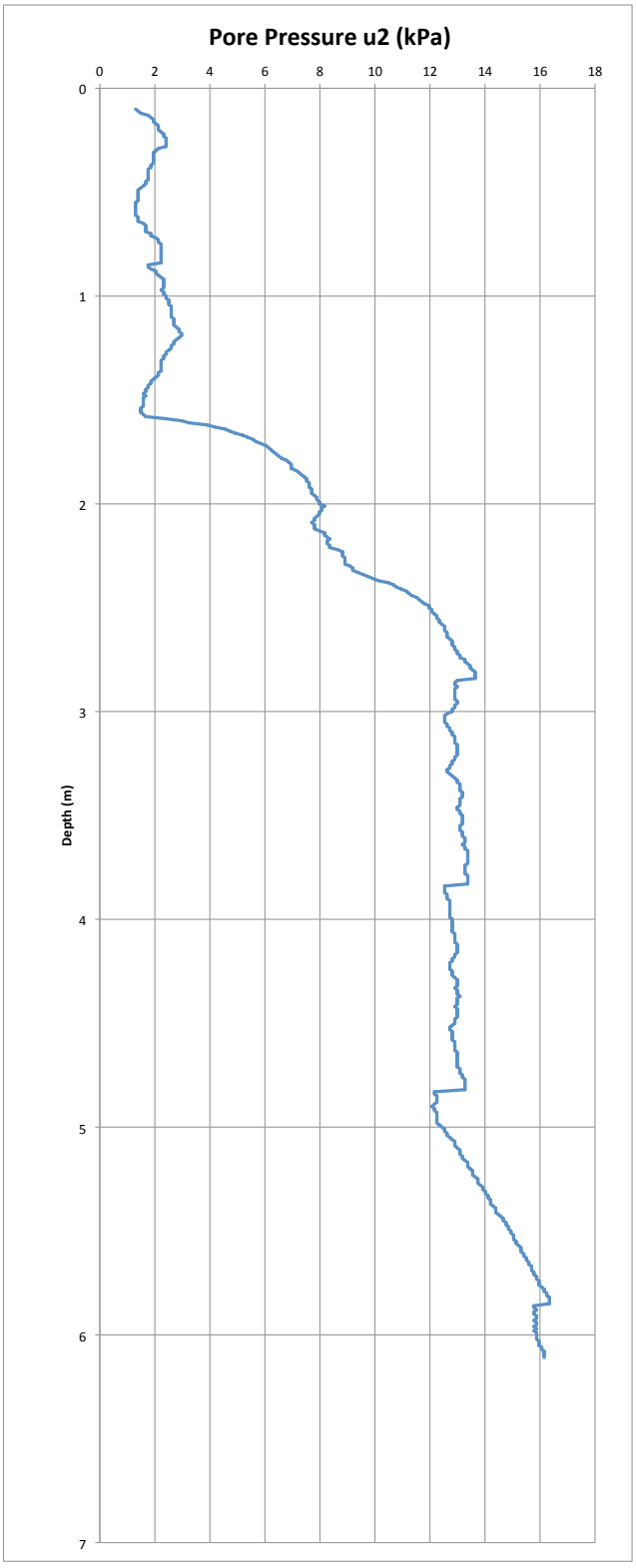
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.2311S 11549.5395E
Probe No:	CPT5	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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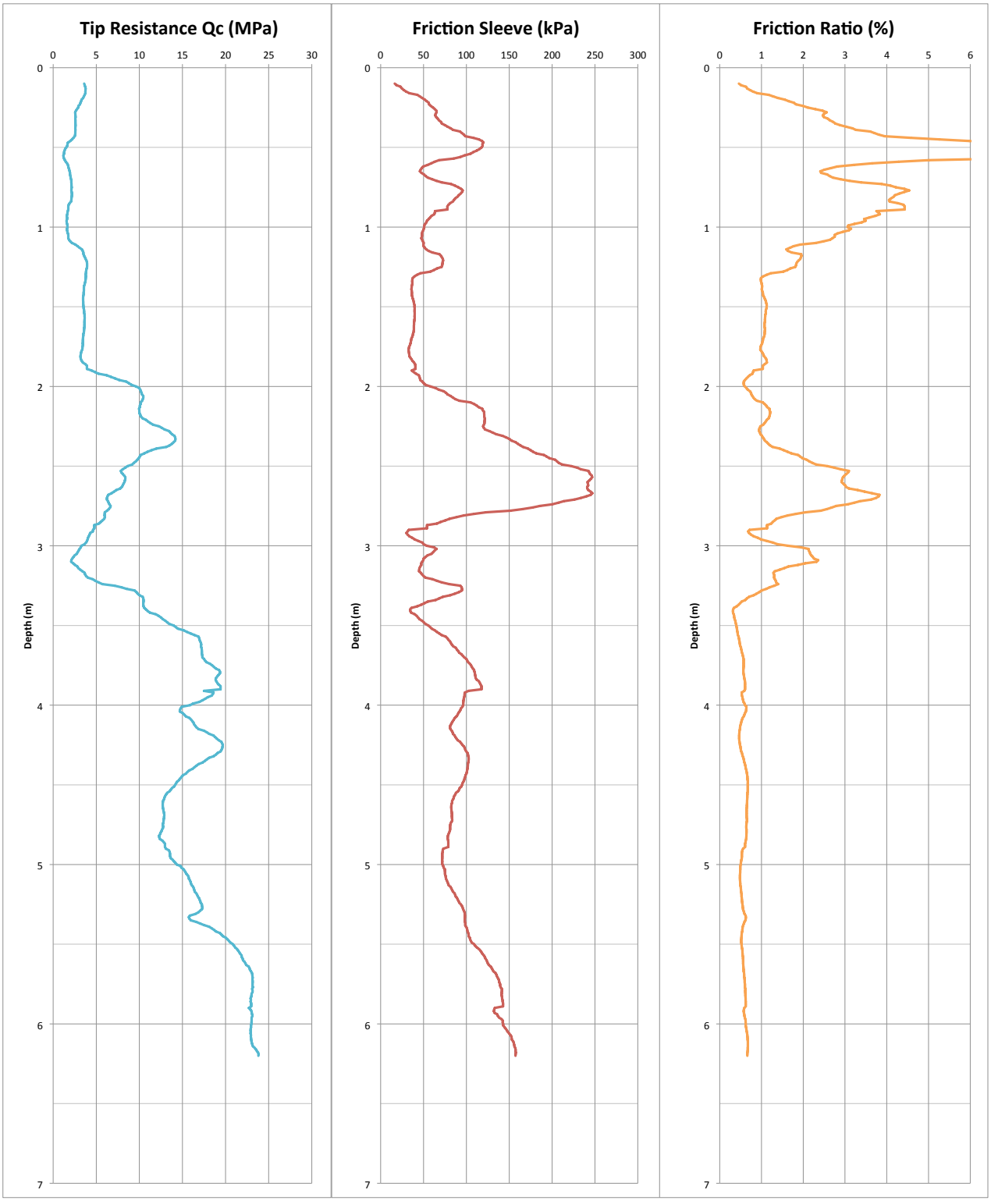
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3174S 11549.5145E
Probe No:	CPT6	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



Water (m)		Refusal	

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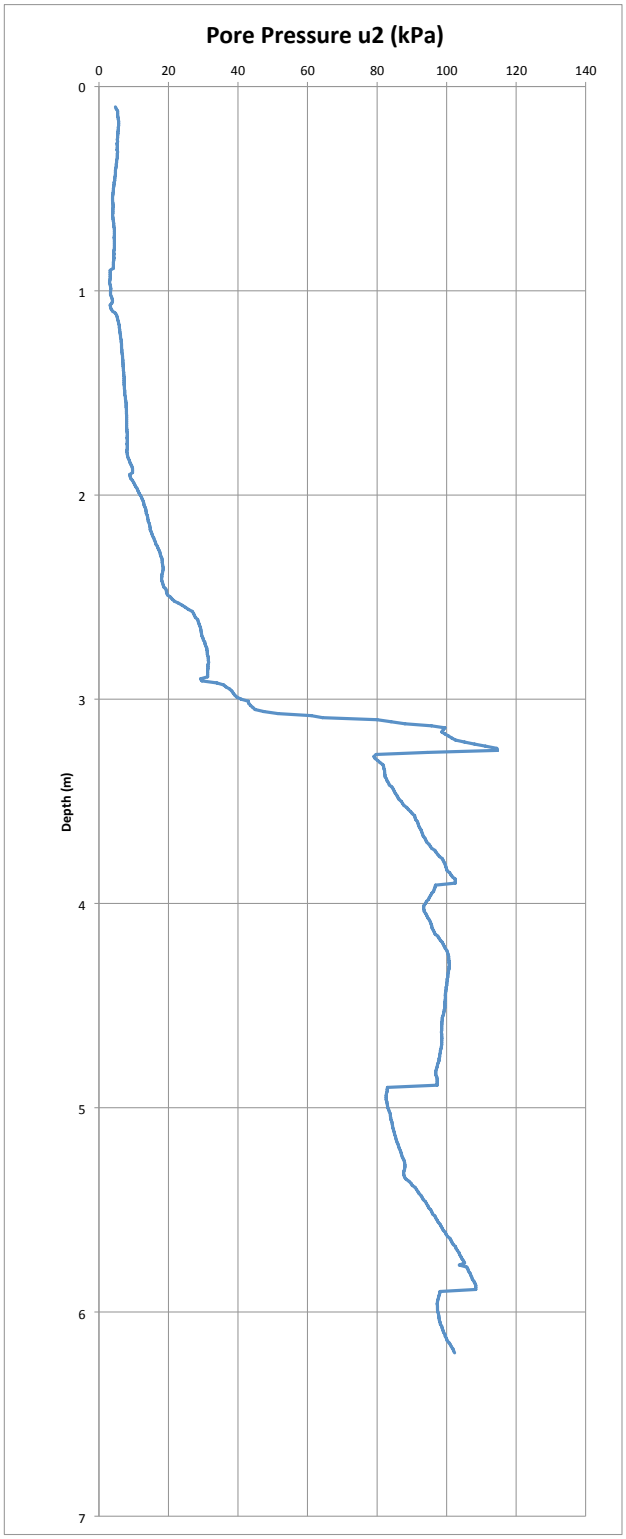
Client:	Mirvac WA Pty Ltd			Project:	J142676/D65859
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.3174S 11549.5145E
Probe No:	CPT6	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH



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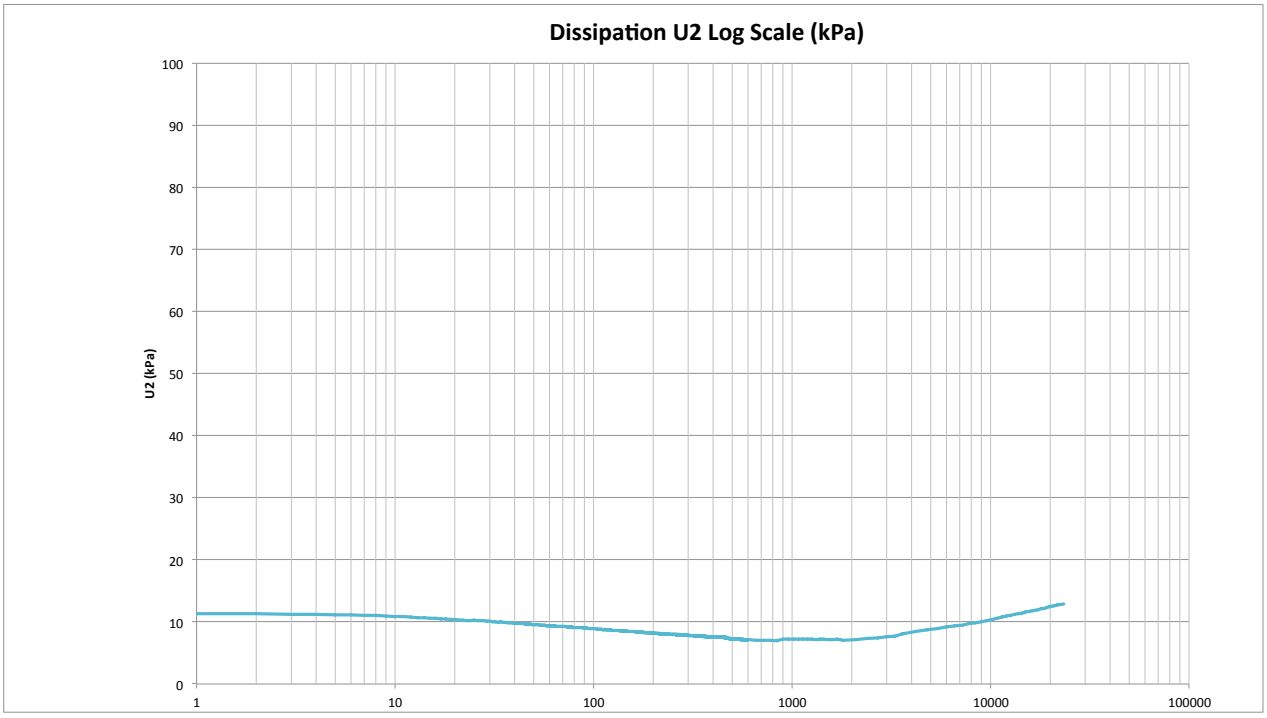
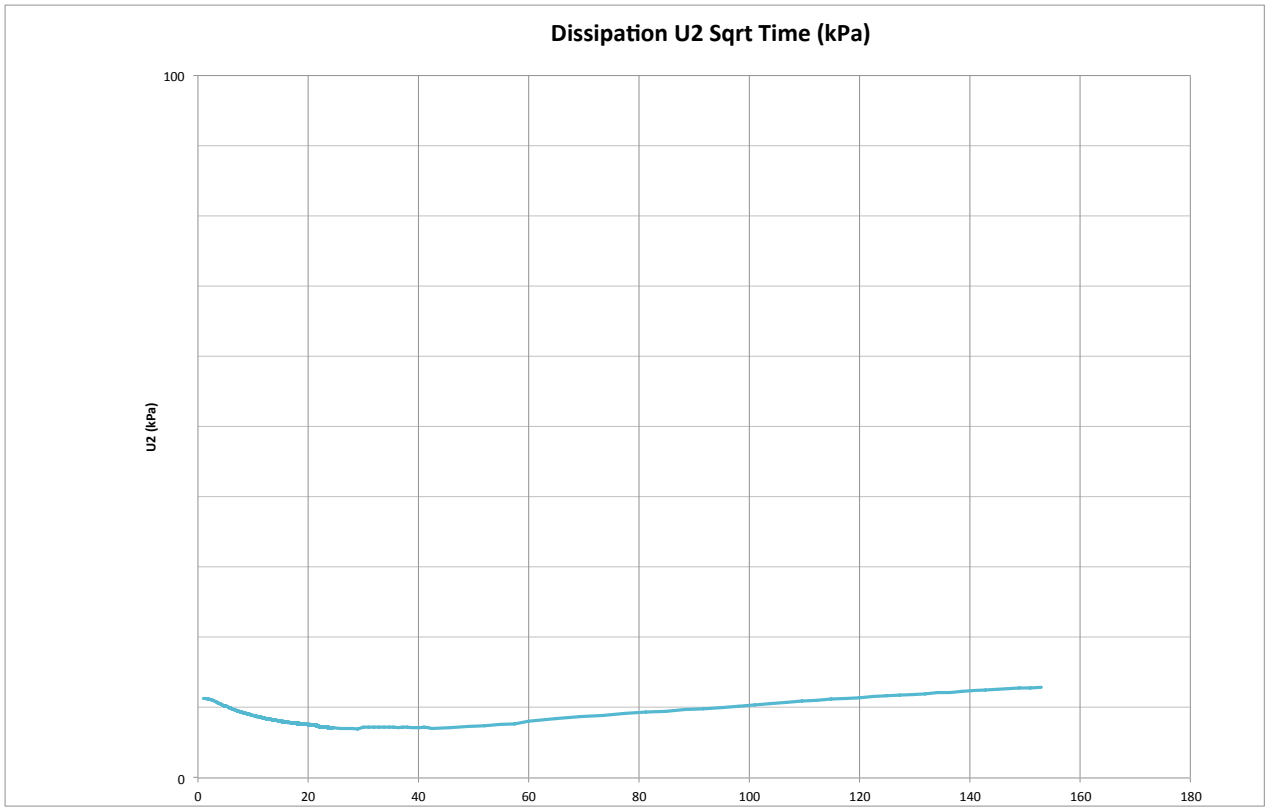
Project:	Lot 746 - 750 Baldivis Rd, Baldivis			GPS:	3219.1748S 11549.4038E
Probe No:	CPT2A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH





Water (m)		Refusal	

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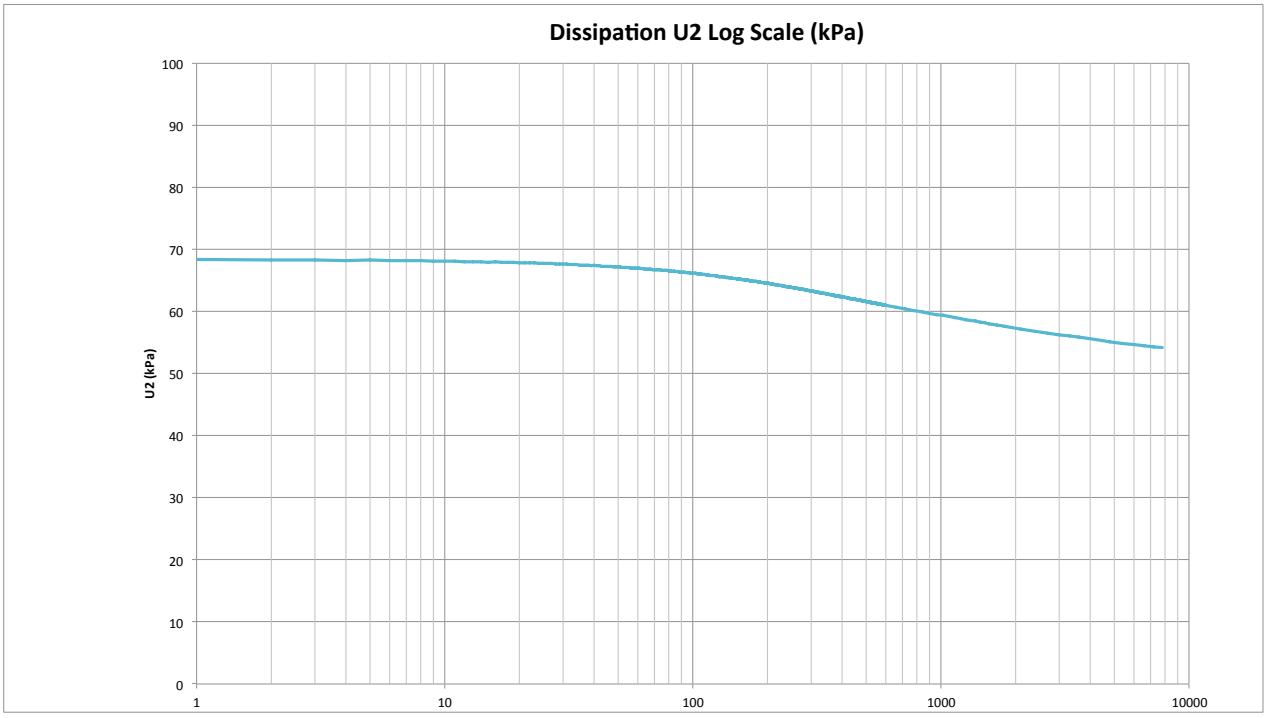
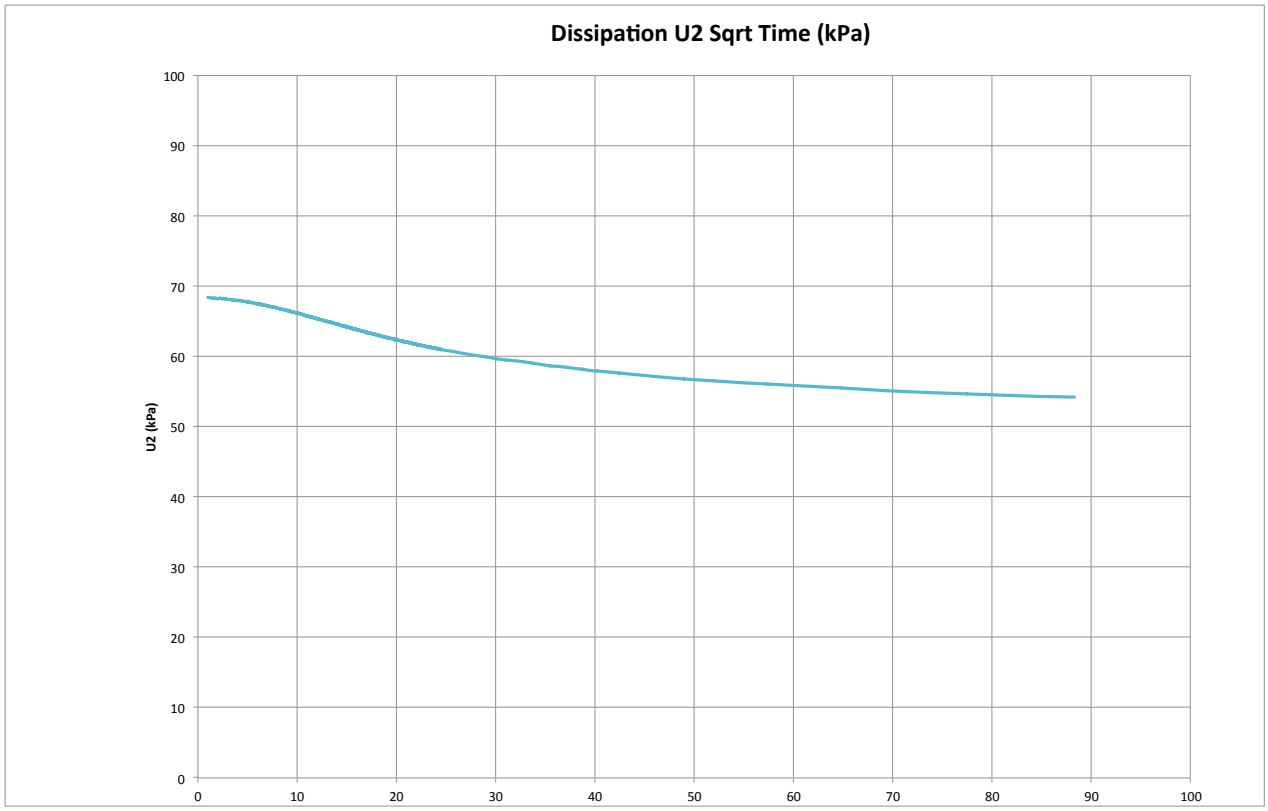
Probe No:	CPT3A	Test Date:	1/04/14	Tested By:	S.ATKINSON/D.SMITH





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APPENDIX 3 – BORE LOGS

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP1**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL				
	BASSENDEAN SAND	SP	SAND; (fine to medium grained), yellow / brown, trace silt, trace organic material (root fibres, decayed plant matters - charcoal), loose, dry to moist		D-M	DRY 1/4/14	1 2 3 2
			- medium dense				4 3
1.0							4 4 4
			- orange / brown, loose				3 3 4
2.0			End of Borehole @1.8m (Resusal on Collapsing Sand)				3 3
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP2**

SOIL BOREOLOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL				
	BASSENDEAN SAND	SP	Silty SAND; (fine to medium grained), dark grey, trace organic material (root fibres), loose, dry to moist		D-M	DRY 1/4/14	2
			- medium dense				5
							5
							8
							5
							8
1.0			- dense, moist		M		9
							24
							8+ Refusal on hard ground
2.0			- trace silt, wet		W		
			End of Borehole @ 2.8m (Target Depth)				
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP3**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL			DRY 1/4/14	
	GUILDFORD FORMATION	SP	SAND; (fine to medium grained), dark grey, with clay, trace organic material (root fibres), medium dense, dry to moist		D-M		4 4 4
1.0		MH	Sandy SILT; (medium to high plasticity), dark grey, trace gravel, loose, dry		D		3 3 3 3 3 2
			- moist		M		2 2 2 2 1 5 5
2.0			- medium dense				
		SC	Clayey SAND; (fine to medium grained), (medium to high plasticity), green / grey, medium dense, moist to wet		M - W		4 7 7
3.0			End of Borehole @ 2.9m (Target Depth)				13 Target Depth

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP4**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL				
	GUILDFORD FORMATION	SP	Silty SAND; (fine to medium grained), dark grey, trace gravel, trace organic material (root fibres), medium dense, dry		D	DRY 1/4/14	4 6
1.0		MH	Sandy SILT; (low to medium plasticity), dark grey / black, trace organic material (root fibres), loose, dry		D		3 2 3 3 4 3 2
		SC	Clayey SAND; (fine to medium grained), yellow / brown, loose, moist - green / yellow / brown - medium dense		M		2 3 5 6 3 3 10 15+ Target Depth
3.0			End of Borehole @ 3.0m (Target Depth)				

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP5**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL			DRY 1/4/14	
	GUILDFORD FORMATION	SM	Silty SAND; (fine to medium grained), dark grey, trace gravel, trace organic material (root fibres), medium dense, dry		D		4 4
		SC	Clayey SAND; (fine to medium grained), dark grey, loose, dry		D		3 3
1.0		SM	Silty SAND; (fine to medium grained), dark grey, trace gravel, trace organic material (root fibres), loose, dry to moist		D - M		4 4 3 6 4
		SC	Clayey SAND; (fine to medium grained), dark grey, trace organic material (roots), medium dense, moist - green / grey		M		5 7 7 8 13 Target Depth
2.0							
3.0			End of Borehole @ 3.0m (Target Depth)				

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP6**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL			DRY 1/4/14	
	GUILDFORD FORMATION	SP	SAND; (fine to medium grained), grey, with silt, trace organic material (root fibres), loose, dry		D		4 3
1.0		MH	Sandy SILT; black, with silt, loose, dry to moist - very loose - loose		D - M		2 2 3 2 1 2 3
2.0		SC	Clayey SAND; (fine to medium dense), (medium to high plasticity), black, loose, moist - moist to wet		M M - W		3 3 3 3 3 Target Depth
3.0			End of Borehole @ 2.5m (Target Depth)				

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP7**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL			DRY 1/4/14	3
	GUILDFORD FORMATION	SP	Silty SAND; (fine to medium grained), dark grey, trace gravel, trace organic material (root fibres), loose, dry		D		4
							2
							4
		MH	Sandy SILT; (fine to medium grained), dark grey, trace gravel, loose, dry to moist				4
1.0							6
			- dense		D - M		4
							7
			- moist				6
							6
			- very loose		M		4
							1
2.0							2
		SC	Clayey SAND; (fine to medium grained), green / grey, loose, moist to wet		M - W		5
							Target Depth
			End of Borehole @ 2.5m (Target Depth)				
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP8**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL			DRY 1/4/14	
	GUILDFORD FORMATION	SP	Silty SAND; (fine to medium grained), pale grey / dark grey, trace gravel, trace organic material (root fibres), loose, dry		D		2
			- medium dense				8
							5
		SC	Clayey SAND; (fine to medium grained), (low to medium plasticity), dark grey, loose, dry to moist		D - M		4
							3
1.0							2
							2
			- medium dense				4
							3
			- moist				3
					M		2
							3
2.0							3
							5
							Target Depth
			End of Borehole @ 2.5m (Target Depth)				
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP9**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL				
	GUILDFORD FORMATION	SP	Silty SAND; (fine to medium grained), dark grey, trace organic material (root fibres), loose to medium dense, dry to moist				2
							4
							2
							4
							4
			- very loose				1
1.0			- loose, moist		D - M		3
			- medium dense			DRY 1/4/14	6
							8
							7
							7
							5
		SC	Clayey SAND; (fine to medium grained), (medium plasticity), green / grey, medium dense, moist		M		4
2.0							4
							Target Depth
			End of Borehole @ 2.5m (Target Depth)				
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

PROJECT SITE: **Lot 746 - 750 Baldivis Road, Baldivis**	Job No: **J142676** Project No: **D65859**	GPS: E: N:	TEST HOLE No. **TP10**

SOIL BORELOG

DEPTH (M)	GEO. INTER.	USCS	DESCRIPTION OF SOIL	GRAPHIC LOG	MOISTURE	WATER LEVEL	DYNAMIC CONE PENETROMETER (BLOWS/150mm)
	FILL		TOPSOIL				
	GUILDFORD FORMATION	SP	Silty SAND; (fine to medium grained), dark grey, trace organic material (root fibres), very loose, dry to moist				1
			- loose		D - M		3
			- moist				4
					M		4
							4
1.0							4
			- moist to wet				4
					M - W	WT @ 1.4m 1/4/14 ▽	4
			- medium dense				5
			- saturated		S		7
		SP	SAND; (fine to medium grained), grey / pale grey, trace silt, medium dense, saturated		S		8
							15+
2.0							
			End of Borehole @ 2.0m (Refusal on saturated sand)				Refusal on hard ground
3.0							

Comments:

DRILLED BY:	LOGGED BY:	APPROVED BY:	DATE DRILLED:	DRILL METHOD:
	TCH	RG	1 April 2014	5T Excavator

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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX 4 – BORE LOG TERMINOLOGY

STRUCTERRE CONSULTING ENGINEERS

Borelog Terminology

SOILS

Consistency (Cohesive Soils)		Relative Density (Non cohesive Soils)					
Soil Type	Undrain Shear Strength (kPa)	Soil Type	'N' Value (SPT) Blows/300mm	PSP Blows/300mm	qc (MPa	Ø (deg)	RD (%)
Very Soft	0 - 12.5	Very Loose	0 - 4	0 - 3	0-2.5	25	>20
Soft	12.5 - 25	Loose	4 - 10	3 - 7	2.5-7.5	25-30	20 - 33
Firm	25 - 50	Medium Dense	10 - 30	7 - 10	7.5-14	30-35	33 - 66
Stiff	50 - 100	Dense	30 - 50	10 - 20	14-24	35-40	66 - 90
Very Stiff	100 - 200	Very Dense	>50	>20	>24	>40	90 - 100
Hard	200 - 500	SPT = Standard Penetrometer Test PSP = Perth Sand Penetrometer Test			RD=Relative Density qc=CPT resistance		

Sensitivity (Cohesive Soils)	
Term	Shear Strength Ratio Undisturbed / Remoulded
Insensitive, Normal	>2
Moderately Sensitive	2 - 4
Sensitive	4 - 8
Extra Sensitive	8 - 16
Quick	>16

Moisture Content	
D	Dry
M	Moist
W	Wet
S	Saturated

Soil Legend

- FILL
- TOPSOIL
- PEAT
- CLAY
- SILT
- SAND
- GRAVEL
- LIMESTONE
- BEDROCK
- CONCRETE
- Combinations e.g. Clay, Silty, Sl. Sandy

USCS

- SW - Well-graded sand
- SP - Poorly-graded sand
- SM - Silty sand
- SC - Clayey Sand
- ML - Low plasticity silt
- MH - elastic silt
- CL - Low plasticity clay
- CH - High plasticity clay
- GW - Well-graded gravel
- GP - Poorly-graded gravel
- Pt - Peat

Sample Type

- Bag Sample
- Core Sample
- Thin Wall Tube Sample (undisturbed)
- Standard Penetration Test Sample (Blows/150mm)

Tests

- Water level in borehole at date shown
- **'N'** SPT blows / 300mm
- **W** Moisture Content %
- ρ Bulk Density (ton per cu.m.)
- **CONS** Consolidation Test
- **PSD** Particle Size Distribution
- **C' ϕ** Effective Stress (Triaxial)
- **UC** Unconfined Compression Test

APPENDIX 5 – LABORATORY TEST RESULTS

STRUCterre

Material Test Certificate

Sample No.	22470	Client	GEOTECH
Job No.	142578	Project	Lot 746-750 Baldivis Road, Baldivis

SAMPLE DETAILS

BH No. / Depth : TP3 0.5-1.0m
Sample History : Air Dried ☐ 50°C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	67
Plastic Limit	AS 1289.3.2.1	34
Plasticity Index	AS 1289.3.3.1	33
Linear Shrinkage	AS 1289.3.4.1	17
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	96
0.425	74
0.075	61

Material Description: sandy SILT trace gravel
USC Group Symbol: OH or MH

Signatory: _____ **Date:** 11-Apr-14
Aline Silva

STRUCterre

Material Test Certificate

Sample No.	23472	Client	GEOTECH
Job No.	J143676	Project	Lot 746-750 Baldwin Road, Baldivis

SAMPLE DETAILS

BH No. / Depth : TP3 2.5-3.0m
Sample History : Air Dried ☐ 50°C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	47
Plastic Limit	AS 1289.3.2.1	18
Plasticity Index	AS 1289.3.3.1	29
Linear Shrinkage	AS 1289.3.4.1	15
Nature of Shrinkage		Curling

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	99
0.425	62
0.075	32

Material Description: clayey SAND trace gravel
USC Group Symbol: SC

Signatory: Asha Silva **Date:** 11-Apr-14

STRUCTERRE consulting engineers

Material Test Certificate

Sample No.	22488	Client	GEOTECH
Job No.	J142878	Project	Lot 746-750 Baldivis Road, Baldivis

SAMPLE DETAILS

BH No. / Depth : TP4, 0.1-0.5m
Sample History : Air Dried ☐ 50°C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	52
Plastic Limit	AS 1289.3.2.1	38
Plasticity Index	AS 1289.3.3.1	14
Linear Shrinkage	AS 1289.3.4.1	10
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	58
0.425	56
0.075	32

Material Description: silty SAND trace gravel
USC Group Symbol: SM

Signatory: _____ **Date:** 11-Apr-14
Alice Silva

STRUCterre

Material Test Certificate

Sample No.	22471	Client	GEOTECH
Job No.	J142676	Project	Lot 748-750 Baldivis Road, Baldivis

SAMPLE DETAILS

Bh No. / Depth : ? 1.0-1.5m
Sample History : Air Dried ☐ 50'C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	52
Plastic Limit	AS 1289.3.2.1	26
Plasticity Index	AS 1289.3.3.1	26
Linear Shrinkage	AS 1289.3.4.1	13
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle-size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	98
0.425	71
0.075	46

Material Description: clayey SAND trace gravel
USC Group Symbol: SC

Signatory: Aline Silva **Date:** 11-Apr-14

STRUCterre

Material Test Certificate

Sample No.	22473	Client	GEOTECH
Job No.	J1402570	Project	Lot 746-750 Baldivis Road, Baldivis

SAMPLE DETAILS

BH No. / Depth : TP7 2.0-2.5m
Sample History : Air Dried ☐ 50°C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	38
Plastic Limit	AS 1289.3.2.1	15
Plasticity Index	AS 1289.3.3.1	23
Linear Shrinkage	AS 1289.3.4.1	11
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	97
0.425	58
0.075	22

Material Description: clayey SAND trace gravel
USC Group Symbol: SC

Signatory: Aline Silva **Date:** 11-Apr-14

STRUCterre

Material Test Certificate

Sample No.	22489	Client	GEOTECH
Job No.	J142878	Project	Lot 748-750 Baldivis Road, Baldivis

SAMPLE DETAILS

BH No. / Depth : 9 1.0-1.5m
Sample History : Air Dried ☐ 50°C Oven Dried ☒

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	44
Plastic Limit	AS 1289.3.2.1	35
Plasticity Index	AS 1289.3.3.1	9
Linear Shrinkage	AS 1289.3.4.1	5
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	100
0.425	46
0.075	18

Material Description: silty SAND
USC Group Symbol: SM

Signatory: Aline Silva **Date:** 11-Apr-14

Qualcon Laboratories Pty. Ltd.

N.A.T.A. Accreditation Number: 10521

as trustee for Qualcon Unit Trust
ABN: 34 736 051 547 ACN: 068 681 369

Unit 2/2 Lorrim Court,
MALAGA. W.A. 6090.
Phone: (08) 9249 9693
Fax: (08) 9248 1822
Email: qualcon@iinet.net.au

ORGANIC MATTER CONTENT REPORT

ASTM D 2974, Method A & C

Report Number : QL4988-14 **Date of Report** : 16-Apr-2014

Client : Structerre Consulting Engineers (Project No. D65859 / Job No. J142670)

Location : Lot 746-750 Baldivis Road, Baldivis

Sampled By : As Received 11-Apr-2014 **Tested By** : OZ

Material Type : Silty Sand **Date Tested** : 11&12-Apr-2014

Furnace Temperature (C) : 440

Test Number	Sample Identification	Moisture Content (%)	Ash Content (%)	Organic Matter Content (%)
3349	TP3 – 0.5m to 1.0m	54	89.6	10.4
3350	TP4 – 0.1m to 0.5m	28	89.3	10.7
3351	TP7 – 1.0m to 1.5m	29	93.4	6.6
3352	TP9 – 1.0m to 1.5m	30	94.7	5.3

Notes :
Note 1 : Organic Matter Content determined as a percentage of oven-dried mass.

Authorised Signatory

G J Donatti

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Geotechnical Engineering Laboratory
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ONE-DIMENSIONAL CONSOLIDATION TEST

-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT : Structerre Consulting Group (Job # D65859 / J142676) **JOB NO :** 1314570
PROJECT : Lot 746 - 750 Baldivis Road **LOCATION :** Baldivis
Sample Id : BH3, Depth : 1.8 - 2.3m **Lab No. :** TT 06570003

Specimen Details :	**Placement**	**Final**
Height :	20.00	18.14
Dry Density (t/m^3) :	1.701	1.874
Moisture Content (%) :	19.9	16.0
Void Ratio :	0.576	0.430
Degree of Saturation :	92.8	99.8

Date Tested : Apr-2014
Sample Description : Dark Bluish Grey, Clayey Sand (med. Gr.)
Sampling Details : nom. 63mm Ø tube sample

CONSOLIDATION DATA

Confining Pressure	Coefficient of Consolidation, c_v	Coefficient of Compressibity, m_v	Coefficient of Permeability, k	Void Ratio
kPa	m^2/Year	m^2/kN	m/sec	e
Initial				0.5758
0.7	Specimen swelled when inudated - loading increased			-
4.2	—	—	—	0.5756
8.2	—	2.5×10^{-04}	—	0.5740
16	—	2.2×10^{-04}	—	0.5713
35	$6.7 \times 10^{+01}$	1.8×10^{-04}	3.9×10^{-09}	0.5658
77	$5.4 \times 10^{+01}$	1.7×10^{-04}	2.9×10^{-09}	0.5547
155	$4.5 \times 10^{+01}$	1.4×10^{-04}	2.0×10^{-09}	0.5384
309	$4.0 \times 10^{+01}$	1.0×10^{-04}	1.3×10^{-09}	0.5141
556	$3.8 \times 10^{+01}$	7.6×10^{-05}	9.0×10^{-10}	0.4863
1082	$4.1 \times 10^{+01}$	4.7×10^{-05}	6.1×10^{-10}	0.4504
2163	$4.5 \times 10^{+01}$	2.3×10^{-05}	3.3×10^{-10}	0.4156
556	—	—	—	0.4183
155	—	—	—	0.4227
35	—	—	—	0.4299

Notes : An assumed particle density of 2.68 t/m3 has been used to determine void ratio
Sample supplied by client

Authorised Signatory : DIGITAL COPY _____
(S. Brodie)

Date : 1/05/2014

Form No AS1289.6.1.1/1 05/1R

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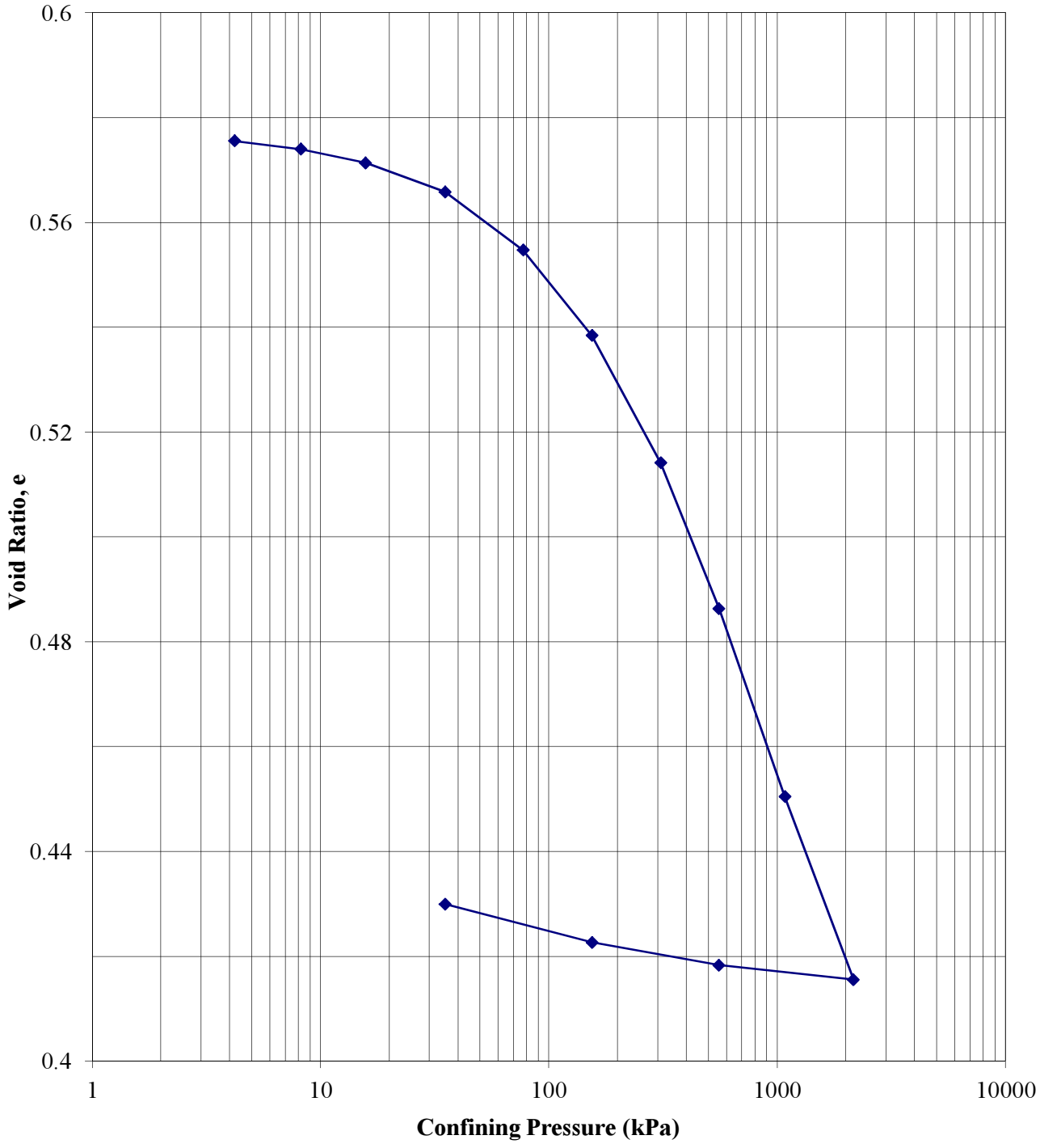
Geotechnical Engineering Laboratory

ONE-DIMENSIONAL CONSOLIDATION TEST
-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT :	Structerre Consulting Group (Job # D65859 / J142676)	**JOB NO :**	1314570
PROJECT :	Lot 746 - 750 Baldivis Road	**LOCATION :**	Baldivis
Sample Id :	BH3, Depth : 1.8 - 2.3m	**Lab No. :**	TT 06570003

VOID RATIO Vs CONFINING PRESSURE PLOT



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Date : 1/05/2014

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ONE-DIMENSIONAL CONSOLIDATION TEST

-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT : Structerre Consulting Group (Job # D65859 / J142676) **JOB NO :** 1314570
PROJECT : Lot 746 - 750 Baldivis Road **LOCATION :** Baldivis
Sample Id : BH4, Depth : 0.5 - 1.0m **Lab No. :** TT 06570004
Date Tested : Apr-2014

Specimen Details :	**Placement**	**Final**
Height :	20.00	16.04
Dry Density (t/m^3) :	1.170	1.458
Moisture Content (%) :	45.3	31.1
Void Ratio :	1.290	0.838
Degree of Saturation :	94.2	99.7

Sample Description :

Black, Silty Clay

Sampling Details :

nom. 63mm Ø tube sample

CONSOLIDATION DATA

Confining Pressure	**Coefficient of Consolidation, c_v**	**Coefficient of Compressibity, m_v**	**Coefficient of Permeability, k**	**Void Ratio**
kPa	m^2/Year	m^2/kN	m/sec	e
Initial				1.2905
0.7	Specimen swelled when inudated - loading increased			-
4.2	Specimen swelled - loading increased			-
8.2	Specimen swelled - loading increased			-
16	Specimen swelled - loading increased			-
35	—	—	—	1.2938
77	—	1.3×10^{-04}	—	1.2816
155	$8.0 \times 10^{+00}$	1.5×10^{-04}	3.8×10^{-10}	1.2555
309	$5.6 \times 10^{+00}$	1.6×10^{-04}	2.9×10^{-10}	1.2000
556	$2.6 \times 10^{+00}$	1.9×10^{-04}	1.6×10^{-10}	1.1017
1082	$1.6 \times 10^{+00}$	1.8×10^{-04}	9.4×10^{-11}	0.9158
2163	$2.3 \times 10^{+00}$	1.1×10^{-04}	7.8×10^{-11}	0.7154
556	—	—	—	0.7346
155	—	—	—	0.7722
35	—	—	—	0.8380

Notes : An assumed particle density of 2.68 t/m3 has been used to determine void ratio
Sample supplied by client

Authorised Signatory : DIGITAL COPY
(S. Brodie)

Date : 1/05/2014

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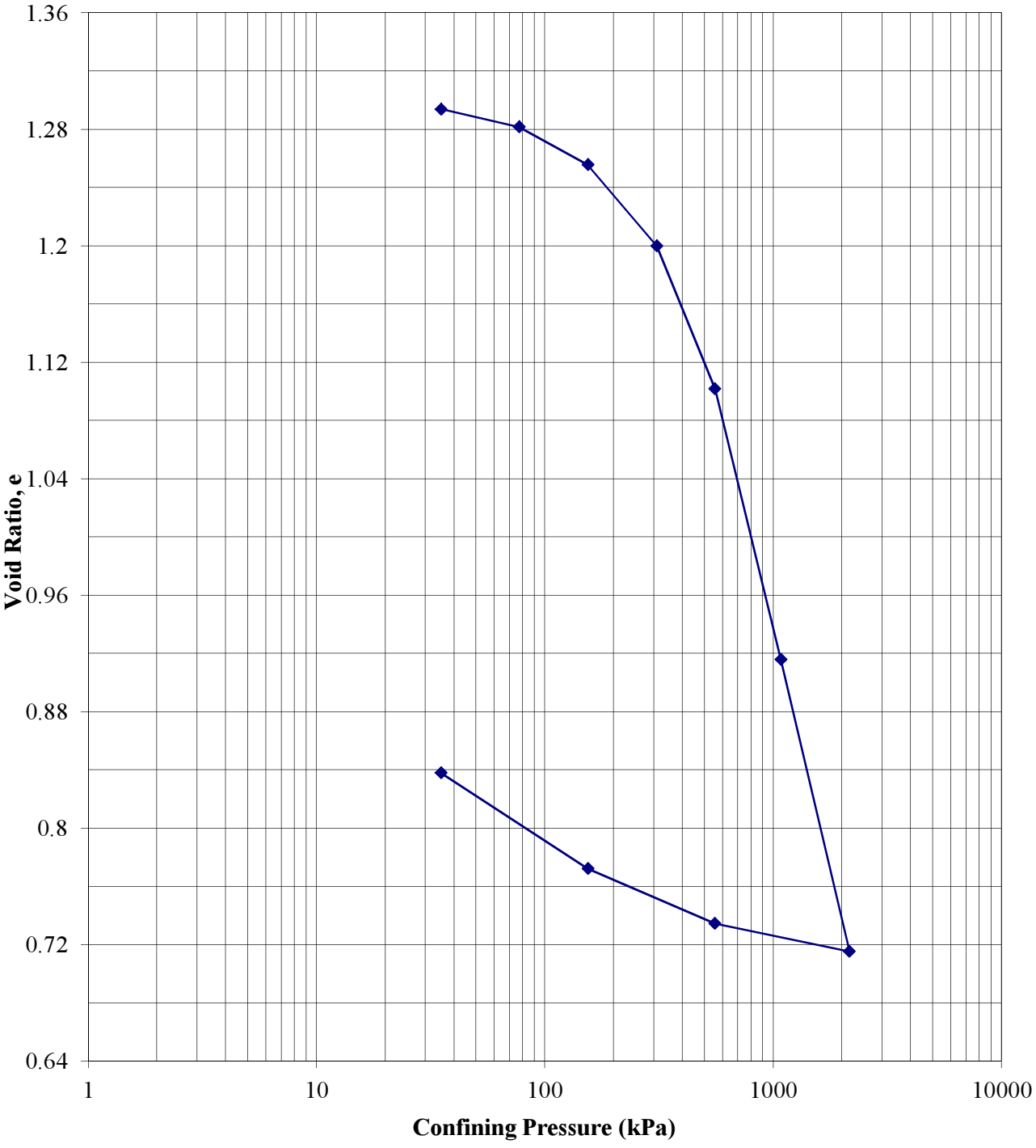
Geotechnical Engineering Laboratory

ONE-DIMENSIONAL CONSOLIDATION TEST
-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT :	Structerre Consulting Group (Job # D65859 / J142676)	**JOB NO :**	1314570
PROJECT :	Lot 746 - 750 Baldivis Road	**LOCATION :**	Baldivis
Sample Id :	BH4, Depth : 0.5 - 1.0m	**Lab No. :**	TT 06570004

VOID RATIO Vs CONFINING PRESSURE PLOT



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(S. Brodie)

Date : 1/05/2014

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Geotechnical Engineering Laboratory
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tricontest@optusnet.com.au Ph: (08) 9240 1444 Fax: (08) 9240 1044

ONE-DIMENSIONAL CONSOLIDATION TEST

-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT : Structerre Consulting Group (Job # D65859 / J142676) **JOB NO :** 1314570
PROJECT : Lot 746 - 750 Baldivis Road **LOCATION :** Baldivis
Sample Id : TP3, Depth : 1.5 - 2.0m **Lab No. :** TT 06570001
Date Tested : Apr-2014

Specimen Details :	**Placement**	**Final**
Height :	20.00	17.63
Dry Density (t/m^3) :	1.582	1.794
Moisture Content (%) :	23.3	18.3
Void Ratio :	0.694	0.494
Degree of Saturation :	90.2	99.6

Sample Description :

Dark Grey, Clayey Sand (med. Gr.)

Sampling Details :

nom. 63mm Ø tube sample

CONSOLIDATION DATA

Confining Pressure	**Coefficient of Consolidation, c_v**	**Coefficient of Compressibity, m_v**	**Coefficient of Permeability, k**	**Void Ratio**
kPa	m^2/Year	m^2/kN	m/sec	e
Initial				0.6942
0.7	Specimen swelled when inudated - loading increased			-
4.2	—	—	—	0.6940
8.2	—	4.1×10^{-04}	—	0.6912
16	—	3.5×10^{-04}	—	0.6867
35	$9.8 \times 10^{+01}$	2.7×10^{-04}	8.3×10^{-09}	0.6780
77	$7.8 \times 10^{+01}$	2.3×10^{-04}	5.8×10^{-09}	0.6616
155	$6.9 \times 10^{+01}$	1.7×10^{-04}	3.6×10^{-09}	0.6407
309	$6.2 \times 10^{+01}$	1.4×10^{-04}	2.7×10^{-09}	0.6062
556	$5.6 \times 10^{+01}$	9.5×10^{-05}	1.7×10^{-09}	0.5694
1082	$5.2 \times 10^{+01}$	6.0×10^{-05}	9.8×10^{-10}	0.5215
2163	$5.2 \times 10^{+01}$	2.9×10^{-05}	4.7×10^{-10}	0.4754
556	—	—	—	0.4784
155	—	—	—	0.4839
35	—	—	—	0.4939

Notes : An assumed particle density of 2.68 t/m3 has been used to determine void ratio
Sample supplied by client

Authorised Signatory : DIGITAL COPY
(S. Brodie)

Date : 1/05/2014
Form No AS1289.6.1.1/1 05/1R

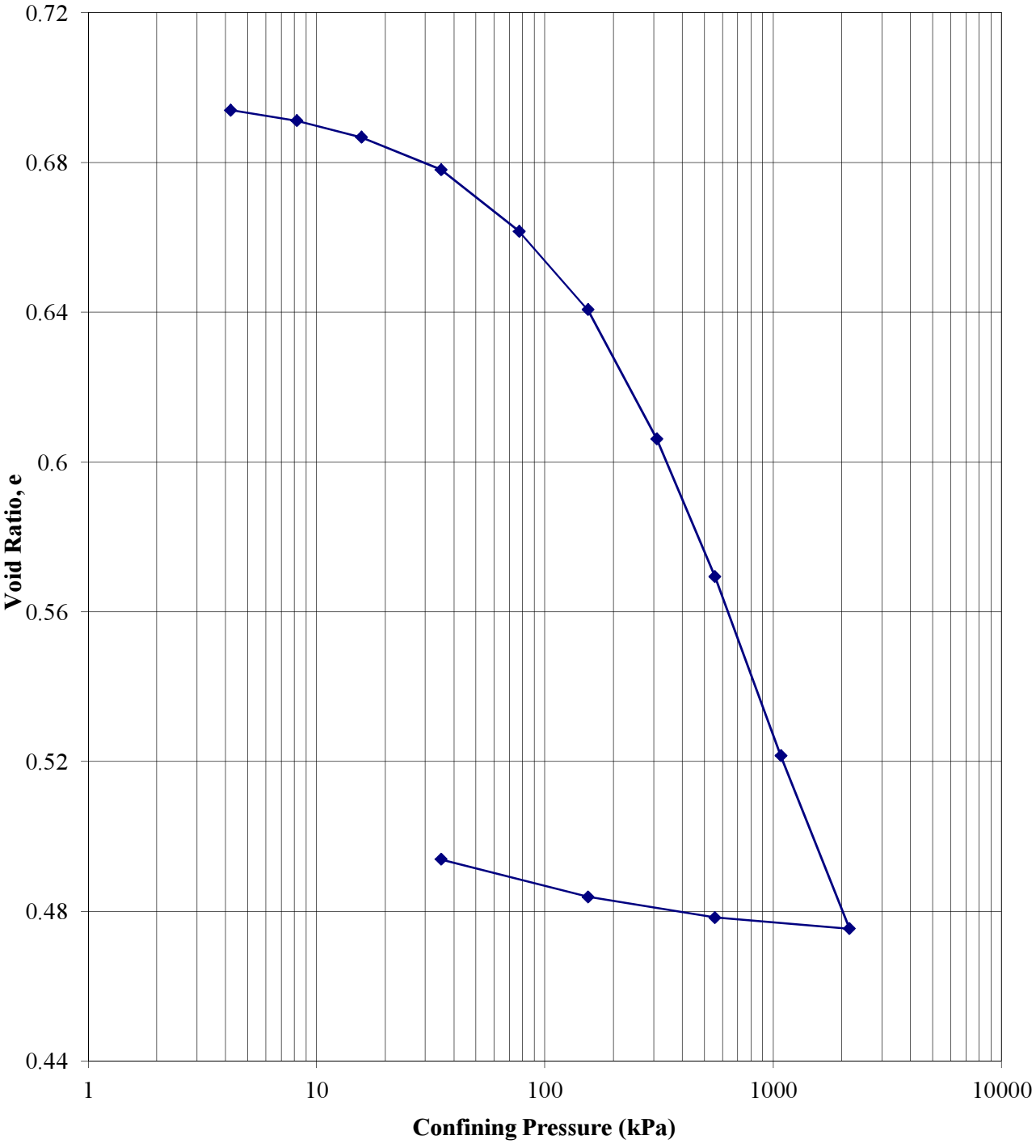
TRICON TESTING
Geotechnical Engineering Laboratory

ONE-DIMENSIONAL CONSOLIDATION TEST
-according to AS 1289.6.6.1 - 1998

REPORT CERTIFICATE

CLIENT :	Structerre Consulting Group (Job # D65859 / J142676)	**JOB NO :**	1314570
PROJECT :	Lot 746 - 750 Baldivis Road	**LOCATION :**	Baldivis
Sample Id :	TP3, Depth : 1.5 - 2.0m	**Lab No. :**	TT 06570001

VOID RATIO Vs CONFINING PRESSURE PLOT



Authorised Signatory : DIGITAL COPY _____
(S. Brodie)

Date : 1/05/2014

Form No AS1289.6.1.1/1 05/1R

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ONE-DIMENSIONAL CONSOLIDATION TEST

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REPORT CERTIFICATE

CLIENT : Structerre Consulting Group (Job # D65859 / J142676) **JOB NO :** 1314570
PROJECT : Lot 746 - 750 Baldivis Road **LOCATION :** Baldivis
Sample Id : TP4, Depth : 0.5 - 1.0m **Lab No. :** TT 06570002
Date Tested : Apr-2014

Specimen Details :	**Placement**	**Final**
Height :	20.00	18.68
Dry Density (t/m^3) :	1.768	1.892
Moisture Content (%) :	15.1	11.6
Void Ratio :	0.516	0.417
Degree of Saturation :	78.3	74.9

Sample Description :
Greyish Brown, Silty Sand (med. Gr.) with pockets of Bluish Grey Clay

Sampling Details :
nom. 63mm Ø tube sample

CONSOLIDATION DATA

Confining Pressure	Coefficient of Consolidation, c_v	Coefficient of Compressibity, m_v	Coefficient of Permeability, k	Void Ratio
kPa	m^2/Year	m^2/kN	m/sec	e
Initial				0.5162
0.7	Specimen swelled when inudated - loading increased			-
4.2	—	—	—	0.5159
8.2	—	2.1×10^{-04}	—	0.5146
16	—	1.8×10^{-04}	—	0.5125
35	$1.4 \times 10^{+02}$	1.5×10^{-04}	6.4×10^{-09}	0.5083
77	$1.1 \times 10^{+02}$	1.3×10^{-04}	4.5×10^{-09}	0.5001
155	$9.9 \times 10^{+01}$	1.0×10^{-04}	3.2×10^{-09}	0.4884
309	$9.5 \times 10^{+01}$	7.4×10^{-05}	2.2×10^{-09}	0.4716
556	$8.3 \times 10^{+01}$	5.2×10^{-05}	1.4×10^{-09}	0.4530
1082	$9.0 \times 10^{+01}$	3.2×10^{-05}	9.1×10^{-10}	0.4291
2163	$1.2 \times 10^{+02}$	1.5×10^{-05}	5.7×10^{-10}	0.4069
556	—	—	—	0.4086
155	—	—	—	0.4114
35	—	—	—	0.4167

Notes : An assumed particle density of 2.68 t/m3 has been used to determine void ratio
Sample supplied by client

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Date : 1/05/2014
Form No AS1289.6.1.1/1 05/1R

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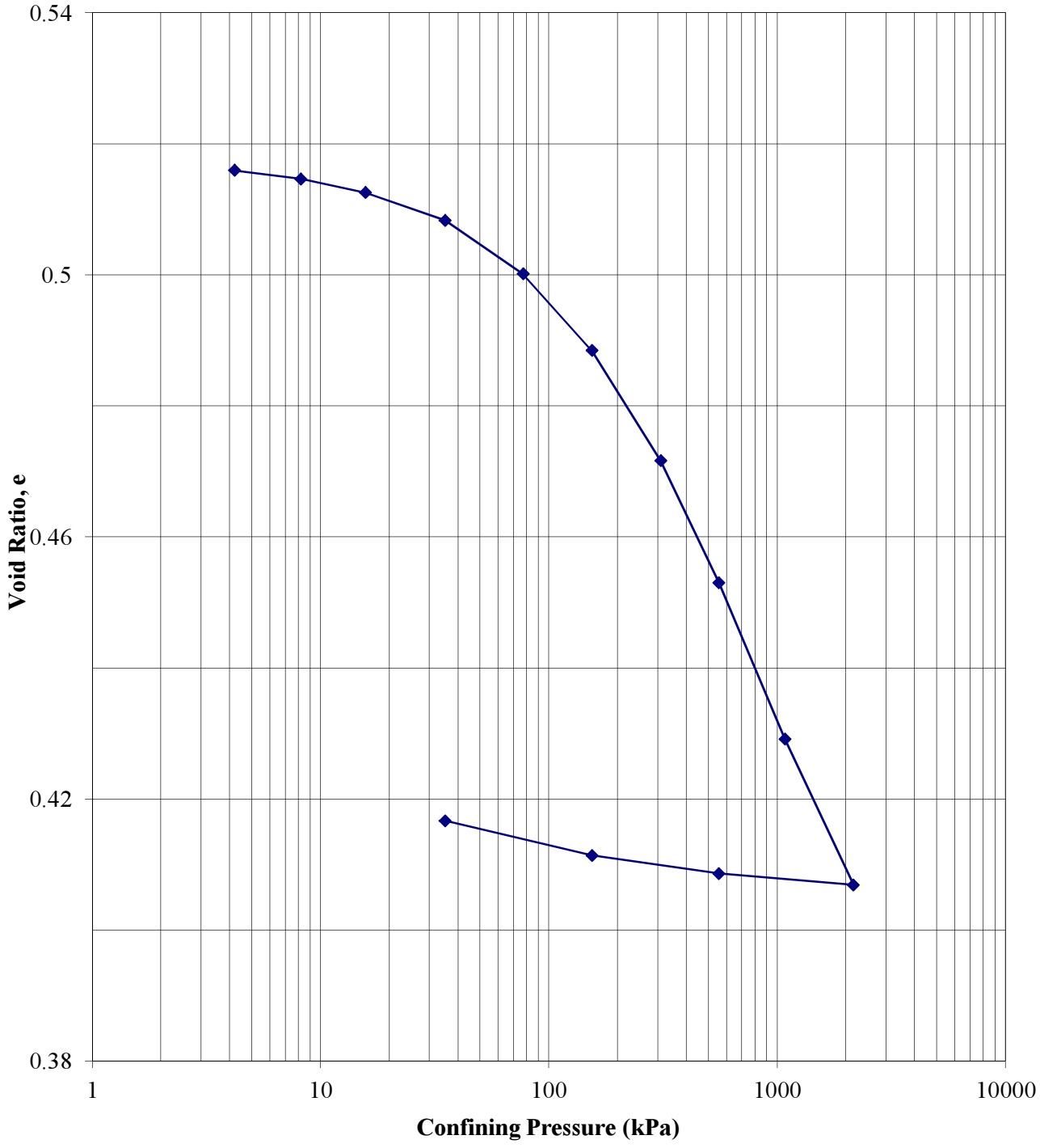
REPORT CERTIFICATE

CLIENT :	Structerre Consulting Group (Job # D65859 / J142676)	**JOB NO :**	1314570
PROJECT :	Lot 746 - 750 Baldivis Road	**LOCATION :**	Baldivis
Sample Id :	TP4, Depth : 0.5 - 1.0m	**Lab No. :**	TT 06570002

VOID RATIO Vs CONFINING PRESSURE PLOT



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(S. Brodie)

Date : 1/05/2014

Form No AS1289.6.1.1/1 05/1R

RPS

APPENDIX 3

Landscape Strategy

FIGURE 1 - LANDSCAPE STRATEGY

PUBLIC OPEN SPACE SUMMARY

FEATURE PARK
- Large expansive turf area for active recreation
- Centrally located and easily accessible to the entire community
- Large gathering spaces to cater for community events
- Large play space and fitness nodes catering for all ages
- Pedestrian/Cycle Path network links into adjacent development.

NEIGHBOURHOOD INFORMAL
- Balance of native planted pockets and open turf areas
- Large gathering nodes with BBQ/picnic facilities
- Nature play and fitness nodes
- Pedestrian/Cycle path network links into adjacent developments
- Informal active recreation space

LOCAL INFORMAL
- Predominantly native planted areas with pockets of turf
- Small gathering nodes and basic picnic/BBQ facilities
- Path network which links into adjacent developments & POS
- Primary focus on passive recreation

TRAMWAY TYPOLOGY
- Retain and protect all existing native vegetation
- Pocket planting of revegetation species
- Informal path network links to development & greater Tramway path system.

MAINTENANCE

All Public Open Space within 746-545 are to be maintained as managed Parklands. Imagery of maintained parkland is as shown and referenced on pages POS C&D. Refer to Bushfire Hazard Assessment for further detail.

NORTH 0 50 100 METRES

LEGEND

- EXTENT OF WORK
- GREENLINKS/WIDENED VERGE/DUP
- BRIDAL PATH
- DRAINAGE STORAGE AREAS
- PLAY ELEMENTS SHELTER
- POTENTIAL ARTWORK /SIGNAGE
- PUBLIC OPEN SPACE (A)

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 2 - LANDSCAPE MASTER PLAN

PLAYFUL

COMFORTABLE

CONSIDERED

CONNECTED

LEGEND

1. ENTRY AREA
2. WIDENED LANDSCAPE VERGE
3. PROPOSED GATHERING SPACE
4. OPEN KICKABOUT SPACE
5. DRAINAGE SWALES
6. PRIMARY SCHOOL OVAL
7. DESIGN TO ADJACENT POS

NORTH

0 50 100 METRES

LOT 746-545 BALDIVIS ROAD, MIRVAC

LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 3 - STREET TREE MASTER PLAN

Agonis flexuosa -
WA Peppermint

Eucalyptus leucoxylon 'Rosea' -
Pink Flowering gum

Corymbia ficifolia -
Red Flowering Gum

Tipuana tipu -
Rosewood

Melaleuca quinquernervia -
Broad Leaved Paperbark

Note:

Street trees located in Public Open Space areas with Building Protection Zone considerations are to apply to the relevant tree canopy separation requirements

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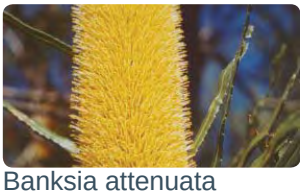
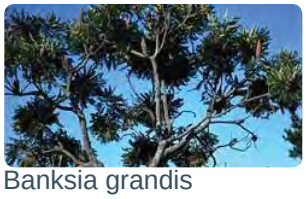
FIGURE 4 - POS TREE PLANTING PALETTE

Agonis flexuosa


Banksia attenuata

Casuarina obesa

Corymbia ficifolia


Banksia grandis

Banksia menziesii

Eucalyptus gomphocephala

Eucalyptus rudis

Melaleuca quinquernervia

Melaleuca lanceolata

Melaleuca preissiana

Xanthorrrhoea preissii

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 5 - POS A CONCEPT

POS TYPOLOGY
- Feature Park (A)

SIZE (excluding verges)
- 1.36 Hectares

CONCEPT
- Provide a large active turf space for the broader community
- Large accessible play space with interest for all ages
- Provide safe pedestrian and cycle linkages
- Exercise circuit linking the functions within the POS
- Provide shaded picnic facilities & bbqs
- Community focal area with space for small events/ markets

FUNCTIONS
- Turf - Larger turf areas for informal recreation
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Picnic Facilities for family/friend & community gatherings
- Play elements for all age groups
- 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

DRAINAGE CONSIDERATIONS
- 1:1 628 m3 storage required
- 1:5 1006 m3 storage required
- 1:10 1024 m3 storage required
- 1:100 2360 m3 storage required

Note: Figures to be finalised during detailed design.

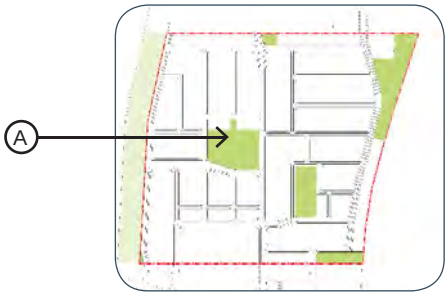

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FIGURE 6- POS B CONCEPT

POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .74 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - informal kick-about areas
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- 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 plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS
- 1:1 520 m3 storage required
- 1:5 840 m3 storage required
- 1:10 856 m3 storage required
- 1:100 1980 m3 storage required

Note: Figures to be finalised during detailed design.

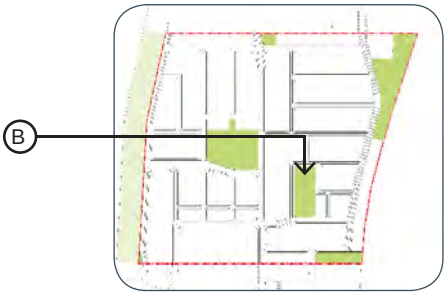

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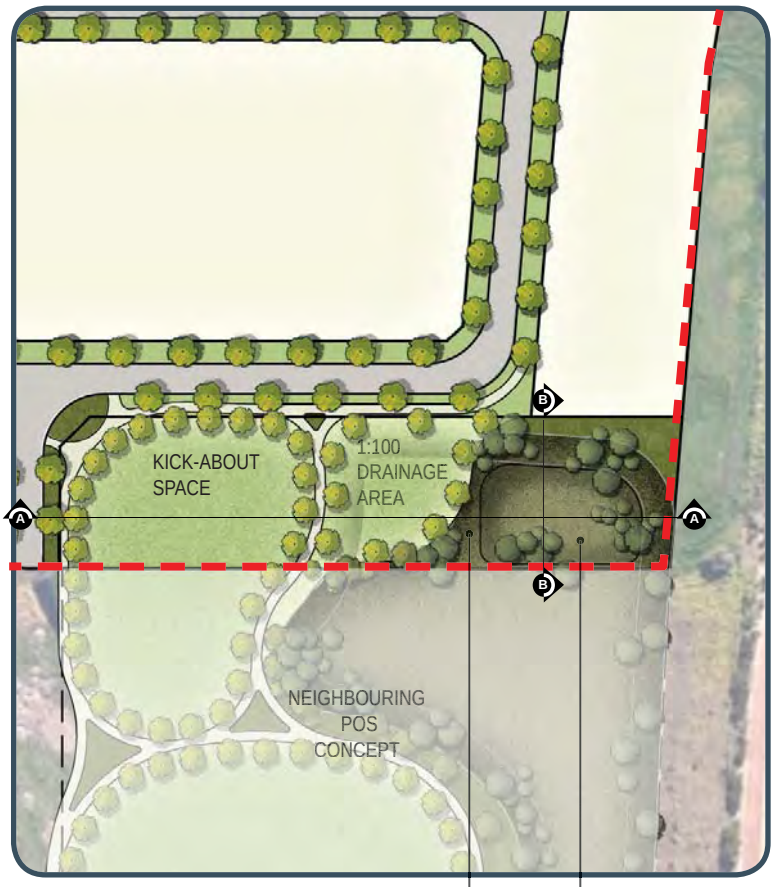
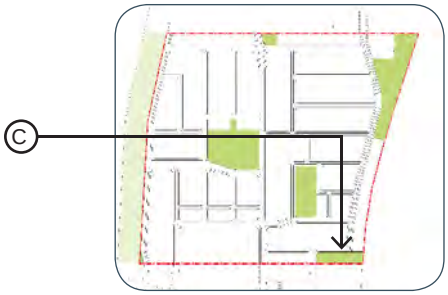
FIGURE 7 - POS C CONCEPT



NORTH

0 20 40 METRES



POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .37 Hectares (Mirvac land holding)
- 2.5 Hectares total area

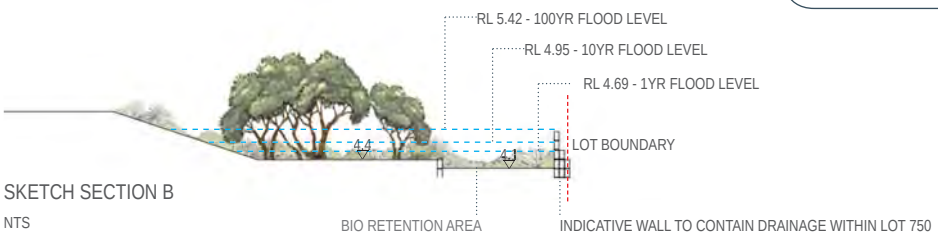
CONCEPT
- Provide a northern extension of a large neighbourhood park to cater for residents within a 150m-300m catchment
- Deliver a fully integrated design response ensuring that the broader area of open space is seamless in its transition between the two residential estates
- Provide large areas of useable kick-about space that is not compromised by drainage infrastructure
- Create a safe local park which is intended to be heavily planted with shade trees and provides low key picnic facilities, recreational facilities and nodes for exercise.
- Provide safe pedestrian and cycle linkages to broader path network linkages.

FUNCTIONS
- Connecting expanses of turf
- Native, water wise planting.
- Maximise shade trees with emphasis on native species
- Retain existing vegetation where possible
- Limited picnic facilities
- Internal path network
- Path network connecting into the broader path network

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

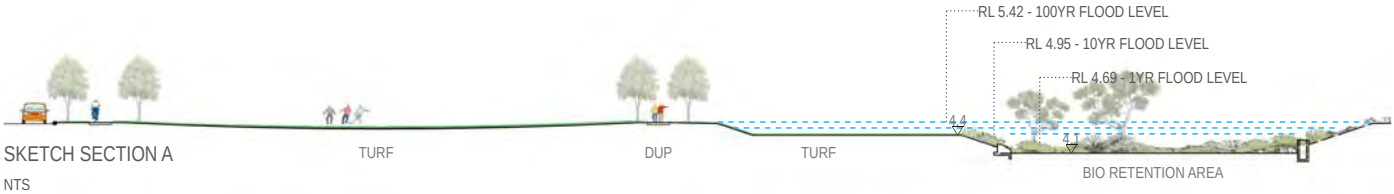
DRAINAGE CONSIDERATIONS
- 1:1 250 m3 storage required
- 1:5 399 m3 storage required
- 1:10 437 m3 storage required
- 1:100 1109 m3 storage required

Note: Figures to be finalised during detailed design.



SKETCH SECTION B

NTS



SKETCH SECTION A

NTS

LOT 746-545 BALDIVIS ROAD, MIRVAC

LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 8 - POS D CONCEPT

POS TYPOLOGY
- Local Informal

SIZE (excluding verges)
- 1.44 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - informal kick-about areas
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- 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
- Planting within Building Protection Zone to be considered. Refer to the FESA planting guidelines for possible species within the BPZ
- Dry garden with gravel mulch, clumping plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS
- 1:1 669 m3 storage required
- 1:5 1098 m3 storage required
- 1:10 1141 m3 storage required
- 1:100 2840 m3 storage required

Note: Figures to be finalised during detailed design.

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LOCAL STRUCTURE PLAN MI-01 REV C

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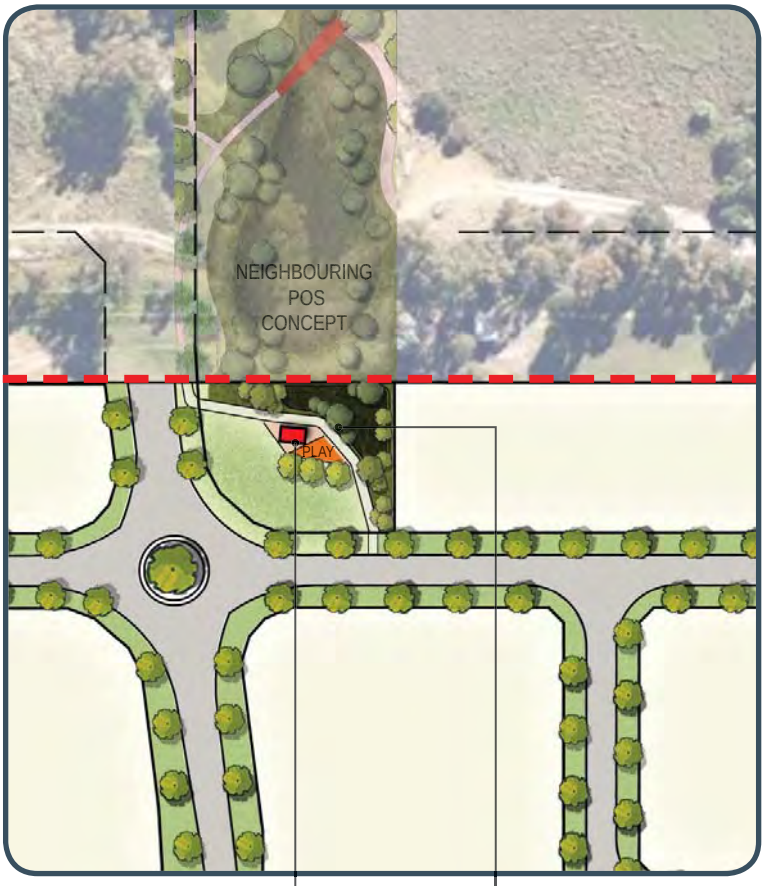
FIGURE 9 - POS E CONCEPT



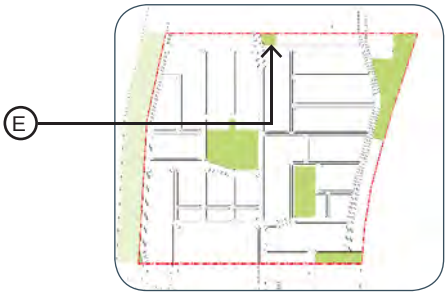
POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .10 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - for passive surveillance
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- Path network connecting into broader path network

ENVIRONMENTAL CONSIDERATIONS
- Waterwise native planting
- Planting design to be zoned according to irrigation requirement, with full irrigation requirements to the informal turf playing area
- Planting within Building Protection Zone to be considered. Refer to the FESA planting guidelines for possible species within the BPZ
- Dry garden with gravel mulch, clumping plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials



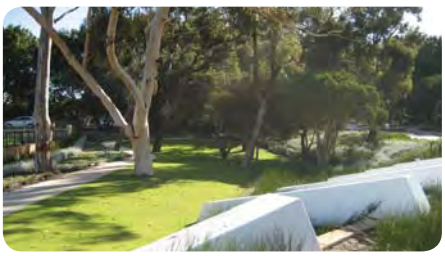


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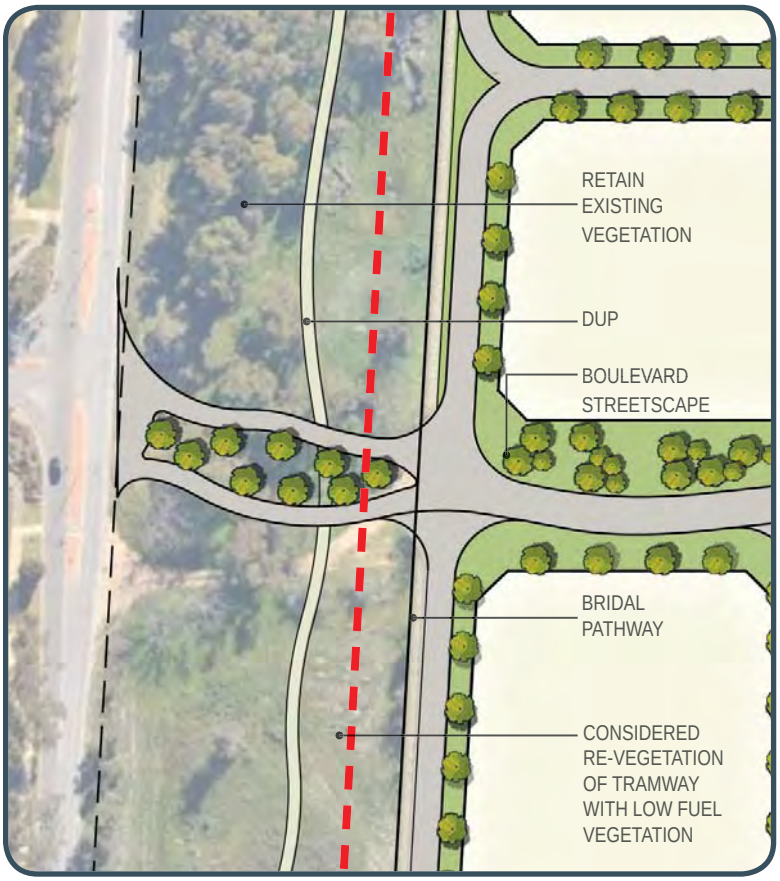
FIGURE 10 - TRAMWAY TYPOLOGY PLAN



NORTH

0 20 40 METRES

CONCEPT

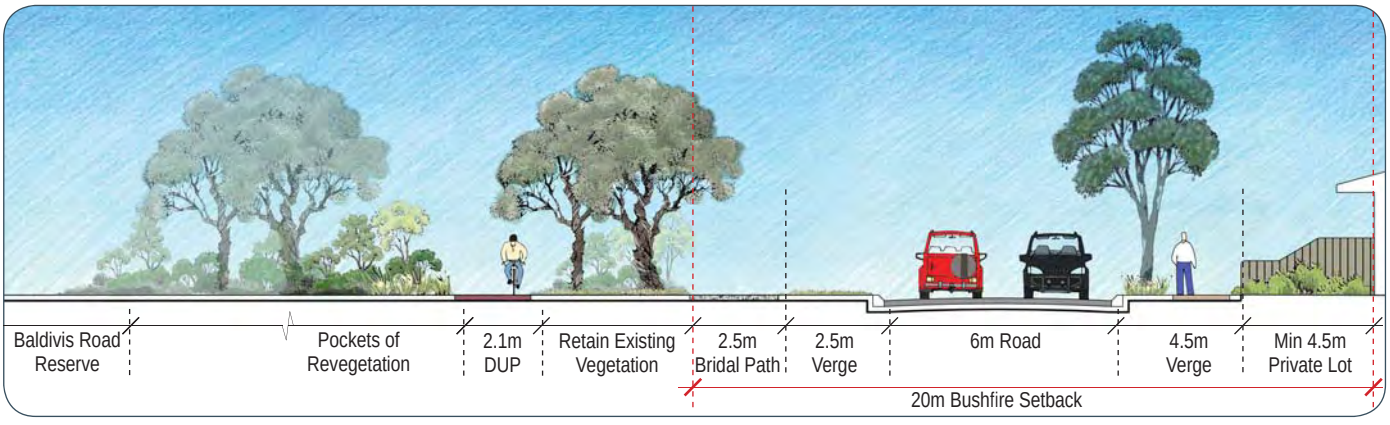
- Maintain and protect all existing vegetation within tramway reserve
- Meandering dual use path runs the length of the tramway and links to greater tramway path networks.
- Limestone Bridal trail runs adjacent to boundary
- Planting pockets of native re-vegetation

FUNCTIONS

- Native re-vegetation planting
- Crushed limestone bridal path
- Dual use path
- Entry Statement at Baldivis Road
- Provide linkages to pedestrian networks within and outside of the development area

ENVIRONMENTAL CONSIDERATIONS

- No irrigation
- Re-vegetation of native plant communities to strategic nodes. Locations to be determined in detailed design
- Removal of weed species



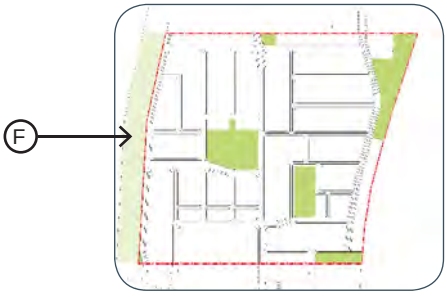


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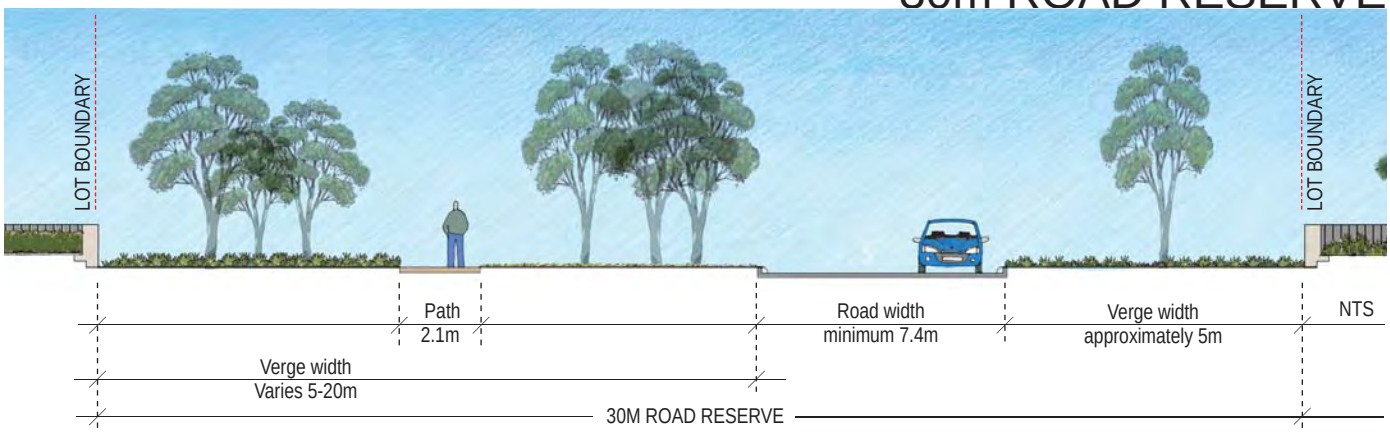
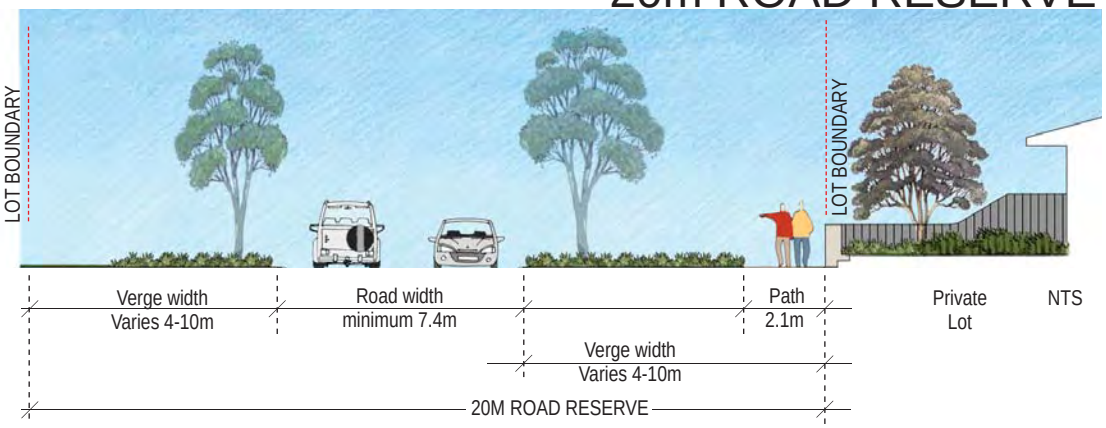
FIGURE 11 - ROAD TYPOLOGY SECTIONS

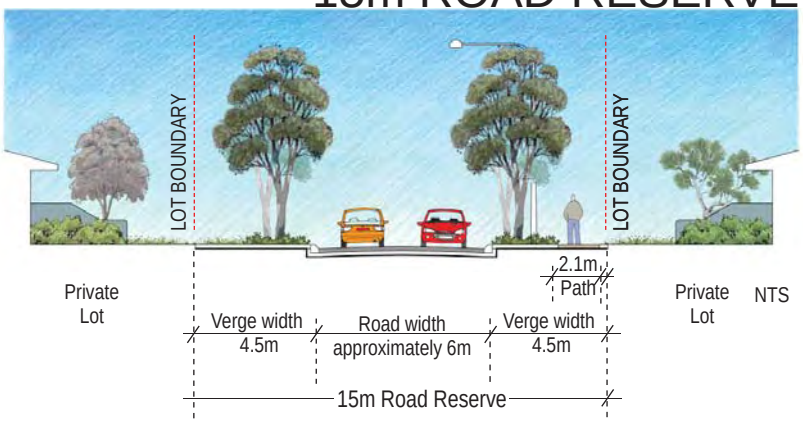
30m ROAD RESERVE

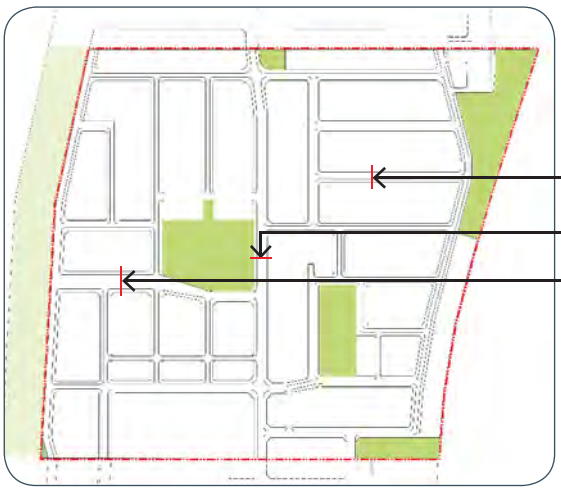


20m ROAD RESERVE



15m ROAD RESERVE





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RPS

APPENDIX 4

DEC Servicing Report

1 General

This report has been prepared to demonstrate the availability of service infrastructure to support the Local Structure Plan on the above land as outlined in the CLE plan.

It is proposed to develop the land into some 530 urban lots and associated POS, with an entry access from Baldivis Road.

The investigations in this report have involved consultation with the various service authorities and Council and a desk top study of the available information over the site to establish the opportunities and constraints to development of the area.

2 Executive Summary

The land the subject of this report is located immediately east of Baldivis Road, west of the Kwinana Freeway and located centrally opposite Pemberton Boulevard. It occupies an area of 36 98 hectares.

The basic land form is in the main low level Guildford Formation soils, with a narrow strip of Bassendean Sands along the Baldivis Rd frontage.

The land is almost completely cleared and used as grazing land. It has an old open drain running south to north located approximately along the centre of the site in a slightly zig - zag configuration, which discharges into an open channel on the abutting property to the north and thence into the MRWA Kwinana Freeway reserve and culvert system to The Peel Main Drain on the east side of the Freeway.

The site accommodates a residence and associated garage on lot 545 and vacant land on the remainder. It varies in elevation from approximately RL 8 metres AHD along Baldivis Rd down to RL 4m AHD at a distance of 150 metres into the site, which level continues to the eastern boundary.

Because the development will be influenced by the 1 in 100 year flood level of the adjacent Peel Main Drain, the final level of the development is set at 500mm above this level at RL 6.1m AHD, thus necessitating over two metres of sand fill in places to attain this level.

The land can be connected to all services, either by extension from neighbouring subdivision developments west and north of the site, or by extension along Baldivis Road. In the case of sewer connection, the northern half of the site can be connected by gravity into an existing scheme, but the southern half is to be connected to a future permanent Water Corporation Waste Water Pumping Station (WWPS) which will be located in the proposed neighbouring development by others. Access to the East Rockingham Waste Water treatment Plant (ERWWTP) has been approved by the Water Corporation.

Some upgrading and construction of Baldivis Road will be required, with the access to the site being located centrally along the frontage of the site from Baldivis Road.

The site will be filled to provide both drainage and class “A” building foundation classification. Because some two thirds of the site is underlain by silty clay soils, ground remediation work is required prior to filling. The filling for the 1 in 100 year flood far exceeds the WAPC required clearance of 1.2m above the AAMGL, which is at approximately RL 3.5m AHD across the site.

3 Site

The site covering an area of 36.98 hectares is located on the east side of Baldivis Road and Tramway Reserve, across to the western boundary of the Kwinana Freeway, and is south of the new development of Australand on its northern boundary and north of the proposed Perron development on its southern boundary. Pemberton Boulevard is located opposite the middle of the Baldivis Road frontage of the site. The site has been completely cleared and used for grazing for some years. It is generally low lying and has the potential to be inundated by the 1 in 100 year flood of the Peel Main Drain, which is located immediately east of the Freeway. It is traversed by a man made agricultural open drain flowing south to north, exiting at the existing Water Corporation drain flowing east into the Freeway reserve and the culvert under the Freeway.

Baldivis Road has been recently been upgraded to current urban standard as part of the new urban development on the west side of the road.

The Environmental Geology map of the Geological Survey of Western Australia classifies this site as "S8" Bassendean Sands on the western edge along Baldivis Road, and S10 "Guildford Formation" across the balance of the site, both being deemed "suitable for urbanisation. However, Geotechnical site investigations have revealed the existence of deep silty clay across the eastern two thirds of the land, being an old flood plain, needing remedial works as detailed in the following earthworks section of this report.

The site has an AAMGL generally varying from RL 4.4m at Baldivis Rd down to RL 3.6 through the centre of the site, and rising to RL 3.8m AHD along the Freeway boundary. The minimum required clearance to this level will be greatly exceeded by the requirements to provide freeboard of 500mm to the 1 in 100 year flood level of the Peel Main Drain. This level is set at RL 6.1m AHD.

4 Development Proposal

It is proposed to develop the land as a residential subdivision of around 530 urban residential lots, with all normal services being;- wastewater, water, power, roads, gas and telecommunications service.

Access to the site will initially and primarily be from Baldivis Road and in the future from other developments north and south of the site, providing permeability.

The existing residence, sheds, septic tanks etc on lot 545 will be demolished as part of the development. The remainder of the site is vacant land.

All drainage is proposed to be detained on site for the 1 in 100 year design storm, with outflow limited to pre-development flows. All drainage will be designed to incorporate best management practices. There will be four drainage basins to accept site stormwater flows, all located within POS areas. Outflow from the basins is to the Peel Main Drain via the Kwinana Freeway reserve drainage.

The urban development area will entail substantial earthworks to provide level building blocks, with lots having retaining walls as required to allow this.

The site filling will enable lots to be sewered from the existing WWPS located north of the site and a proposed WWPS south of the site.

5 Earthworks & Retaining Walls

The site requires filling to at least 6.1m AHD to meet the requirements of the 1 in 100 year flood level of the Peel Main Drain. Some fill will be placed in excess of this level in order to achieve drainage and sewer construction. Thus the site will be generally flat, with small differences caused by road design plus sewer and drainage design.

Because of the nature of underlying soils across some two thirds of the site, which are unsuitable for development without some remedial works prior to filling operations, it is proposed to utilize a method

of deep dynamic compaction to stabilize these soils, rather than excavating and carting the unsuitable soils off site to a tip, with associated dewatering, ASS remediation and replacement with expensive imported fill, and then importing and placing extra fill to attain the RL 6.1m finished ground level. The developer is desirous of attaining "A" site foundation classification for the finished lots, and the above deep dynamic compaction method is the only available method which will provide this. Minimal disturbance of the soil and ASS remediation is required for this method. We are advised that such methods are also being used for adjacent site developments.

Each lot will be finished level, with installation of low retaining walls to suit, except where lots back onto POS, where it is likely retaining walls may be up to 1.5m in height. Retaining walls will be constructed using reconstituted limestone blocks.

All fill will be imported to the site, via Baldivis Road from approved sand pits. It will be free draining to meet the geotechnical specifications and site drainage and building requirements. There is an embargo on site earthworks during the spring and summer, from October to March inclusive, due to easterly and south westerly winds causing dust and sand blows. The site will be fenced with appropriate wind fencing along all boundaries to minimize this, and watering down of stockpiles, stripped areas and filling operations. A Dust Management Plan will be provided by the Contractor at each stage of development, such to be approved by the City of Rockingham prior to starting site works.

Where roads or lots join between land holdings with separate ownership, levels on the roads and lot boundaries will be either matched to existing level or co-ordinated to ensure that a staged development approach can be accommodated. Walls may be required along boundaries if agreement cannot be reached with the adjoining owner. This may require retaining walls on a temporary basis within the road reserve.

6 Roads

All roads will be constructed to City of Rockingham standards and design approvals.

Baldivis Road along the frontage of the site has recently been upgraded to Boulevard standard. The development plan shows a central local connector road traversing the site from north to south, thus connecting with similar roads planned for developments north and south of the site.

The entry road to the site will connect with the new roundabout on Baldivis Road at the intersection with Pemberton Boulevard. This road traverses the Tramway reserve, where clearing will be minimized to allow road construction as approved by the City of Rockingham.

7 Drainage

A LWMS has been carried out over the site by RPS Consultants. The site falls within the Mundijong Drainage District and has a restricted outflow to the Peel Main Drain.

Generally stormwater runoff from roads will be collected by pits and conveyed by pipes to designated basins, which will attenuate volumes to pre-development levels for discharge into the outfall channels along the Kwinana Freeway reserve.

Subsoil drains will be used extensively to control any rise in groundwater, but will not be placed any lower than the agreed AAMGL for the site. All drainage pipes will be bedded on crushed rock to help with the control of groundwater.

Currently the site is drained by a man made agricultural open drain which falls south to north, exiting the site at the Water Corporation undeclared main drain in lot 545 immediately north of the site. This Main Drain discharges to the Kwinana Freeway reserve and ultimately via culverts under the Freeway, to the Peel Main Drain.

For this development, the site has been divided into four drainage catchments, three of which accept the majority of site stormwater drainage, exiting the site via a controlled overflow in the north east corner

via an overflow, where the existing outfall drain within lot 545 will be formalized by means of a box culvert drain and a portion of "living Steam" at the freeway end to match the existing outfall level to the Freeway reserve..

The southern catchment basin, which is the minor catchment of the site, will discharge allowed discharge via an overflow directly to the Freeway reserve.

Each basin has a restricted outflow, as per the allowance for the Mundijong Drainage District requirement, to the Kwinana Freeway reserve.

Catchments have been established based on topography, fill and minimum road grades to ensure optimization of basin areas and minimization of impact on POS.

Generally the low points in each basin have been designated as infiltration swales to cater for stormwater flow from 2% of the connected impervious area to act as a biological treatment zone. The base of such is set at a minimum of 300mm above the control Groundwater level (CGL).

Areas of basins greater than the above requirement are a minimum of 500mm above the CGL to allow active recreational use of the areas.

All basins will have the maximum depth of water of 1.32m for the 1 in 100 year ARI storm.

The LWMS has determined the AAMGL for the site, at which level subsoil drains will be placed so that no lowering of the water table below the AAMGL will occur with the development, but any rise in groundwater will be controlled.

8 Power

Sufficient power supply exists in the area to supply the development. A high voltage line is located along Baldivis Road, from which supply will be drawn.

All internal power reticulation lines and transformer installations will be constructed at the cost of the developer. Transformer and switch station sites will be determined at the detailed subdivision design stage to Western Power approval.

9 Water Supply

At present there is a 300mm water main past the site in Baldivis Road. Some augmentation to this supply will be required via a connection from Eighty Rd and Fifty Rd. This augmentation is expected to be made either by the Water Corporation or prefunded by other developers, and is not a pre-requisite to the development of the site.

Internal reticulation mains will be designed to Water Corporation approval to complete links through the site to developments north and south of the site.

10 Sewer

The site falls into two sewer catchments, each discharging to a Waste Water Pump Station (WWPS) as determined by Water Corporation sewer planning.

The northern half of the site falls within the catchment of the existing Baldivis North (WWPS') "I" located adjacent to Baldivis Road north of the adjacent Australand Development. Sewers to the site will be constructed by Australand to their southern boundary, from where Mirvac will extend the sewer into their site.

According to current Water Corporation sewer planning, the southern half of the site falls within the catchment of the proposed WWPS "C", which is now to be located and constructed within the Perron land development immediately south of the site by Perron. Sewers from the Perron development will be

extended to the site by their development. This WWPS will discharge into a 225mm sewer extended through the Australand and the Mirvac (this development) land.

It is expected that the first stages of the development will be within the existing WWPS catchment, thus allowing some time for the proposed WWPS to be constructed.

Fill required by the 1 in 100 year flood of the Peel Main drain is generally sufficient to allow each WWPS to serve the development.

The Water Corporation has now achieved approval for the linking sewer mains to the East Rockingham Waste Water Treatment Plant (ERWWTP), and as a result they are agreeing to new developments in this area.

11 Telephone

The new urban development will be served by the NBN or another provider for broadband and telephony. Capacity exists off Baldivis Road and the adjacent development which may require minor extensions to facilitate connection.

12 Gas

Gas services are located in Baldivis Road and the adjacent development and have sufficient capacity to serve the area with minimal augmentation.

DEVELOPMENT ENGINEERING CONSULTANTS PTY LTD

THIS REPORT IS DATED 21 AUGUST 2014.

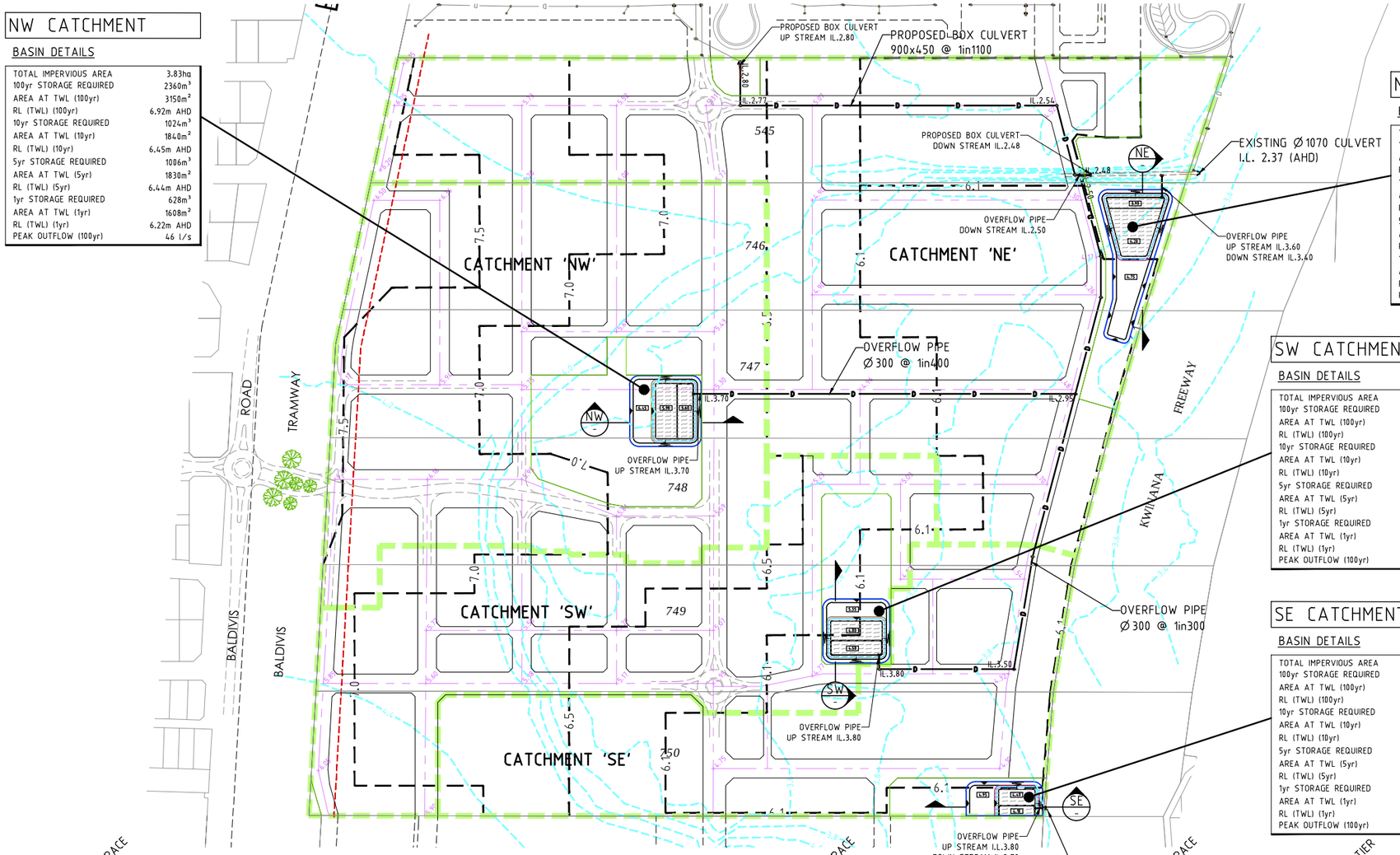
APPENDIX 5

Drainage Catchment Plan

NW CATCHMENT

BASIN DETAILS

TOTAL IMPERVIOUS AREA	3.83ha
100yr STORAGE REQUIRED	2360m³
AREA AT TWL (100yr)	3150m²
RL (TWL) (100yr)	6.92m AHD
10yr STORAGE REQUIRED	1024m³
AREA AT TWL (10yr)	1840m²
RL (TWL) (10yr)	6.45m AHD
5yr STORAGE REQUIRED	1006m³
AREA AT TWL (5yr)	1830m²
RL (TWL) (5yr)	6.44m AHD
1yr STORAGE REQUIRED	628m³
AREA AT TWL (1yr)	1608m²
RL (TWL) (1yr)	6.22m AHD
PEAK OUTFLOW (100yr)	46 l/s



NE CATCHMENT

BASIN DETAILS

TOTAL IMPERVIOUS AREA	4.89ha
100yr STORAGE REQUIRED	2840m³
AREA AT TWL (100yr)	3961m²
RL (TWL) (100yr)	5.22m AHD
10yr STORAGE REQUIRED	1141m³
AREA AT TWL (10yr)	2187m²
RL (TWL) (10yr)	4.75m AHD
5yr STORAGE REQUIRED	1098m³
AREA AT TWL (5yr)	2163m²
RL (TWL) (5yr)	4.73m AHD
1yr STORAGE REQUIRED	669m³
AREA AT TWL (1yr)	1919m²
RL (TWL) (1yr)	4.52m AHD
PEAK OUTFLOW (100yr)	62 l/s

SW CATCHMENT

BASIN DETAILS

TOTAL IMPERVIOUS AREA	2.98ha
100yr STORAGE REQUIRED	1980m³
AREA AT TWL (100yr)	2674m²
RL (TWL) (100yr)	5.82m AHD
10yr STORAGE REQUIRED	856m³
AREA AT TWL (10yr)	1556m²
RL (TWL) (10yr)	5.35m AHD
5yr STORAGE REQUIRED	840m³
AREA AT TWL (5yr)	1556m²
RL (TWL) (5yr)	5.34m AHD
1yr STORAGE REQUIRED	520m³
AREA AT TWL (1yr)	1352m²
RL (TWL) (1yr)	5.12m AHD
PEAK OUTFLOW (100yr)	32 l/s

SE CATCHMENT

BASIN DETAILS

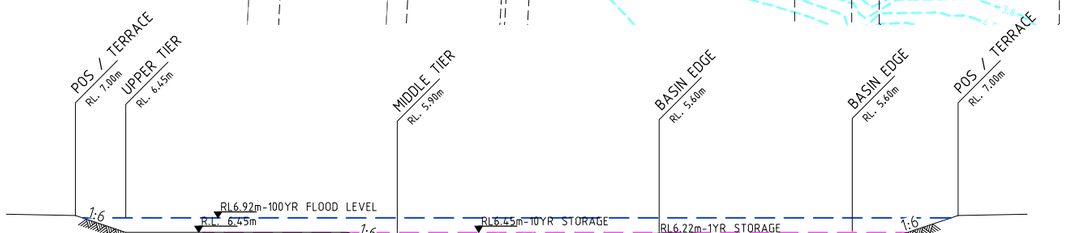
TOTAL IMPERVIOUS AREA	1.96ha
100yr STORAGE REQUIRED	1109m³
AREA AT TWL (100yr)	1549m²
RL (TWL) (100yr)	5.42m AHD
10yr STORAGE REQUIRED	437m³
AREA AT TWL (10yr)	761m²
RL (TWL) (10yr)	4.95m AHD
5yr STORAGE REQUIRED	399m³
AREA AT TWL (5yr)	744m²
RL (TWL) (5yr)	4.90m AHD
1yr STORAGE REQUIRED	250m³
AREA AT TWL (1yr)	676m²
RL (TWL) (1yr)	4.69m AHD
PEAK OUTFLOW (100yr)	28 l/s

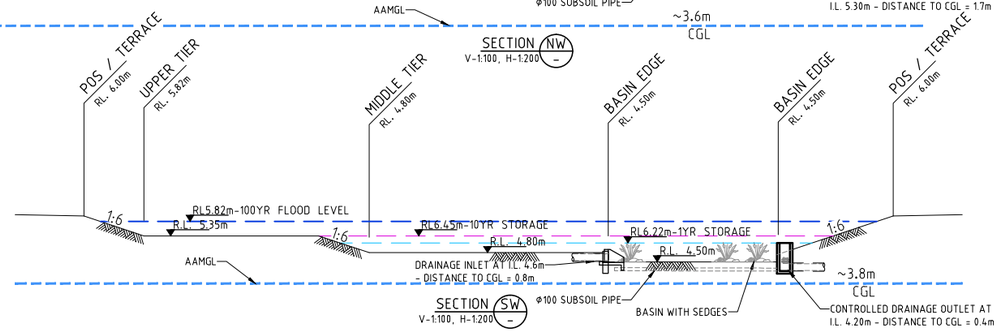
LEGEND

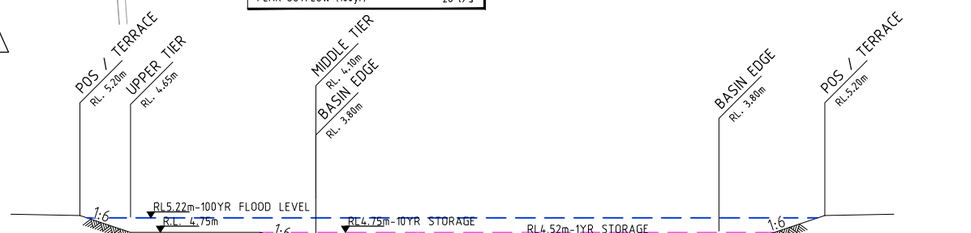
- CATCHMENT AREA
- 6.50 — FINISHED SURFACE CONTOURS
- 2.50 — GROUND WATER CONTOURS
- DRAINAGE BASIN
- FLOW ARROW
- MB01 — NAME; E 691.633m; N 491.285m; R.L.0.00m — SURFACE LEVEL; 2.5m — DEPTH; Ø150 — BORE DIAMETER — MONITORING BORE
- +5.10 — SUBSOIL DRAINAGE / INVERT
- LOTS CONNECTED TO DRAINAGE (LOTS < 300m²)

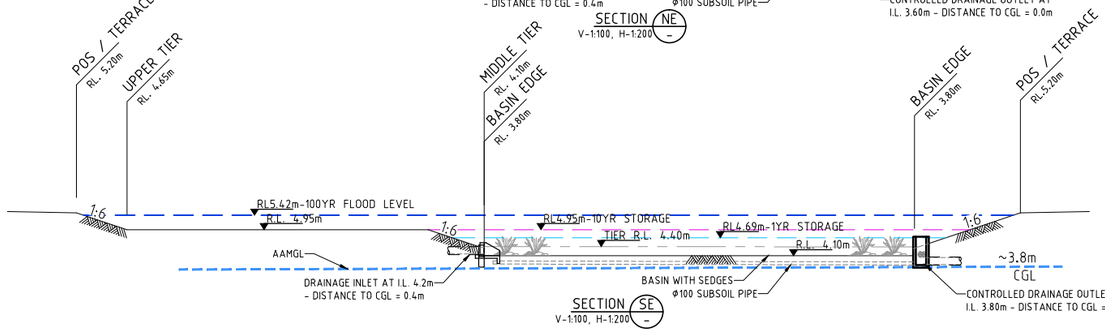
CATCHMENT AREA INFORMATION

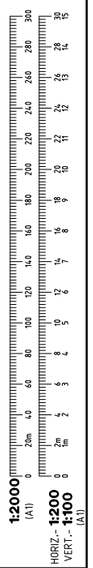
CATCHMENT	TOTAL AREA	LOT AREA - SOAKWELLS	LOT AREA - CONNECTED TO DRAINAGE	ROAD RESERVE AREA	POS AREA
NW	100669m²	42026m²	14766m²	29342m²	14535m²
NE	137564m²	65237m²	22921m²	33833m²	15524m²
SW	70550m²	28801m²	10119m²	24074m²	7556m²
SE	60974m²	39157m²	6710m²	11403m²	3704m²











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No.	DATE	BY	REVISION	
D	15/08/14	BWB	GROUND WATER CONTOURS & DRAINAGE ADDED, 'NE' & 'SE' BASIN LEVELS REVISED	SRA
C	07/08/14	BWB	LOT 545 SUBSOIL DRAINAGE, INVERTS AND LEVELS REVISED	SRA
B	01/08/14	BWB	CATCHMENT 'NE' AMENDED TO INCLUDE LOT 545. BASIN 'NE' AMENDED TO SUIT	SRA
A	29/07/14	BWB	INITIAL ISSUE	SRA

CLIENT: **MIRVAC LIMITED**

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

PROJECT: **LOTS 746-750 BALDIVIS ROAD BALDIVIS**
W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT CATCHMENT PLAN POST-DEVELOPMENT (OPTION 2)**
CAD DRAWING DO NOT MANUALLY ALTER

SCALE	DRAWN	CHECK	REV No.
1:2000	BWB	SRA	D
DATE: JULY 2014	DESIGNED: BWB	APPROVED: SRA	

PROJECT NUMBER: **BDVMIR01** DRAWING NUMBER: **L04A**

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APPENDIX 6

Drainage Calculations

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Mirvac Development "Pike land"
Baldivis

Location: Catchment SW

DEVELOPMENT ENGINEERING CONSULTANTS

Data to be Input

Rainfall ARI (Years)		100	
1 in 1 Year Impervious Catchment(Ha)		2.19	
Required Storage(1 in 1Yr 1 Hr)(m^3)		337	
2% of Connected Impervious Area (m^2)		438	
Available Storage(m^3)		1980	
Soakage Outflow(l/s/m^2)		0.0001	
Allowable Outflow (l/s) (1 year)	1.10	l/s/ha	7.76
Allowable Outflow (l/s) (5 year)	2.10	l/s/ha	14.79
Allowable Outflow (l/s) (10 year)	3.00	l/s/ha	21.17
Allowable Outflow (l/s) (100 year	4.50	l/s/ha	31.75 **(Per Water Corporation requirements for Peel Main Drain)**

Catchment Details	Roads	Lots (Connected)	Lots (Unconnected)	POS*	Basin Area	Total		
Gross Catchment Area	**2.41**	**1.0119**	**2.8801**	**0.5056**	**0.25**	**7.06**		
Run-Off Co-efficient(C_{10})	0.70	0.45	0.17	0	1.00			
ARI Multiplier	1.00	1.22	1.00	1.41	1.00			
Run-Off Co-efficient(Cy)	0.70	0.55	0.17	0.00	1.00			
Impervious Area(Ha)	**1.69**	**0.56**	**0.49**	**0.00**	**0.25**	**2.98**	**0.42**	**Effective C**

Data From A,R & R Volume 2

Location		**Perth WA**
Map 1	$^2I_1$	20.6
Map 2	$^2I_{12}$	4.5
Map 3	$^2I_{72}$	1.3
Map 4	$^{50}I_1$	35.5
Map 5	$^{50}I_{12}$	7
Map 6	$^{50}I_{72}$	2.1
Map 7	G	0.68
Map 8	F2	4.82
Map 9	F50	17

Road Catchment Area:

RR Width(m)	**Length(m)**	**Area (Total)**
20	0	-
18	0	-
40	0	-
16	0	-
15	0	-
14	0	-
12.5	0	-
6	0	-
		24,074

Tc(mins)	**Tc(hrs)**	**I(mm/hr)**	**Q(l/s)**	**Total V in**	**Preliminary Height(m)**	**Q out (Soakage)(l/s)**	**V out (Soakage)**	**Net Storage (After Soakage)**	**Time of Water in Basin(hrs)**	**V out (Req'd)**	**Q out(l/s)**
20	0.33	98.74	817	981	0.50	0.21	0.254604	981	35.1	0	0
30	0.50	75.22	623	1121	0.50	0.21	0.381906	1120	40.1	0	0
45	0.75	56.30	466	1258	0.50	0.21	0.572859	1258	45.0	0	0
60	1.00	45.44	376	1354	0.50	0.21	0.763812	1353	48.5	0	0
120	2.00	31.59	262	1883	0.50	0.21	1.527624	1881	67.4	0	0
240	4.00	19.11	158	2279	0.50	0.21	3.055248	2276	70.9	296	21

Project: Mirvac Development "Pike land" Baldivis

Location: Catchment SW

DEVELOPMENT ENGINEERING CONSULTANTS

480	8.00	11.56	96	2757	0.50	0.21	6.110496	2751	70.9	771	27
960	16.00	8.08	67	3852	0.50	0.21	12.220992	3840	70.9	1860	32
2880	48.00	3.65	30	5217	0.50	0.21	36.662976	5180	70.9	3200	19
4320	72.00	2.62	22	5631	0.50	0.21	54.994464	5576	70.9	3596	14

Lower Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
0	40	11

RL(Base) 4.5

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Treatment Storage above LWL	Detention Storage above LWL	The Designated Height allows Storage for
4.5	0	440	546	1760	0	0	0	Static Water Level
4.8	0.3	440	546	1760	132	132	132	Top of Lower Level

TOTAL STORAGE TO TOP OF LOWER TIER **132** m^3

Middle Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	40.0	27.0

RL(Base) 4.8

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
5.12	0.32	1352	1505	4849	388	520	1 Year Storage
5.34	0.54	1556	1720	5230	708	840	5 Year Storage
5.35	0.55	1566	1730	5248	724	856	10 Year Storage
5.35	0.55	1566	1730	5248	724	856	Top of Storage

TOTAL STORAGE TO TOP OF MIDDLE TIER **856** m^3

Upper Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	43.3	49.0

RL(Base) 5.35

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
5.82	0.47	2674	2885	9560	1125	1980	100 Year Storage

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Mirvac Development "Pike land"
Baldivis

Location: Catchment SE

DEVELOPMENT ENGINEERING CONSULTANTS

Data to be Input

Rainfall ARI (Years)			100
1 in 1 Year Impervious Catchment(Ha)			1.09
Required Storage(1 in 1Yr 1 Hr)(m^3)			168
2% of Connected Impervious Area (m^2)			218
Available Storage(m^3)			1110
Soakage Outflow(l/s/m^2)			0.0001
Allowable Outflow (l/s) (1 year)	1.10	l/s/ha	6.71
Allowable Outflow (l/s) (5 year)	2.10	l/s/ha	12.78
Allowable Outflow (l/s) (10 year)	3.00	l/s/ha	18.29
Allowable Outflow (l/s) (100 year	4.50	l/s/ha	27.44

(Per Water Corporation requirements for Peel Main Drain)

Catchment Details	Roads	Lots (Connected)	Lots (Unconnected)	POS*	Basin Area	Total		
Gross Catchment Area	**1.10**	**0.6813**	**3.9451**	**0.2222**	**0.15**	**6.10**		
Run-Off Co-efficient(C_{10})	0.70	0.45	0.17	0	1.00			
ARI Multiplier	1.00	1.22	1.00	1.41	1.00			
Run-Off Co-efficient(Cy)	0.70	0.55	0.17	0.00	1.00			
Impervious Area(Ha)	**0.77**	**0.37**	**0.67**	**0.00**	**0.15**	**1.96**	**0.32**	**Effective C**

Data From A,R & R Volume 2

Location		Perth WA
Map 1	$^2I_1$	20.6
Map 2	$^2I_{12}$	4.5
Map 3	$^2I_{72}$	1.3
Map 4	$^{50}I_1$	35.5
Map 5	$^{50}I_{12}$	7
Map 6	$^{50}I_{72}$	2.1
Map 7	G	0.68
Map 8	F2	4.82
Map 9	F50	17

Road Catchment Area:

RR Width(m)	Length(m)	Area (Total)
20	0	-
18	0	-
40	0	-
16	0	-
15	0	-
14	0	-
12.5	0	-
6	0	-
		10,988

Tc(mins)	Tc(hrs)	I(mm/hr)	Q(l/s)	Total V in	Preliminary Height(m)	Q out (Soakage)(l/s)	V out (Soakage)	Net Storage (After Soakage)	Time of Water in Basin(hrs)	V out (Req'd)	Q out(l/s)
20	0.33	98.74	539	646	0.50	0.13	0.157644	646	26.8	0	0
30	0.50	75.22	410	739	0.50	0.13	0.236466	738	30.6	0	0
45	0.75	56.30	307	829	0.50	0.13	0.354699	829	34.3	0	0
60	1.00	45.44	248	892	0.50	0.13	0.472932	892	37.0	0	0
120	2.00	31.59	172	1241	0.50	0.13	0.945864	1240	46.0	130	18
240	4.00	19.11	104	1502	0.50	0.13	1.891728	1500	46.0	390	27

Project: Mirvac Development "Pike land" Baldivis

Location: Catchment SE

DEVELOPMENT ENGINEERING CONSULTANTS

480	8.00	11.56	63	1816	0.50	0.13	3.783456	1813	46.0	703	24
960	16.00	8.08	44	2538	0.50	0.13	7.566912	2531	46.0	1421	25
2880	48.00	3.65	20	3437	0.50	0.13	22.700736	3415	46.0	2305	13
4320	72.00	2.62	14	3711	0.50	0.13	34.051104	3677	46.0	2567	10

Lower Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
0	28	8

RL(Base) 3.8

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Treatment Storage above LWL	Detention Storage above LWL	The Designated Height allows Storage for
3.8	0	224	300	896	0	0	0	Static Water Level
4.1	0.3	224	300	896	67	67	67	Top of Lower Level

TOTAL STORAGE TO TOP OF LOWER TIER **67** m^3

Middle Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
3	28.0	21.0

RL(Base) 4.1

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
4.39	0.29	676	785	2526	183	250	1 Year Storage
4.6	0.5	744	858	2655	332	399	5 Year Storage
4.65	0.55	761	876	2686	370	437	10 Year Storage
4.65	0.55	761	876	2686	370	437	Top of Storage

TOTAL STORAGE TO TOP OF MIDDLE TIER **437** m^3

Upper Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
3	58.0	22.7

RL(Base) 4.65

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
5.12	0.47	1549	1726	5718	672	1109	100 Year Storage

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Mirvac Development "Pike land"
Baldivis

Location: Catchment NW

DEVELOPMENT ENGINEERING CONSULTANTS

Data to be Input

Rainfall ARI (Years)		100	
1 in 1 Year Impervious Catchment(Ha)		2.68	
Required Storage(1 in 1Yr 1 Hr)(m^3)		413	
2% of Connected Impervious Area (m^2)		536	
Available Storage(m^3)		2350	
Soakage Outflow(l/s/m^2)		0.0001	
Allowable Outflow (l/s) (1 year)	1.10	l/s/ha	11.07
Allowable Outflow (l/s) (5 year)	2.10	l/s/ha	21.10
Allowable Outflow (l/s) (10 year)	3.00	l/s/ha	30.20
Allowable Outflow (l/s) (100 year	4.50	l/s/ha	45.30

(Per Water Corporation requirements for Peel Main Drain)

Catchment Details	Roads	Lots (Connected)	Lots (Unconnected)	POS*	Basin Area	Total		
Gross Catchment Area	**2.93**	**1.4766**	**4.2026**	**1.2035**	**0.25**	**10.07**		
Run-Off Co-efficient(C_{10})	0.70	0.45	0.17	0	1.00			
ARI Multiplier	1.00	1.22	1.00	1.41	1.00			
Run-Off Co-efficient(Cy)	0.70	0.55	0.17	0.00	1.00			
Impervious Area(Ha)	**2.05**	**0.81**	**0.71**	**0.00**	**0.25**	**3.83**	**0.38**	**Effective C**

Data From A,R & R Volume 2

Location		Perth WA
Map 1	$^2I_1$	20.6
Map 2	$^2I_{12}$	4.5
Map 3	$^2I_{72}$	1.3
Map 4	$^{50}I_1$	35.5
Map 5	$^{50}I_{12}$	7
Map 6	$^{50}I_{72}$	2.1
Map 7	G	0.68
Map 8	F2	4.82
Map 9	F50	17

Road Catchment Area:

RR Width(m)	Length(m)	Area (Total)
20	0	-
18	0	-
40	0	-
16	0	-
15	0	-
14	0	-
12.5	0	-
6	0	-
		29,342

Tc(mins)	Tc(hrs)	I(mm/hr)	Q(l/s)	Total V in	Preliminary Height(m)	Q out (Soakage)(l/s)	V out (Soakage)	Net Storage (After Soakage)	Time of Water in Basin(hrs)	V out (Req'd)	Q out(l/s)
20	0.33	98.74	1050	1260	0.50	0.25	0.30558	1260	31.6	0	0
30	0.50	75.22	800	1440	0.50	0.25	0.45837	1440	36.1	0	0
45	0.75	56.30	599	1617	0.50	0.25	0.687555	1616	40.6	0	0
60	1.00	45.44	483	1740	0.50	0.25	0.91674	1739	43.6	0	0
120	2.00	31.59	336	2419	0.50	0.25	1.83348	2417	58.9	67	9
240	4.00	19.11	203	2928	0.50	0.25	3.66696	2924	58.9	574	40

Project: Mirvac Development "Pike land"
Baldivis

Location: Catchment NW

DEVELOPMENT ENGINEERING CONSULTANTS

480	8.00	11.56	123	3542	0.50	0.25	7.33392	3534	58.9	1184	41
960	16.00	8.08	86	4949	0.50	0.25	14.66784	4934	58.9	2584	45
2880	48.00	3.65	39	6702	0.50	0.25	44.00352	6658	58.9	4308	25
4320	72.00	2.62	28	7235	0.50	0.25	66.00528	7169	58.9	4819	19

Lower Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
0	43	12.5

RL(Base) 5.6

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Treatment Storage above LWL	Detention Storage above LWL	The Designated Height allows Storage for
5.6	0	538	653	2150	0	0	0	Static Water Level
5.9	0.3	538	653	2150	161	161	161	Top of Lower Level

TOTAL STORAGE TO TOP OF LOWER TIER **161** m^3

Middle Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	43.0	30.5

RL(Base) 5.9

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
6.22	0.32	1608	1775	5825	466	628	1 Year Storage
6.44	0.54	1830	2007	6241	844	1006	5 Year Storage
6.45	0.55	1840	2018	6260	863	1024	10 Year Storage
6.45	0.55	1840	2018	6260	863	1024	Top of Storage

TOTAL STORAGE TO TOP OF MIDDLE TIER **1024** m^3

Upper Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	46.3	55.0

RL(Base) 6.45

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
6.92	0.47	3150	3379	11360	1336	2360	100 Year Storage

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Mirvac Development "Pike land"
Baldivis

Location: Catchment NE

DEVELOPMENT ENGINEERING CONSULTANTS

Data to be Input

Rainfall ARI (Years)		1	
1 in 1 Year Impervious Catchment(Ha)		3.10	
Required Storage(1 in 1Yr 1 Hr)(m^3)		477	
2% of Connected Impervious Area (m^2)		620	
Available Storage(m^3)		1620	
Soakage Outflow(l/s/m^2)		0.0001	
Allowable Outflow (l/s) (1 year)	1.10	l/s/ha	7.07
Allowable Outflow (l/s) (5 year)	2.10	l/s/ha	13.47
Allowable Outflow (l/s) (10 year)	3.00	l/s/ha	19.27
Allowable Outflow (l/s) (100 year	4.50	l/s/ha	28.91

(Per Water Corporation requirements for Peel Main Drain)

Catchment Details	Roads	Lots (Connected)	Lots (Unconnected)	POS*	Basin Area	Total		
Gross Catchment Area	**1.55**	**1.0627**	**3.0246**	**0.6387**	**0.15**	**6.42**		
Run-Off Co-efficient(C_{10})	0.70	0.45	0.00	0	1.00			
ARI Multiplier	1.00	0.56	1.00	0.62	1.00			
Run-Off Co-efficient(Cy)	0.70	0.25	0.00	0.00	1.00			
Impervious Area(Ha)	**1.08**	**0.27**	**0.00**	**0.00**	**0.15**	**1.50**	**0.23**	**Effective C**

Data From A,R & R Volume 2

Location		**Perth WA**
Map 1	$^2I_1$	20.6
Map 2	$^2I_{12}$	4.5
Map 3	$^2I_{72}$	1.3
Map 4	$^{50}I_1$	35.5
Map 5	$^{50}I_{12}$	7
Map 6	$^{50}I_{72}$	2.1
Map 7	G	0.68
Map 8	F2	4.82
Map 9	F50	17

Road Catchment Area:

RR Width(m)	**Length(m)**	**Area (Total)**
20	0	-
18	0	-
40	0	-
16	0	-
15	0	-
14	0	-
12.5	0	-
6	0	-
		15,486

Tc(mins)	**Tc(hrs)**	**I(mm/hr)**	**Q(l/s)**	**Total V in**	**Preliminary Height(m)**	**Q out (Soakage)(l/s)**	**V out (Soakage)**	**Net Storage (After Soakage)**	**Time of Water in Basin(hrs)**	**V out (Req'd)**	**Q out(l/s)**
20	0.33	29.76	124	149	0.50	0.04	0.044676	149	5.9	0	0
30	0.50	23.61	98	177	0.50	0.04	0.067014	177	7.0	0	0
45	0.75	18.45	77	208	0.50	0.04	0.100521	208	8.2	0	0
60	1.00	15.38	64	231	0.50	0.04	0.134028	231	9.1	0	0
120	2.00	10.76	45	323	0.50	0.04	0.268056	323	12.7	0	0
240	4.00	6.92	29	416	0.50	0.04	0.536112	415	16.3	0	0

Project: Mirvac Development "Pike land" Baldivis

Location: Catchment NE

DEVELOPMENT ENGINEERING CONSULTANTS

480	8.00	4.45	19	535	0.50	0.04	1.072224	534	21.0	0	0
960	16.00	2.79	12	670	0.50	0.04	2.144448	668	26.4	0	0
2880	48.00	1.34	6	964	0.50	0.04	6.433344	957	37.9	0	0
4320	72.00	0.99	4	1066	0.50	0.04	9.650016	1056	41.9	0	0

Lower Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
0	26	14.3

RL(Base) 3.8

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Treatment Storage above LWL	Detention Storage above LWL	The Designated Height allows Storage for
3.8	0	372	456	1487	0	0	0	Static Water Level
4.1	0.3	372	456	1487	112	112	112	Top of Lower Level

TOTAL STORAGE TO TOP OF LOWER TIER **112** m^3

Middle Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	45.0	19.0

RL(Base) 4.1

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
4.39	0.29	1090	1236	3878	281	393	1 Year Storage
4.6	0.5	1275	1431	4224	530	641	5 Year Storage
4.65	0.55	1321	1479	4308	594	706	10 Year Storage
4.65	0.55	1321	1479	4308	594	706	Top of Storage

TOTAL STORAGE TO TOP OF MIDDLE TIER **706** m^3

Upper Tier Drainage Basin Dimensions:

Side Slopes 1:	Length(m)	Breadth(m)
6	48.3	35.0

RL(Base) 4.65

TWL(mAHD)	Height(m)	A(TWL)	Equiv Fenced Site Area	Average Area	Vol(m^3)	Total Detention Storage	The Designated Height allows Storage for
5.12	0.47	2192	2385	7733	910	1616	100 Year Storage

APPENDIX 7

Water Corporation Correspondence

RECEIVED
- 5 OCT 2007
PARSONS BRINCKERHOFF

WATER CORPORATION

JT1 2007 07244 Vol1
Russell Nelson
Ph: 9420 3361

18 September 2007

629 Newcastle Street
Leederville 6007
Western Australia
PO Box 100
Leederville 6902
Perth Western Australia
Tel (+61 8) 9420 2420
www.watercorporation.com.au
ABN 28 003 434 917

Parson Brinckerhoff Pty Ltd
PO Box 1232
SUBIACO WA 6904

Dear Sir,

East Baldivis District Water Management Strategy

Thank you for your report dated the July 2007, regarding the above matter and apologise for the delayed response.

The Corporation has assessed the report and provides the following comments

Drainage Matters
The Corporation Peel sub F and sub H drains are only designed to serve rural areas. With he proposed rezoning of this land the Corporation requires that the City of Rockingham agrees to take over and maintain these rural drains to Urban drainage standards. The Corporation will only control the final connection of these drains into the Peel main drain.

The Corporation completed the Peel MD capacity review in 2002 and has results for the 2 and 10 year storm events. Due to the high tailwater predicted by the Serpentine River flood Study which completely submerges the Peel Main Drain, the Corporation was unable to run the 100year storm events as part of this review. The developer should liaise with the Corporation over the results of the Capacity review.

The modelled discharges into the Peel MD in the report are considered to be high. Maximum discharge into the Peel MD should be 3 l/s/gross ha and 4.5 l/s/gross ha for the 10 year and 100 year storm events respectively. This is the same as the drainage criteria set for the Forrestdale MD catchment. In addition the corporation modelling predicts a peak flow of approx 500l/s into the Peel MD during the critical 10 year 48 hour storm event.

It is suggested that the minimum fill levels should be 1.5m above the AAMGL to allow the local authority drainage system to function adequately.

Flowpaths through the development should be identified in the event that soakage basins to the west of Baldivis Rd fail to cope.

Section 4.4 Funding and ongoing Maintenance

Table 4.4.1
The Corporation is only responsible for the potable water and wastewater services. The non potable services are NOT part of the Corporations responsibilities in this area.

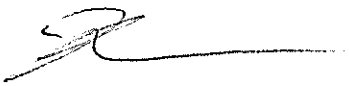
The Corporation is generally supportive of initiatives that consider non drinking water as a means to assist in meeting drinking water reductions and should the developer wish the Corporation to consider becoming a service provider for non potable supplies a detailed proposal must first be forward for the Corporation to assess. Details regarding these types of proposals need to be firmed up and resolved as early in the planning process as possible. Of interest in this proposal is the impact on Corporation's other services in the area, the degree of water efficiency that this scheme delivers (the targets we are currently working toward are 40-60 kL/person/year for scheme water and total water usage – ie scheme plus non drinking water - to deliver the State Water Plan target of 100kL/person/year), we are also interested in the cost effectiveness of the scheme and standard of the proposed assets.

The Corporation is currently in the process of developing tools to assist the development industry to navigate their way through the decision making surrounding non drinking water schemes

General comments
It should be noted that the Corporation is not supportive of rezoning of this area from Rural to Urban on the MRS until such time as the East Rockingham Wastewater Treatment Plant is progressed to a suitable point to ensure that services can be provided to meet development.

The Corporation welcomes the opportunity to discuss any aspect of this advice and should you require any further assistance, please contact Russell Nelson on (08) 9420 3361.

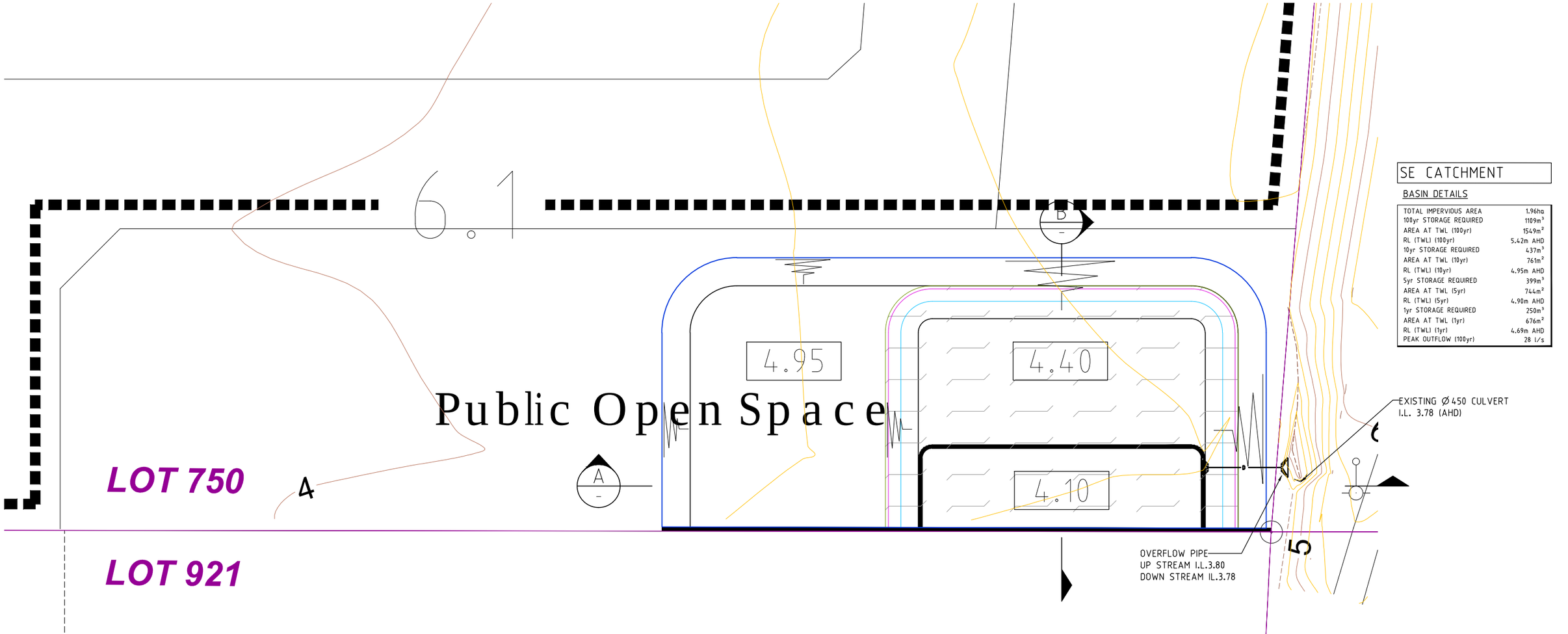
Yours sincerely,



Russell Nelson
Senior Infrastructure Advisor
Development Services

APPENDIX 8

SE Basin Detail

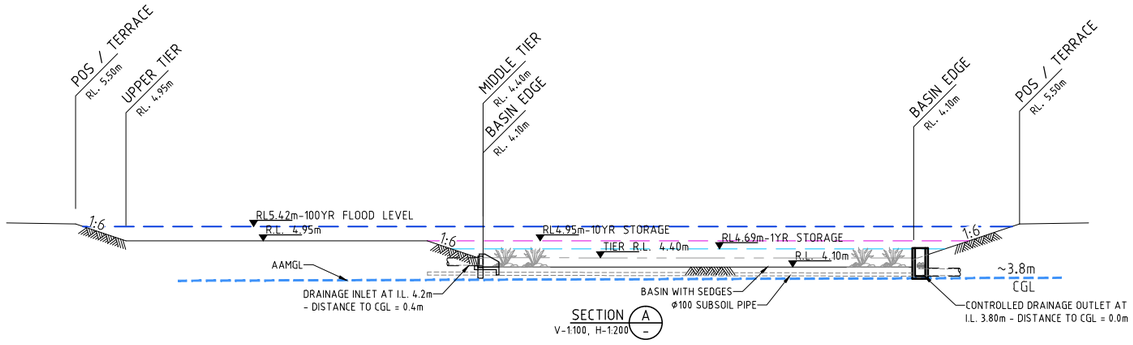


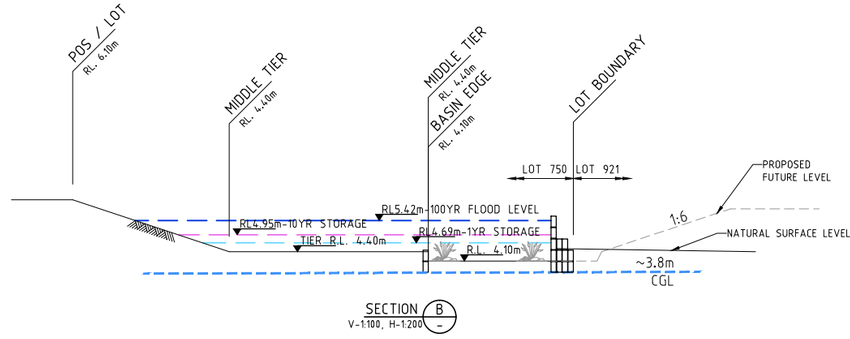
SE CATCHMENT

BASIN DETAILS

TOTAL IMPERVIOUS AREA	1.96ha
100yr STORAGE REQUIRED	1109m³
AREA AT TWL (100yr)	1549m²
RL (TWL) (100yr)	5.42m AHD
10yr STORAGE REQUIRED	437m³
AREA AT TWL (10yr)	761m²
RL (TWL) (10yr)	4.95m AHD
5yr STORAGE REQUIRED	399m³
AREA AT TWL (5yr)	744m²
RL (TWL) (5yr)	4.90m AHD
1yr STORAGE REQUIRED	250m³
AREA AT TWL (1yr)	676m²
RL (TWL) (1yr)	4.69m AHD
PEAK OUTFLOW (100yr)	28 l/s

BASIN LAYOUT PLAN
SCALE 1:200





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No.	DATE	BY	REVISION	
B	22/08/14	BWB	LEVEL NOTATION REVISED IN SECTION A & B	SRA
A	22/08/14	BWB	INITIAL ISSUE	SRA

CLIENT: **MIRVAC LIMITED**

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

PROJECT: **LOTS 746-750 BALDIVIS ROAD BALDIVIS**

W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT DRAINAGE BASIN PLAN & DETAILS "SE CATCHMENT"**

CAD DRAWING DO NOT MANUALLY ALTER

SCALE	DRAWN	CHECK	REV No.
AS SHOWN	BWB	SRA	B
DATE	DESIGNED	APPROVED	
AUG 2014	BWB	SRA	

PROJECT NUMBER **BDVMIR01** DRAWING NUMBER **L09**

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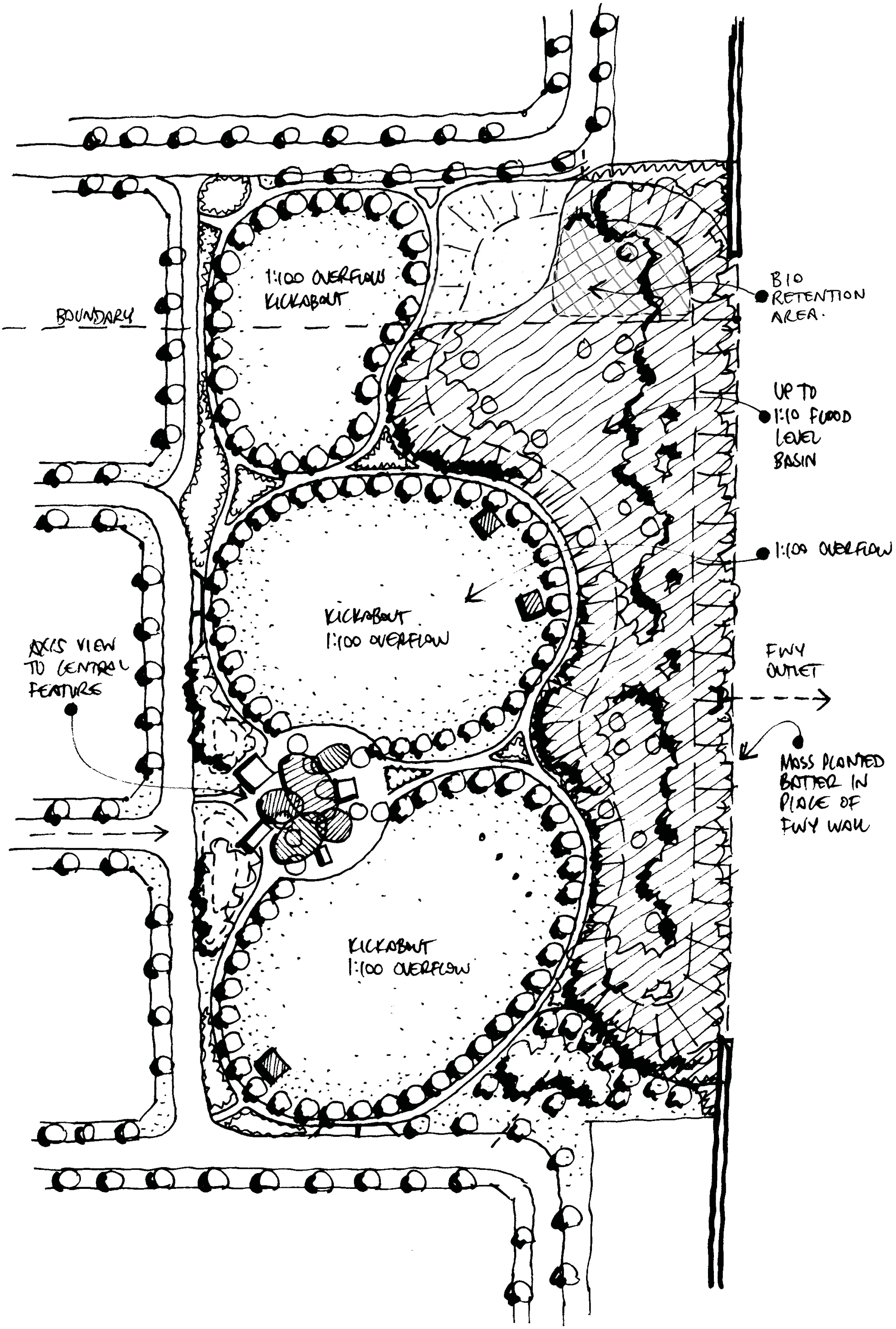
APPENDIX 9

Lots 921 and 750 Indicative Combined POS and Drainage



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date • 01/10/2014
rev • B
scale • nts

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BALDIVIS POS DRAINAGE OPTION

INDICATIVE LANDSCAPE CONCEPT

emerge ASSOCIATES
Integrated Science & Design

APPENDIX 5:

Earthworks and Servicing Strategy

- Development Engineering Consultants

DEVELOPMENT
ENGINEERING
CONSULTANTS

Our Ref: Servicing Report July 2014 Rev0
16 July 2014

LOT 746 - 750 & 545 BALDIVIS ROAD, BALDIVIS

ENGINEERING SERVICES REPORT - REF BDVMIR01

1 General

This report has been prepared to demonstrate the availability of service infrastructure to support the Local Structure Plan on the above land as outlined in the CLE plan.

It is proposed to develop the land into some 530 urban lots and associated POS, with an entry access from Baldivis Road.

The investigations in this report have involved consultation with the various service authorities and Council and a desk top study of the available information over the site to establish the opportunities and constraints to development of the area.

2 Executive Summary

The land the subject of this report is located immediately east of Baldivis Road, west of the Kwinana Freeway and located centrally opposite Pemberton Boulevard. It occupies an area of 36 98 hectares.

The basic land form is in the main low level Guildford Formation soils, with a narrow strip of Bassendean Sands along the Baldivis Rd frontage.

The land is almost completely cleared and used as grazing land. It has an old open drain running south to north located approximately along the centre of the site in a slightly zig - zag configuration, which discharges into an open channel on the abutting property to the north and thence into the MRWA Kwinana Freeway reserve and culvert system to The Peel Main Drain on the east side of the Freeway.

The site accommodates a residence and associated garage on lot 545 and vacant land on the remainder. It varies in elevation from approximately RL 8 metres AHD along Baldivis Rd down to RL 4m AHD at a distance of 150 metres into the site, which level continues to the eastern boundary.

Because the development will be influenced by the 1 in 100 year flood level of the adjacent Peel Main Drain, the final level of the development is set at 500mm above this level at RL 6.1m AHD, thus necessitating over two metres of sand fill in places to attain this level.

The land can be connected to all services, either by extension from neighbouring subdivision developments west and north of the site, or by extension along Baldivis Road. In the case of sewer connection, the northern half of the site can be connected by gravity into an existing scheme, but the southern half is to be connected to a future permanent Water Corporation Waste Water Pumping Station (WWPS) which will be located in the proposed neighbouring development by others. Access to the East Rockingham Waste Water treatment Plant (ERWWTP) has been approved by the Water Corporation.

Some upgrading and construction of Baldivis Road will be required, with the access to the site being located centrally along the frontage of the site from Baldivis Road.

The site will be filled to provide both drainage and class “A” building foundation classification. Because some two thirds of the site is underlain by silty clay soils, ground remediation work is required prior to filling. The filling for the 1 in 100 year flood far exceeds the WAPC required clearance of 1.2m above the AAMGL, which is at approximately RL 3.5m AHD across the site.

3 Site

The site covering an area of 36.98 hectares is located on the east side of Baldivis Road and Tramway Reserve, across to the western boundary of the Kwinana Freeway, and is south of the new development of Australand on its northern boundary and north of the proposed Perron development on its southern boundary. Pemberton Boulevard is located opposite the middle of the Baldivis Road frontage of the site. The site has been completely cleared and used for grazing for some years. It is generally low lying and has the potential to be inundated by the 1 in 100 year flood of the Peel Main Drain, which is located immediately east of the Freeway. It is traversed by a man made agricultural open drain flowing south to north, exiting at the existing Water Corporation drain flowing east into the Freeway reserve and the culvert under the Freeway.

Baldivis Road has been recently been upgraded to current urban standard as part of the new urban development on the west side of the road.

The Environmental Geology map of the Geological Survey of Western Australia classifies this site as "S8" Bassendean Sands on the western edge along Baldivis Road, and S10 "Guildford Formation" across the balance of the site, both being deemed "suitable for urbanisation. However, Geotechnical site investigations have revealed the existence of deep silty clay across the eastern two thirds of the land, being an old flood plain, needing remedial works as detailed in the following earthworks section of this report.

The site has an AAMGL generally varying from RL 4.4m at Baldivis Rd down to RL 3.6 through the centre of the site, and rising to RL 3.8m AHD along the Freeway boundary. The minimum required clearance to this level will be greatly exceeded by the requirements to provide freeboard of 500mm to the 1 in 100 year flood level of the Peel Main Drain. This level is set at RL 6.1m AHD.

4 Development Proposal

It is proposed to develop the land as a residential subdivision of around 530 urban residential lots, with all normal services being;- wastewater, water, power, roads, gas and telecommunications service.

Access to the site will initially and primarily be from Baldivis Road and in the future from other developments north and south of the site, providing permeability.

The existing residence, sheds, septic tanks etc on lot 545 will be demolished as part of the development. The remainder of the site is vacant land.

All drainage is proposed to be detained on site for the 1 in 100 year design storm, with outflow limited to pre-development flows. All drainage will be designed to incorporate best management practices. There will be four drainage basins to accept site stormwater flows, all located within POS areas. Outflow from the basins is to the Peel Main Drain via the Kwinana Freeway reserve drainage.

The urban development area will entail substantial earthworks to provide level building blocks, with lots having retaining walls as required to allow this.

The site filling will enable lots to be sewered from the existing WWPS located north of the site and a proposed WWPS south of the site.

5 Earthworks & Retaining Walls

The site requires filling to at least 6.1m AHD to meet the requirements of the 1 in 100 year flood level of the Peel Main Drain. Some fill will be placed in excess of this level in order to achieve drainage and sewer construction. Thus the site will be generally flat, with small differences caused by road design plus sewer and drainage design.

Because of the nature of underlying soils across some two thirds of the site, which are unsuitable for development without some remedial works prior to filling operations, it is proposed to utilize a method

of deep dynamic compaction to stabilize these soils, rather than excavating and carting the unsuitable soils off site to a tip, with associated dewatering, ASS remediation and replacement with expensive imported fill, and then importing and placing extra fill to attain the RL 6.1m finished ground level. The developer is desirous of attaining "A" site foundation classification for the finished lots, and the above deep dynamic compaction method is the only available method which will provide this. Minimal disturbance of the soil and ASS remediation is required for this method. We are advised that such methods are also being used for adjacent site developments.

Each lot will be finished level, with installation of low retaining walls to suit, except where lots back onto POS, where it is likely retaining walls may be up to 1.5m in height. Retaining walls will be constructed using reconstituted limestone blocks.

All fill will be imported to the site, via Baldivis Road from approved sand pits. It will be free draining to meet the geotechnical specifications and site drainage and building requirements. There is an embargo on site earthworks during the spring and summer, from October to March inclusive, due to easterly and south westerly winds causing dust and sand blows. The site will be fenced with appropriate wind fencing along all boundaries to minimize this, and watering down of stockpiles, stripped areas and filling operations. A Dust Management Plan will be provided by the Contractor at each stage of development, such to be approved by the City of Rockingham prior to starting site works.

Where roads or lots join between land holdings with separate ownership, levels on the roads and lot boundaries will be either matched to existing level or co-ordinated to ensure that a staged development approach can be accommodated. Walls may be required along boundaries if agreement cannot be reached with the adjoining owner. This may require retaining walls on a temporary basis within the road reserve.

6 Roads

All roads will be constructed to City of Rockingham standards and design approvals.

Baldivis Road along the frontage of the site has recently been upgraded to Boulevard standard. The development plan shows a central local connector road traversing the site from north to south, thus connecting with similar roads planned for developments north and south of the site.

The entry road to the site will connect with the new roundabout on Baldivis Road at the intersection with Pemberton Boulevard. This road traverses the Tramway reserve, where clearing will be minimized to allow road construction as approved by the City of Rockingham.

7 Drainage

A LWMS has been carried out over the site by RPS Consultants. The site falls within the Mundijong Drainage District and has a restricted outflow to the Peel Main Drain.

Generally stormwater runoff from roads will be collected by pits and conveyed by pipes to designated basins, which will attenuate volumes to pre-development levels for discharge into the outfall channels along the Kwinana Freeway reserve.

Subsoil drains will be used extensively to control any rise in groundwater, but will not be placed any lower than the agreed AAMGL for the site. All drainage pipes will be bedded on crushed rock to help with the control of groundwater.

Currently the site is drained by a man made agricultural open drain which falls south to north, exiting the site at the Water Corporation undeclared main drain in lot 545 immediately north of the site. This Main Drain discharges to the Kwinana Freeway reserve and ultimately via culverts under the Freeway, to the Peel Main Drain.

For this development, the site has been divided into four drainage catchments, three of which accept the majority of site stormwater drainage, exiting the site via a controlled overflow in the north east corner

via an overflow, where the existing outfall drain within lot 545 will be formalized by means of a box culvert drain and a portion of "living Steam" at the freeway end to match the existing outfall level to the Freeway reserve..

The southern catchment basin, which is the minor catchment of the site, will discharge allowed discharge via an overflow directly to the Freeway reserve.

Each basin has a restricted outflow, as per the allowance for the Mundijong Drainage District requirement, to the Kwinana Freeway reserve.

Catchments have been established based on topography, fill and minimum road grades to ensure optimization of basin areas and minimization of impact on POS.

Generally the low points in each basin have been designated as infiltration swales to cater for stormwater flow from 2% of the connected impervious area to act as a biological treatment zone. The base of such is set at a minimum of 300mm above the control Groundwater level (CGL).

Areas of basins greater than the above requirement are a minimum of 500mm above the CGL to allow active recreational use of the areas.

All basins will have the maximum depth of water of 1.32m for the 1 in 100 year ARI storm.

The LWMS has determined the AAMGL for the site, at which level subsoil drains will be placed so that no lowering of the water table below the AAMGL will occur with the development, but any rise in groundwater will be controlled.

8 Power

Sufficient power supply exists in the area to supply the development. A high voltage line is located along Baldivis Road, from which supply will be drawn.

All internal power reticulation lines and transformer installations will be constructed at the cost of the developer. Transformer and switch station sites will be determined at the detailed subdivision design stage to Western Power approval.

9 Water Supply

At present there is a 300mm water main past the site in Baldivis Road. Some augmentation to this supply will be required via a connection from Eighty Rd and Fifty Rd. This augmentation is expected to be made either by the Water Corporation or prefunded by other developers, and is not a pre-requisite to the development of the site.

Internal reticulation mains will be designed to Water Corporation approval to complete links through the site to developments north and south of the site.

10 Sewer

The site falls into two sewer catchments, each discharging to a Waste Water Pump Station (WWPS) as determined by Water Corporation sewer planning.

The northern half of the site falls within the catchment of the existing Baldivis North (WWPS') "I" located adjacent to Baldivis Road north of the adjacent Australand Development. Sewers to the site will be constructed by Australand to their southern boundary, from where Mirvac will extend the sewer into their site.

According to current Water Corporation sewer planning, the southern half of the site falls within the catchment of the proposed WWPS "C", which is now to be located and constructed within the Perron land development immediately south of the site by Perron. Sewers from the Perron development will be

extended to the site by their development. This WWPS will discharge into a 225mm sewer extended through the Australand and the Mirvac (this development) land.

It is expected that the first stages of the development will be within the existing WWPS catchment, thus allowing some time for the proposed WWPS to be constructed.

Fill required by the 1 in 100 year flood of the Peel Main drain is generally sufficient to allow each WWPS to serve the development.

The Water Corporation has now achieved approval for the linking sewer mains to the East Rockingham Waste Water Treatment Plant (ERWWTP), and as a result they are agreeing to new developments in this area.

11 Telephone

The new urban development will be served by the NBN or another provider for broadband and telephony. Capacity exists off Baldivis Road and the adjacent development which may require minor extensions to facilitate connection.

12 Gas

Gas services are located in Baldivis Road and the adjacent development and have sufficient capacity to serve the area with minimal augmentation.

DEVELOPMENT ENGINEERING CONSULTANTS PTY LTD

THIS REPORT IS DATED 21 AUGUST 2014.

APPENDIX 6:

Landscape Master Plan - Emerge Associates

OCTOBER 2014

LOT 746-545 BALDIVIS ROAD MIRVAC

Local Structure Plan Rev C

emerge ASSOCIATES

Integrated Science & Design

FIGURE 1 - LANDSCAPE STRATEGY

PUBLIC OPEN SPACE SUMMARY

FEATURE PARK
- Large expansive turf area for active recreation
- Centrally located and easily accessible to the entire community
- Large gathering spaces to cater for community events
- Large play space and fitness nodes catering for all ages
- Pedestrian/Cycle Path network links into adjacent development.

NEIGHBOURHOOD INFORMAL
- Balance of native planted pockets and open turf areas
- Large gathering nodes with BBQ/picnic facilities
- Nature play and fitness nodes
- Pedestrian/Cycle path network links into adjacent developments
- Informal active recreation space

LOCAL INFORMAL
- Predominantly native planted areas with pockets of turf
- Small gathering nodes and basic picnic/BBQ facilities
- Path network which links into adjacent developments & POS
- Primary focus on passive recreation

TRAMWAY TYPOLOGY
- Retain and protect all existing native vegetation
- Pocket planting of revegetation species
- Informal path network links to development & greater Tramway path system.

MAINTENANCE

All Public Open Space within 746-545 are to be maintained as managed Parklands. Imagery of maintained parkland is as shown and referenced on pages POS C&D. Refer to Bushfire Hazard Assessment for further detail.

NORTH 0 50 100 METRES

LEGEND

- EXTENT OF WORK
- GREENLINKS/WIDENED VERGE/DUP
- BRIDAL PATH
- DRAINAGE STORAGE AREAS
- PLAY ELEMENTS SHELTER
- POTENTIAL ARTWORK /SIGNAGE
- PUBLIC OPEN SPACE (A)

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 2 - LANDSCAPE MASTER PLAN

PLAYFUL

COMFORTABLE

CONSIDERED

CONNECTED

LEGEND

1. ENTRY AREA
2. WIDENED LANDSCAPE VERGE
3. PROPOSED GATHERING SPACE
4. OPEN KICKABOUT SPACE
5. DRAINAGE SWALES
6. PRIMARY SCHOOL OVAL
7. DESIGN TO ADJACENT POS

NORTH

0 50 100 METRES

LOT 746-545 BALDIVIS ROAD, MIRVAC

LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 3 - STREET TREE MASTER PLAN

Agonis flexuosa -
WA Peppermint

Eucalyptus leucoxylon 'Rosea' -
Pink Flowering gum

Corymbia ficifolia -
Red Flowering Gum

Tipuana tipu -
Rosewood

Melaleuca quinquernervia -
Broad Leaved Paperbark

Note:

Street trees located in Public Open Space areas with Building Protection Zone considerations are to apply to the relevant tree canopy separation requirements

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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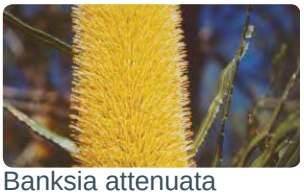
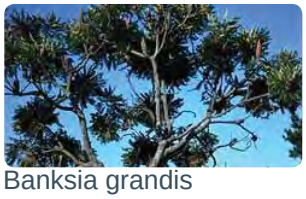
FIGURE 4 - POS TREE PLANTING PALETTE

Agonis flexuosa


Banksia attenuata

Casuarina obesa

Corymbia ficifolia


Banksia grandis

Banksia menziesii

Eucalyptus gomphocephala

Eucalyptus rudis

Melaleuca quinquernervia

Melaleuca lanceolata

Melaleuca preissiana

Xanthorrrhoea preissii

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 5 - POS A CONCEPT

POS TYPOLOGY
- Feature Park (A)

SIZE (excluding verges)
- 1.36 Hectares

CONCEPT
- Provide a large active turf space for the broader community
- Large accessible play space with interest for all ages
- Provide safe pedestrian and cycle linkages
- Exercise circuit linking the functions within the POS
- Provide shaded picnic facilities & bbqs
- Community focal area with space for small events/ markets

FUNCTIONS
- Turf - Larger turf areas for informal recreation
- Native waterwise planting with areas of dry gardens
- Maximise shade trees
- Picnic Facilities for family/friend & community gatherings
- Play elements for all age groups
- 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

DRAINAGE CONSIDERATIONS
- 1:1 628 m3 storage required
- 1:5 1006 m3 storage required
- 1:10 1024 m3 storage required
- 1:100 2360 m3 storage required

Note: Figures to be finalised during detailed design.

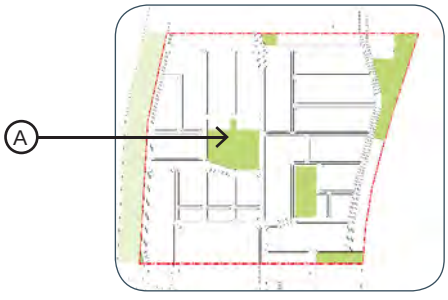

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FIGURE 6- POS B CONCEPT

POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .74 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - informal kick-about areas
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- 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 plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS
- 1:1 520 m3 storage required
- 1:5 840 m3 storage required
- 1:10 856 m3 storage required
- 1:100 1980 m3 storage required

Note: Figures to be finalised during detailed design.

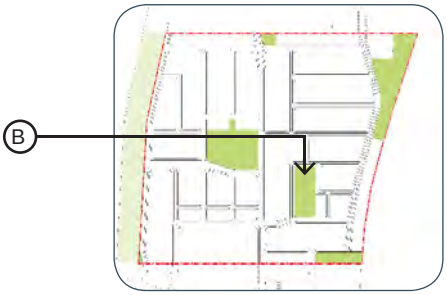

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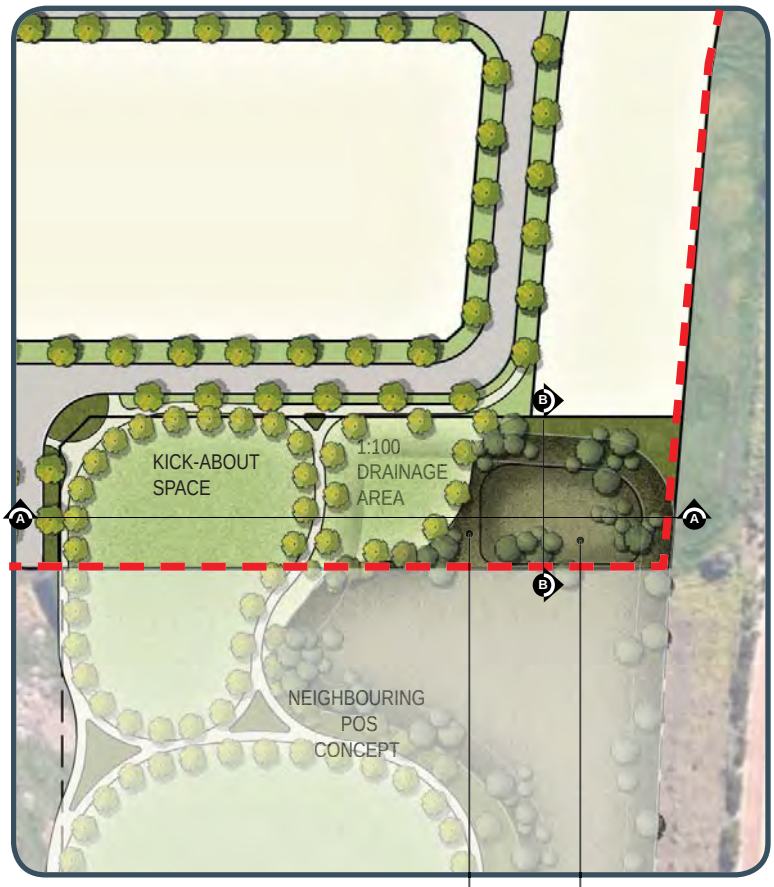
FIGURE 7 - POS C CONCEPT



NORTH

0 20 40 METRES

POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .37 Hectares (Mirvac land holding)
- 2.5 Hectares total area

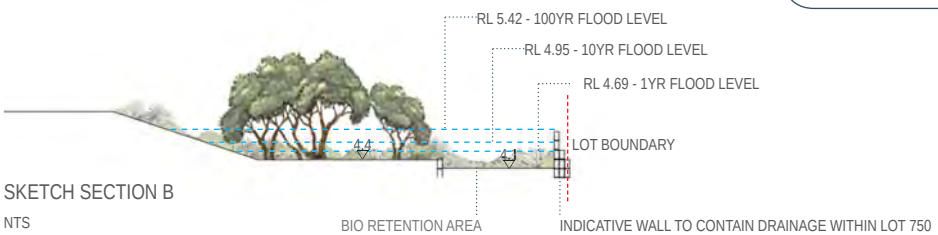
CONCEPT
- Provide a northern extension of a large neighbourhood park to cater for residents within a 150m-300m catchment
- Deliver a fully integrated design response ensuring that the broader area of open space is seamless in its transition between the two residential estates
- Provide large areas of useable kick-about space that is not compromised by drainage infrastructure
- Create a safe local park which is intended to be heavily planted with shade trees and provides low key picnic facilities, recreational facilities and nodes for exercise.
- Provide safe pedestrian and cycle linkages to broader path network linkages.

FUNCTIONS
- Connecting expanses of turf
- Native, water wise planting.
- Maximise shade trees with emphasis on native species
- Retain existing vegetation where possible
- Limited picnic facilities
- Internal path network
- Path network connecting into the broader path network

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

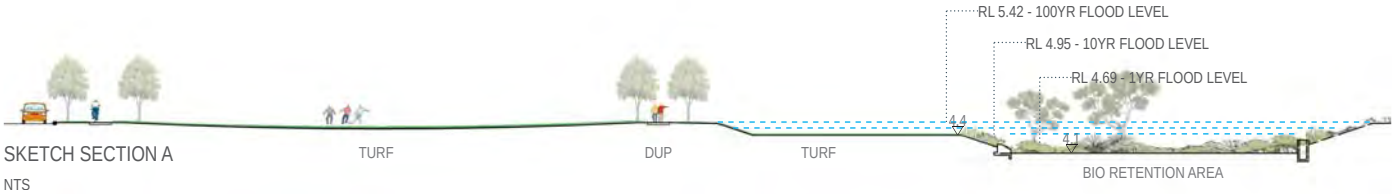
DRAINAGE CONSIDERATIONS
- 1:1 250 m3 storage required
- 1:5 399 m3 storage required
- 1:10 437 m3 storage required
- 1:100 1109 m3 storage required

Note: Figures to be finalised during detailed design.



SKETCH SECTION B

NTS



SKETCH SECTION A

NTS

LOT 746-545 BALDIVIS ROAD, MIRVAC

LOCAL STRUCTURE PLAN MI-01 REV C

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FIGURE 8 - POS D CONCEPT

POS TYPOLOGY
- Local Informal

SIZE (excluding verges)
- 1.44 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - informal kick-about areas
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- 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
- Planting within Building Protection Zone to be considered. Refer to the FESA planting guidelines for possible species within the BPZ
- Dry garden with gravel mulch, clumping plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials

DRAINAGE CONSIDERATIONS
- 1:1 669 m3 storage required
- 1:5 1098 m3 storage required
- 1:10 1141 m3 storage required
- 1:100 2840 m3 storage required

Note: Figures to be finalised during detailed design.

LOT 746-545 BALDIVIS ROAD, MIRVAC
LOCAL STRUCTURE PLAN MI-01 REV C

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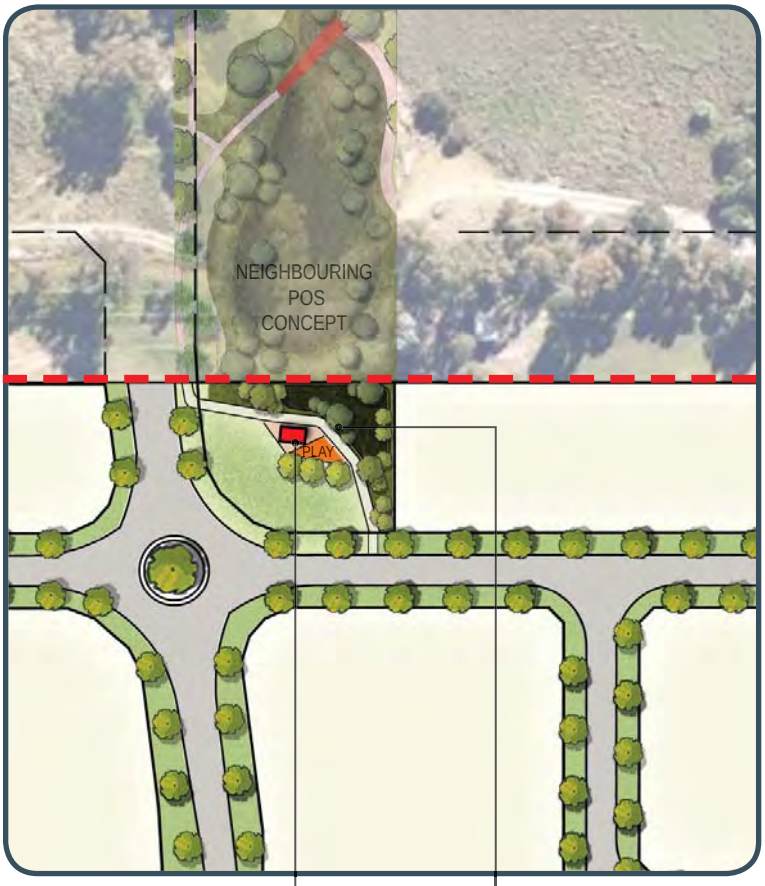
FIGURE 9 - POS E CONCEPT



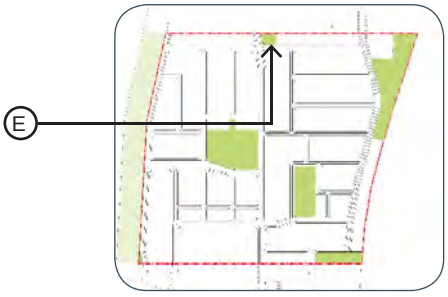
POS TYPOLOGY
- Neighbourhood Informal

SIZE (excluding verges)
- .10 Hectares

CONCEPT
- Provide a Neighbourhood Park to cater for residents within a 200-400m walkable catchment
- Provide a park with a balance of native planting and open turf areas for recreation.
- Provide connection through the site via a cycle/pedestrian pathway which also links to the broader POS network.

FUNCTIONS
- Turf - for passive surveillance
- Native waterwise vegetation
- Maximise shade trees
- Picnic facilities for family/friend gatherings
- Play elements for all ages
- Path network connecting into broader path network

ENVIRONMENTAL CONSIDERATIONS
- Waterwise native planting
- Planting design to be zoned according to irrigation requirement, with full irrigation requirements to the informal turf playing area
- Planting within Building Protection Zone to be considered. Refer to the FESA planting guidelines for possible species within the BPZ
- Dry garden with gravel mulch, clumping plans and limited irrigation
- Source local materials where possible
- Consider the long term maintenance requirements for all materials



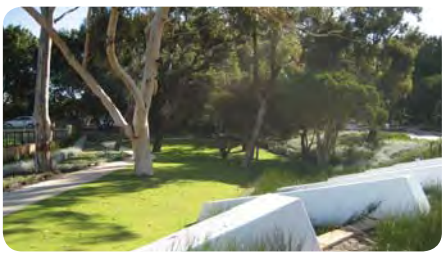


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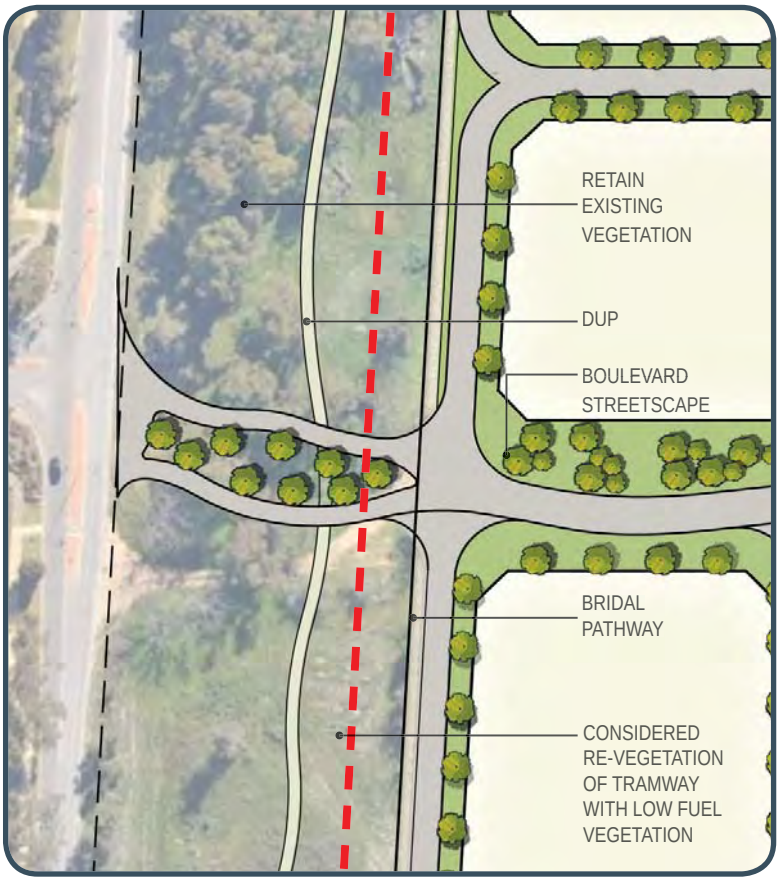
FIGURE 10 - TRAMWAY TYPOLOGY PLAN



NORTH

0 20 40 METRES

CONCEPT

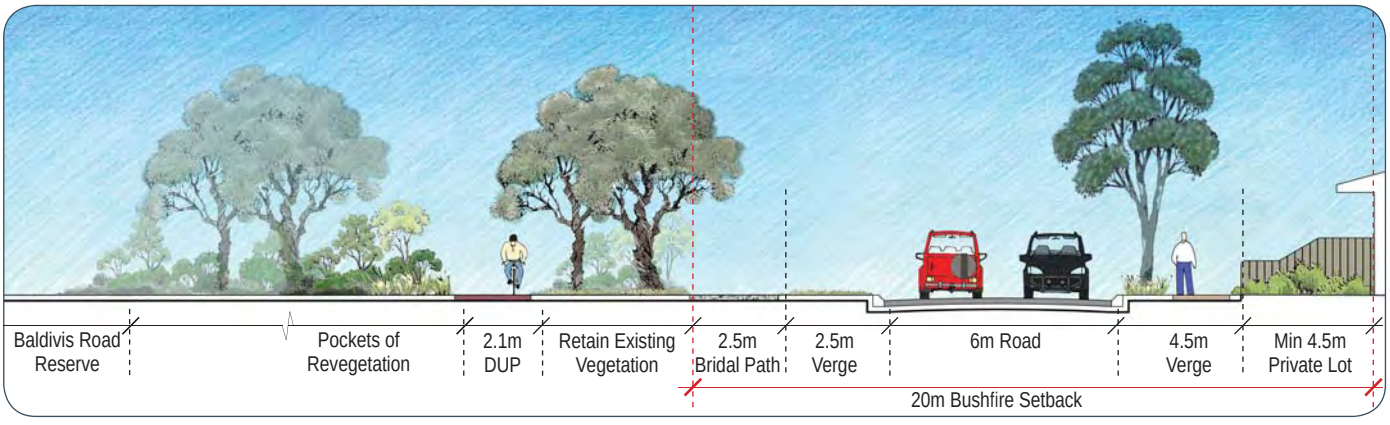
- Maintain and protect all existing vegetation within tramway reserve
- Meandering dual use path runs the length of the tramway and links to greater tramway path networks.
- Limestone Bridal trail runs adjacent to boundary
- Planting pockets of native re-vegetation

FUNCTIONS

- Native re-vegetation planting
- Crushed limestone bridal path
- Dual use path
- Entry Statement at Baldivis Road
- Provide linkages to pedestrian networks within and outside of the development area

ENVIRONMENTAL CONSIDERATIONS

- No irrigation
- Re-vegetation of native plant communities to strategic nodes. Locations to be determined in detailed design
- Removal of weed species



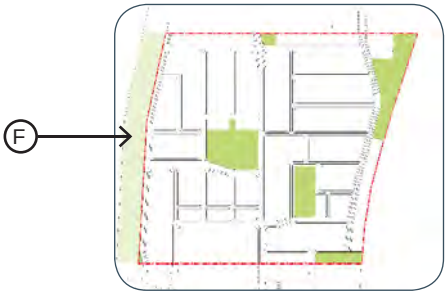


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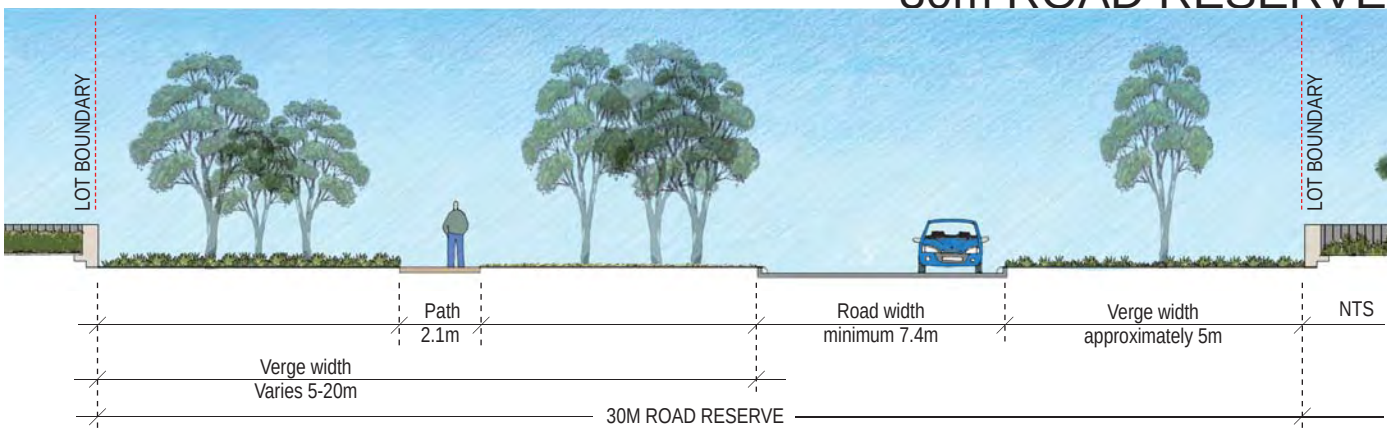
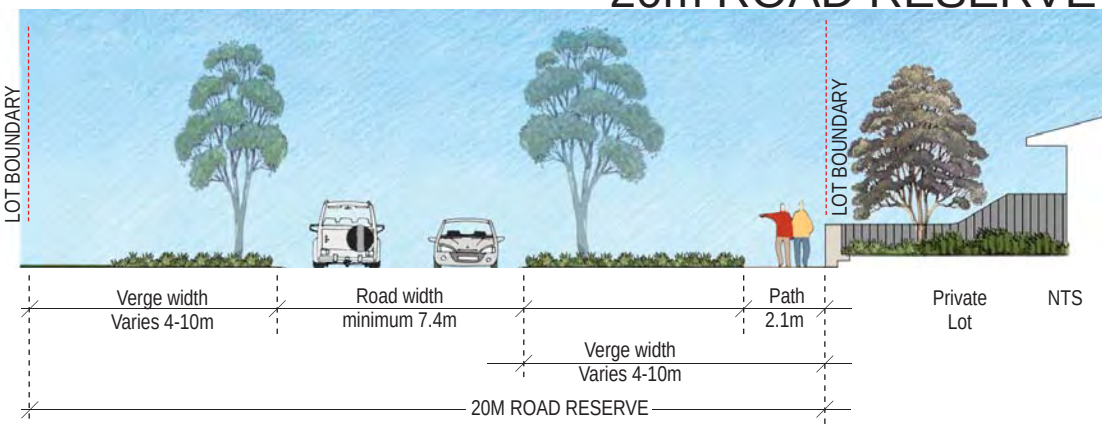
FIGURE 11 - ROAD TYPOLOGY SECTIONS

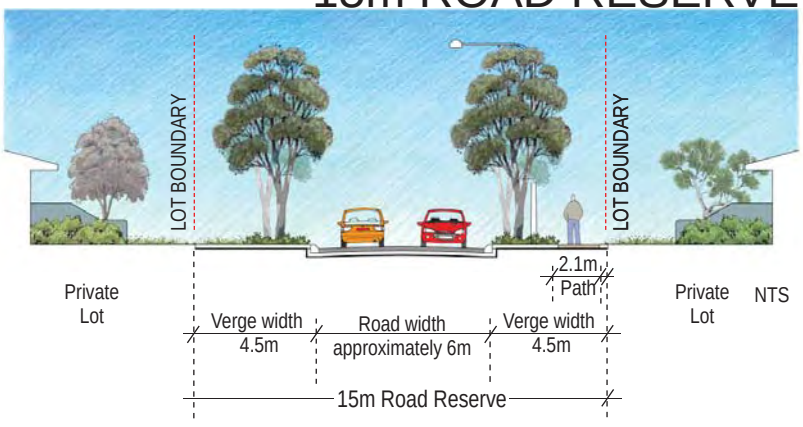
30m ROAD RESERVE

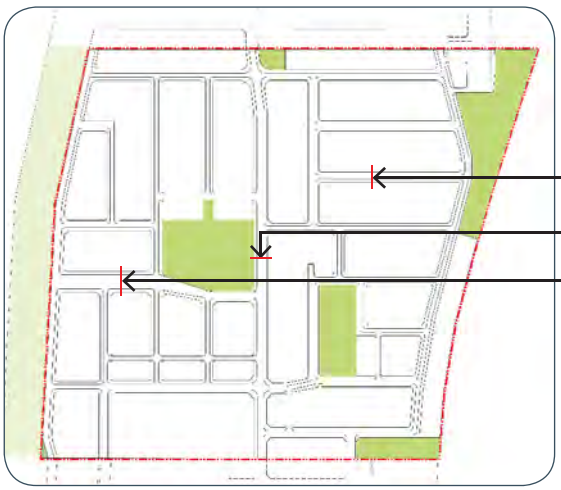


20m ROAD RESERVE



15m ROAD RESERVE





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APPENDIX 7:

Transport Assessment - Transcore

Lots 545 & 746-750 Baldivis Rd, East Baldivis Local Structure Plan

Transport Assessment

PREPARED FOR:
Mirvac (WA) Pty Ltd

August 2014

Document history and status

Author	Revision	Approved by	Date	Revision type
R White	r01		18/07/2014	Draft
R White	r01a	B Bordbar	20/08/2014	Final

File name: t13250rw-r01a.docx

Author: Robin White

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Client: Mirvac (WA) Pty Ltd

Project: Lots 746-750 Baldivis Road, East Baldivis LSP

Document revision: r01a

Project number: t13.250

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1.0 Introduction

This Transport Assessment has been prepared by Transcore on behalf of Mirvac (WA) Pty Ltd. The subject of this report is the proposed Local Structure Plan (LSP) for Lots 545 & 746-750 Baldivis Rd, East Baldivis, in the City of Rockingham.

The LSP area is located east of Baldivis Road and west of Kwinana Freeway, as shown in Figure 1 in relation to the various zones and reservations of the Metropolitan Region Scheme (MRS).

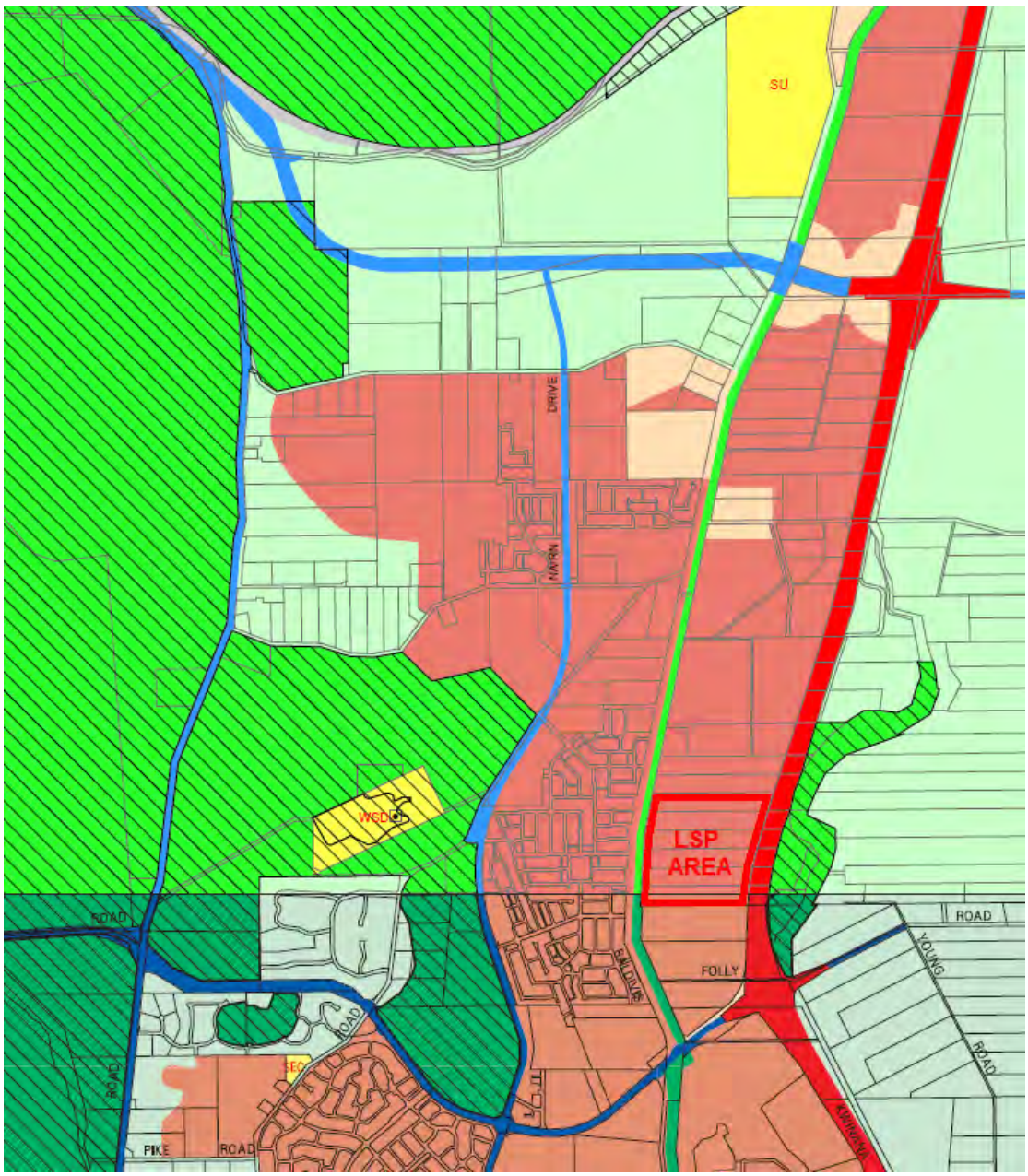

Figure 1: Site location

2.0 Proposed Local Structure Plan

The proposed Local Structure Plan (LSP) for Lots 545 & 746-750 Baldivis Rd, East Baldivis is shown in Figure 2.

Figure 2: Proposed Local Structure Plan

The LSP area is anticipated to yield approximately 530 residential lots.

The LSP area includes the northern portion of a proposed primary school site that overlaps the southern boundary of the LSP area.

3.0 Existing Situation

3.1 Existing Land Use

Existing land uses in the LSP area are rural with only a few dwellings on the site, as shown in Figure 3.

Figure 3: Existing land use

Adjacent land uses to the north and south are also rural with very few dwellings, although residential subdivision development has now commenced within the adjoining LSP area immediately to the north of the subject site.

On the west side of Baldivis Road there are new residential areas that have been developed in recent years with new residential development currently progressing northward from this area.

On the eastern side of Baldivis Road (abutting the LSP area) is a former tramway reserve that is now reserved for parks and recreation in the MRS, as can be seen on Figure 1.

The Kwinana Freeway forms the eastern boundary of the LSP area, as can also be seen on Figure 1.

3.2 Existing Road Network

Baldivis Road is constructed as a single carriageway, two-lane, rural road providing north south access through Baldivis for connections to the Kwinana Freeway at Mundijong Road, Safety Bay Road and Karnup Road. Baldivis Road has a 70km/h speed limit between Safety Bay Road and the LSP area. A speed limit of 80km/h applies about 500m north of Eighty Road (north of the LSP area).

In some places Baldivis Road has been upgraded to include a 2m to 3m-wide painted median with raised traffic islands. This includes the section adjacent to the northern part of the LSP area (from approximately 150m north of Pemberton Bvd to 200m north of Amazon Drive) which has 12m-wide seal width between kerbs and marked as two 1.5m cycle lanes, two 3.5m traffic lanes and a 2m painted median with raised traffic islands. Adjacent to the southern part of the LSP area it is constructed as a 7.4m-wide two-lane urban road.

Main Roads WA recorded weekday traffic flows of 6,510 vehicles per day (vpd) on Baldivis Road north of Safety Bay Road in October 2012 and 7,333 vpd south of Mundijong Road in May 2013. The October 2012 count indicated that heavy vehicles make up 6.9% of this existing traffic flow on Baldivis Road.

There is one existing intersection on Baldivis Road adjacent to the LSP area. The Baldivis Road / Pemberton Bvd intersection is a priority-controlled (i.e. give way) T-junction with central traffic islands on all three approaches. The Baldivis Road / Amazon Drive roundabout is located approximately 480m north of Pemberton Bvd and the Tamworth Bvd roundabout is located approximately 330m south of Pemberton Bvd.

Pemberton Boulevard provides a link from Baldivis Road to Nairn Drive via Kingaroy Drive, with a roundabout at the Nairn Dr / Kingaroy Dr intersection. The western section is a 7m-wide two-lane urban street but the eastern section is approximately 13m wide with a 4m median.

Kwinana Freeway is classified as a Primary Distributor and is reserved as a Primary Regional Road in the MRS. It is currently constructed as dual 2-lane carriageways in this area and has a posted speed limit of 100km/h. The closest freeway interchanges are at Safety Bay Road, 500m south of the LSP area and at Mundijong Road, 2.8km north of the LSP area. The most recent available Main Roads WA traffic count on the freeway in this area was approximately 51,200 vpd (average weekday traffic, south of Mundijong Road) in August 2011, with 9.9% being heavy vehicles.

3.3 Public Transport

The closest existing bus route to the LSP area is Bus Route No. 568 from Warnbro Train Station, which currently terminates at Nairn Drive / Kingaroy Drive, as shown in Figure 4. The closest bus stops are on Tamworth Boulevard or Pemberton Boulevard about 800m south or southwest of the LSP area

Bus route 568 provides an hourly service Monday to Friday between 5.30am and 9pm (with more frequent service in the peak direction in AM and PM peak periods) and hourly on Saturday and Sunday from 8 or 9am to 7pm, approximately.

A deviation of route 568 links to the Stockland Baldivis Shopping Centre on Safety Bay Road, with this deviation operating from approximately 8am to 4pm on weekdays, 9am to 5pm on Saturdays and 11am to 5pm on Sundays.

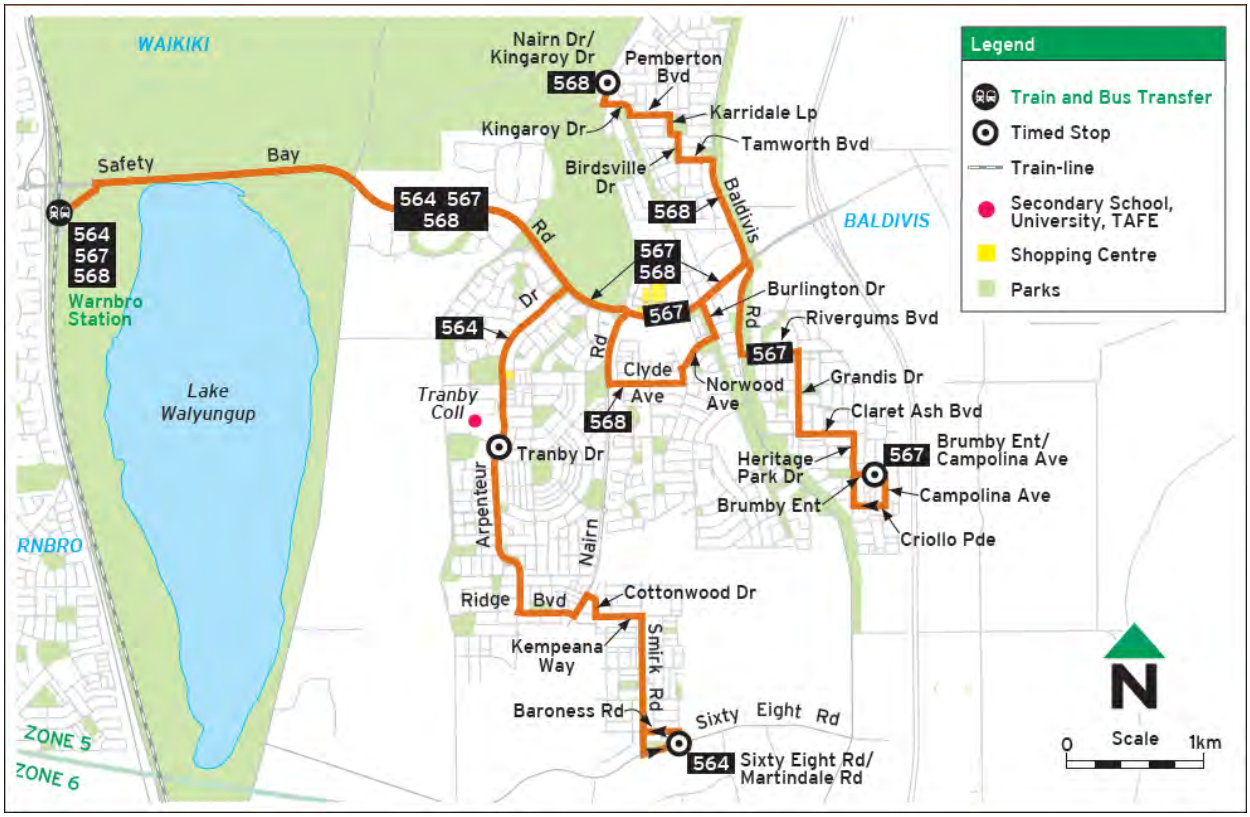

Figure 4: Existing bus routes

3.4 Pedestrian and Cyclist Facilities

The entirely rural northern section of Baldivis Road (north of the LSP area) has no existing footpaths or cycle facilities but there is a shared path on the west side of Baldivis Road from approximately 200m north of Amazon Drive, which extends as far south as Tamworth Boulevard then connects to the path network on other residential streets parallel to Baldivis Road.

The two-lane boulevard section of Baldivis Road adjacent to the northern part of the LSP area includes 1.5m on-road cycle lanes from approximately 150m north of Pemberton Bvd to 200m north of Amazon Drive.

The Department of Transport's Perth Bike Map series (see Figure 5) shows that Baldivis Road is considered a good road riding environment. It also shows the Principal Shared Path on the western side of the Kwinana Freeway, which runs along the eastern boundary of the LSP area.

Figure 5: Bike map

3.5 Changes to Surrounding Road Network

Long-term road network planning for this part of the Metropolitan Region includes the future extension of Nairn Drive as the main north south district distributor road through Baldivis and Karnup. The alignment of this planned Other Regional Road (also referred to as a blue road) in the Metropolitan Region Scheme (MRS) is shown in Figure 1. The first 2-lane carriageway of Nairn Drive is currently constructed up to Amazon Drive, linking into Eighty Road.

3.6 Public Transport Network Planning

The *City of Rockingham Baldivis Road Needs Study Update Traffic and Infrastructure Report* (draft, January 2012) includes a Transperth service development plan prepared by the Public Transport Authority (see Figure 6 below). This includes a proposed future bus route along the proposed north south Neighbourhood Connector road link in the East Baldivis area east of Baldivis Road.

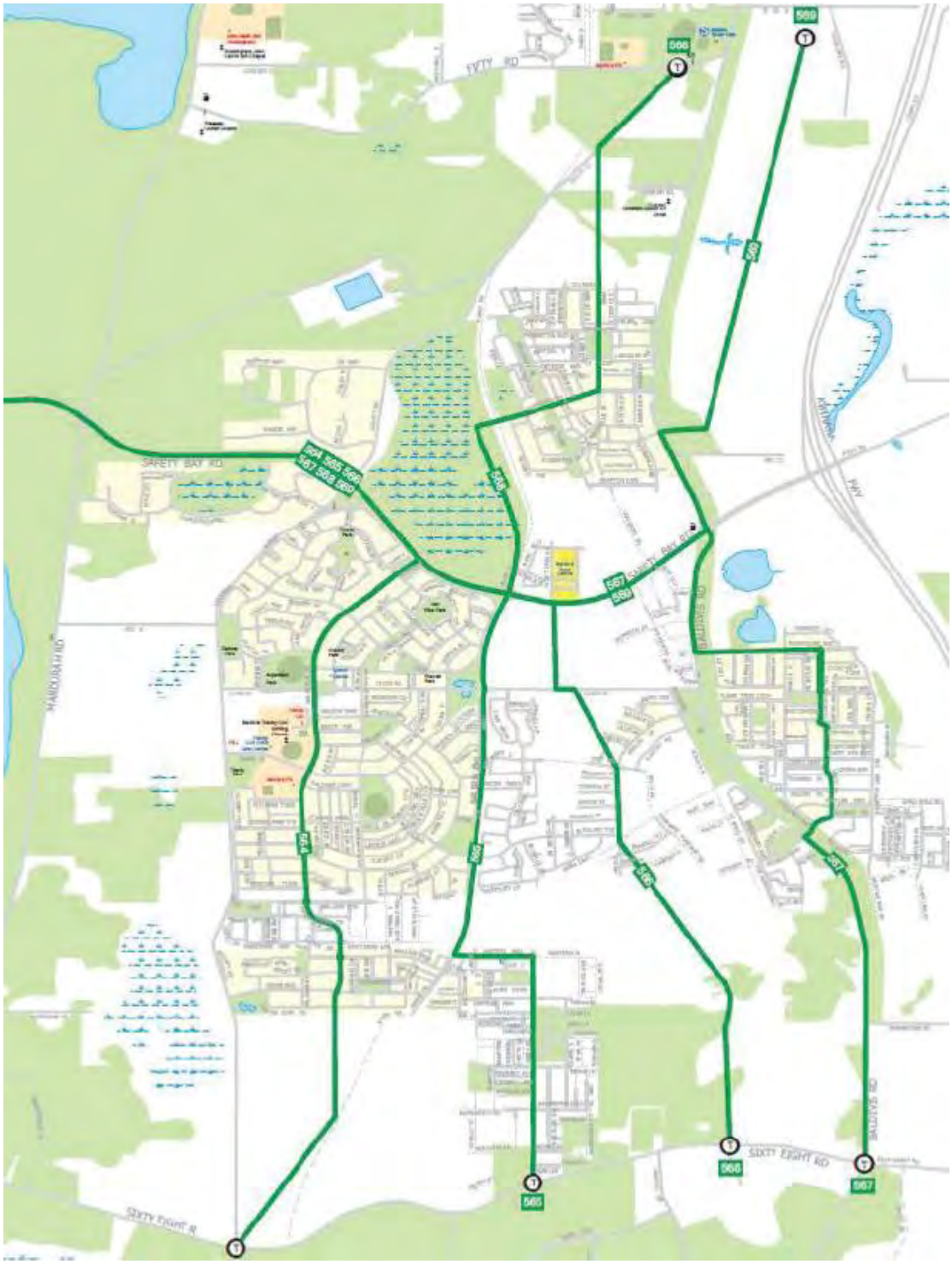

Figure 6: Transperth Service Development Plan Map

4.0 Proposed Transport Network

4.1 Road Hierarchy

The hierarchy of roads in and around the LSP area is illustrated in Figure 7 using the road hierarchy defined in Liveable Neighbourhoods (2007).

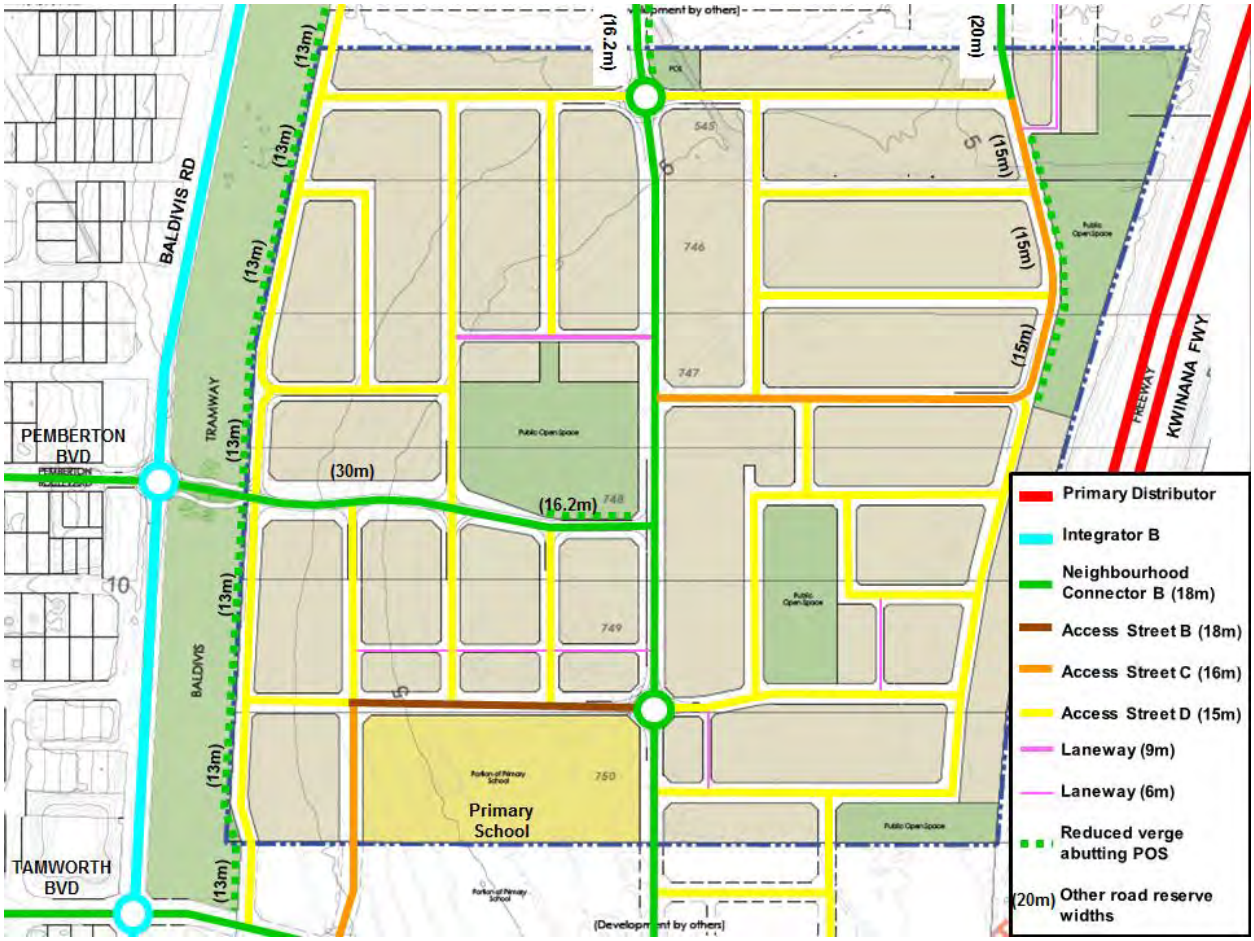

Figure 7: Road Hierarchy

Some key characteristics of the relevant road classifications have been summarised in Table 1 below. These are generally based on Liveable Neighbourhoods guidelines although the proposed widths do vary slightly from the standard Liveable Neighbourhoods cross-section diagrams.

Table 1: Road Hierarchy

Road Classification	Indicative upper volume (vpd)	Indicative road reserve width (m)	Indicative road pavement width (m)
Integrator B	15,000	29.2m	2 x 5m (incl. cycle lanes), 6m median & embayed parking
Neighbourhood Connector A	7,000	24.4m (23m min)	2 x 5m (incl. cycle lanes), 2m median & embayed parking
Neighbourhood Connector B	3,000	19.2m (18m min)	7.4m (plus embayed parking)
Access Street B	3,000	17.9m	6m (plus embayed parking)
Access Street C	3,000	16m	7.2m
Access Street D	1,000	15m	6m
Laneway	300	6m	6m typical

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

Baldivis Road

Baldivis Road will be an Integrator B road in the Liveable Neighbourhoods road hierarchy. The existing upgraded section adjacent to the northern end of the LSP area demonstrates the road cross section that has been considered appropriate adjacent to previous subdivision areas. It involves two 5m carriageways and a 2m median.

Neighbourhood Connectors

The East Baldivis District Structure Plan (DSP) indicates east west Neighbourhood Connector roads connecting to Baldivis Road at Amazon Drive (north of the LSP area and at Tamworth Bvd (south of the LSP area. A new east west Neighbourhood Connector was subsequently added connecting at Pemberton Bvd to allow independent development of this LSP area as well. The DSP also indicates a north south Neighbourhood Connector road route through the site. The proposed LSP plan makes allowance for these main Neighbourhood Connector links.

The LSP for the area immediately to the north of the subject site actually provides an additional north south Neighbourhood Connector link that crosses the northern boundary of the subject site closer to the eastern edge. That is a logical place for a neighbourhood connector spine road in that northern site but not through Lots 545 & 746-750 as it is close to the eastern edge of this LSP area. Consequently, this eastern road is shown as tapering down to an ordinary Access Street C in the proposed LSP for Lots 545 & 746-750, as shown in Figure 7. The use of Access Street C for this connection maintains a 7.2m road carriageway width that will be blended seamlessly with the road carriageway width of the Neighbourhood Connector B to the north.

Traffic flows on both of the proposed Neighbourhood Connectors within the LSP area will be below 3000 vpd, so it is appropriate for them to be classified as Neighbourhood Connector B roads. The type B is proposed as an 18m wide road reserve as the minimum normally permitted in Liveable Neighbourhoods, with a standard 7.4m carriageway (two 3.7m traffic lanes) and a typical verge width of 5.3m including embayed parking where appropriate for adjacent development.

The main north south Neighbourhood Connector B across the northern boundary of the LSP area has been approved with a road reserve width of 16.2m in the subdivision approval for the adjoining site north of this boundary (WAPC Application No. 148669) due to a reduced verge width adjacent to POS. This width of 16.2m is continued southward within the LSP area adjacent to the continuation of that same POS. This principle of 16.2m width adjacent to POS is also applied on the east west Neighbourhood Connector B within the LSP area, as noted on Figure 7.

Access Streets

The basic standard of access street proposed in this subdivision is a 6m wide carriageway in a 15m road reserve. This Access Street D results in 4.5m verges on both sides, with embayed parking accommodated in the verges where required, such as to provide visitor parking for lots serviced by rear laneways. This road standard is proposed where the future total traffic volumes are less than 1000 vpd.

Access Streets with a future traffic volume over 1000 vpd would be designed as an Access Street C. This is based on a 16m road reserve width and either a 7.2m carriageway width or 6m plus embayed parking where required.

The eastern Access Street C should have a 7.2m road carriageway as a continuation of the road width of the Neighbourhood Connector B across the northern boundary of the LSP area. A one-metre reduction of the road reserve width from 16m to 15m adjacent to POS is applied on part of this road, which is permitted in the WAPC *Liveable Neighbourhoods* policy. Future traffic volumes on this route will be less than 1000 vpd, so there is no justification for continuing this at Neighbourhood Connector B standard within this LSP area.

On the frontage roads abutting the Baldivis Tramway reserve (which is a Parks and Recreation reservation in the MRS) there will be little, if any, requirement for underground services or parking in the western verge, so the western verge abutting the Tramway Reserve is proposed to be reduced in accordance with guidance in Liveable Neighbourhoods, resulting in a proposed road reserve width of 13m for those particular access streets fronting the Tramway reserve. This leaves a 2.5m western verge on these access streets. This is consistent with the 13m access streets approved alongside the Tramway reserve in the subdivision approval for the adjoining site to the north (WAPC Application No. 148669).

Laneways
The proposed road reserve width of the laneways is 6.0 metres. These would typically be designed with flush kerbing (i.e. at the same level as the laneway pavement) and central drainage, and can accommodate two-way vehicle 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 is to be constructed in the road reserve adjacent to proposed lots serviced by laneways where possible.

One laneway on the northern side of the central POS is indicated as 9.0 metres wide, which will allow on street parking to be provided for the adjacent laneway lots fronting the POS.

4.2 Public Transport

Existing bus services in this area are described in section 3.3 of this report and current planning by the Public Transport Authority is discussed in section 3.6. This includes a proposed future bus route along the proposed north south Neighbourhood Connector road link through this LSP area.

4.3 Pedestrian and Cyclist Facilities

The proposed pedestrian and cyclist network for the LSP area is outlined in Figure 8.

In accordance with current practice adopted by the City of Rockingham it is proposed to construct all paths to a minimum width of 2.0 metres so that they can all be designated as shared paths for pedestrians and cyclists. A 2.5m width would be required in high pedestrian-traffic locations such as adjacent to schools and activity centres, so Figure 8 indicates a 2.5m shared path on all frontages around the primary school site in this LSP area.

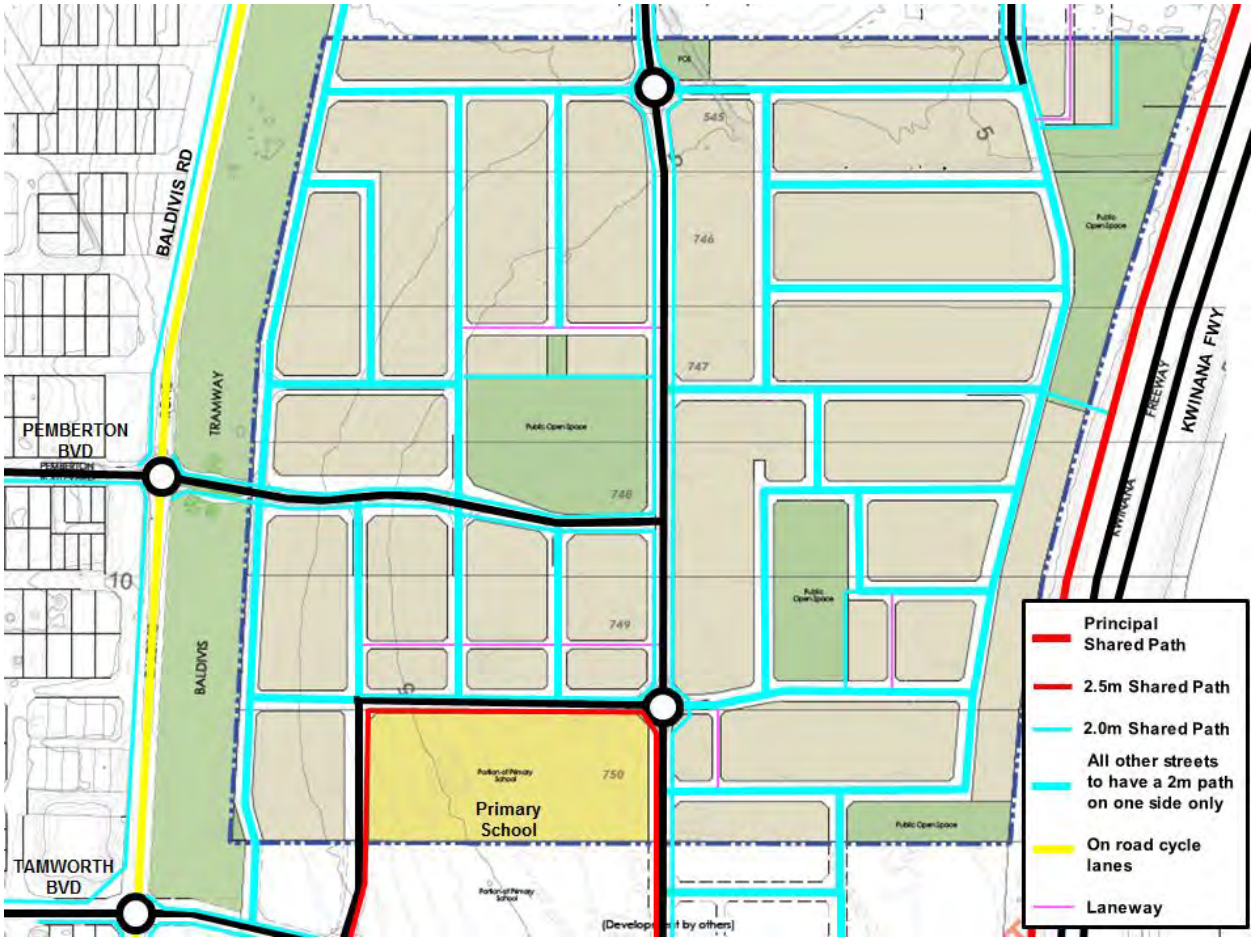

Figure 8: Pedestrian and cyclist facilities

Paths will be provided on at least one side of all roads. There would be paths on both sides on Integrator Arterial and Neighbourhood Connector roads. In the case of Baldivis Road the existing path (where constructed) is provided on the western side of Baldivis Road. As shown on Figure 8 the paths along the frontage roads bordering the tramway reserve can be linked to provide a path along the eastern side of the combined Baldivis Road and tramway reserve.

Laneway lots are to have footpath access to visitor parking bays provided in a nearby road reserve.

On-street cycle lanes are normally included on Integrator A, Integrator B and Neighbourhood Connector A roads, as indicated in the details of the road hierarchy listed in Table 1. There are none of these categories of roads within the LSP area apart from Baldivis Road itself. As noted earlier, on-road cycle lanes have been included on previously upgraded sections of Baldivis Road in this area and it is anticipated this standard will continue to be applicable.

A potential shared path connection is proposed within the LSP area to the Principle Shared Path on the western side of Kwinana Freeway, as shown in Figure 8.

5.0 Integration with Surrounding Area

The road network of the LSP area will connect to the surrounding road network at a number of locations.

This will include one intersection onto Baldivis Road, connecting with the existing Pemberton Bvd west of Baldivis Road.

To the north and south there will be several connections to future residential areas on neighbouring landholdings. These tie into planned road connections in the Local Structure Plans already prepared for those neighbouring landholdings.

The LSP path network will also provide opportunities for connection with future development in these areas and to the Principle Shared Path on the western side of Kwinana Freeway.

6.0 Analysis of the Transport Network

6.1 Assessment Period

The assessment year that has been adopted for this analysis is 2031, with full development of Baldivis as envisaged in the Western Australian Planning Commission's *Directions 2031 and Beyond* planning framework (Aug 2010) and *Outer Metropolitan Perth and Peel Sub-regional Strategy* (draft, Aug 2010).

6.2 Traffic generation and distribution

Transcore has developed a subregional traffic model of weekday traffic flows for the Mandurah-Rockingham area using the EMME transport modelling software package. This model has been developed in more detail for various projects in the Karnup-Baldivis area including this proposed LSP. Overall, the future scenario modelled in this area reflects the land use aspirations of *Directions 2031* as detailed in the *Outer Metropolitan Perth and Peel Sub-regional Strategy*.

The daily traffic generation rate used in the Baldivis West LSP area for this transport assessment is 8 vehicle trips per day (vpd) per dwelling, which corresponds to peak hour trip generation rates recommended in the Western Australian Planning Commission (WAPC) *Transport Assessment Guidelines for Development* (2006).

The anticipated 530 dwellings of the LSP area will therefore generate approximately 4240 vpd, with some of these being internal trips including trips to and from the primary school.

The traffic model has assigned 1160 vehicle trips per day for the primary school that straddles the southern boundary of the LSP area (nominally 430 students as the standard primary school format currently adopted by the state government), which is higher than the trip rate of 2vpd/day per student normally used for school sites. This is considered appropriate for this site as it makes allowance for higher student numbers in the early years while the surrounding development is occupied mainly by young families.

The distribution of these trips is determined by the traffic model in proportion to the location of trip productions and attractors for work trips, education trips and other trips (shopping, social, recreational, etc.) among all the land uses in the traffic model. The distribution of trips to and from the ODP area is summarised in Table 2.

Table 2: External Trip Distribution

Approach Road	Proportion
Baldivis Road (north of Pemberton Bvd)	9.2%
Neighbourhood connector (north)	24.6%
Subdivision roads (north)	17.2%
Pemberton Bvd (west)	1.5%
Tamworth Bvd (west)	5.7%
Baldivis Road (south of Tamworth Bvd)	16.3%
Neighbourhood connector (south)	22.7%
Subdivision roads (south)	2.8%
Total	**100%**

6.3 Traffic Flow Forecasts

The future total daily traffic flows on the road network in and around the LSP area has been modelled for the future scenario of full development of this area as discussed above. The modelled surrounding district road network reflects advice from City of Rockingham officers including constraints on future intersection capacity further north at Baldivis Rd / Mundijong Rd intersection. It should be noted that a lower speed limit has been modelled on Baldivis Road than on the parallel Nairn Drive route to reflect the higher standard of Nairn Drive.

Figure 9 illustrates future total daily traffic flows anticipated on the road network of the LSP area and also shows how much of this traffic is associated with the land uses proposed in the LSP area.

When the transport assessment was previously prepared for the adjacent LSP area to the north it was assumed that there would be an eastern north south Neighbourhood Connector B running diagonally across this site, despite not being shown in the district structure plan. That concept has not turned out to be practical in the current LSP, so the traffic flows modelled on that eastern link are lower in this report than they were in the transport assessment for the LSP area to the north.

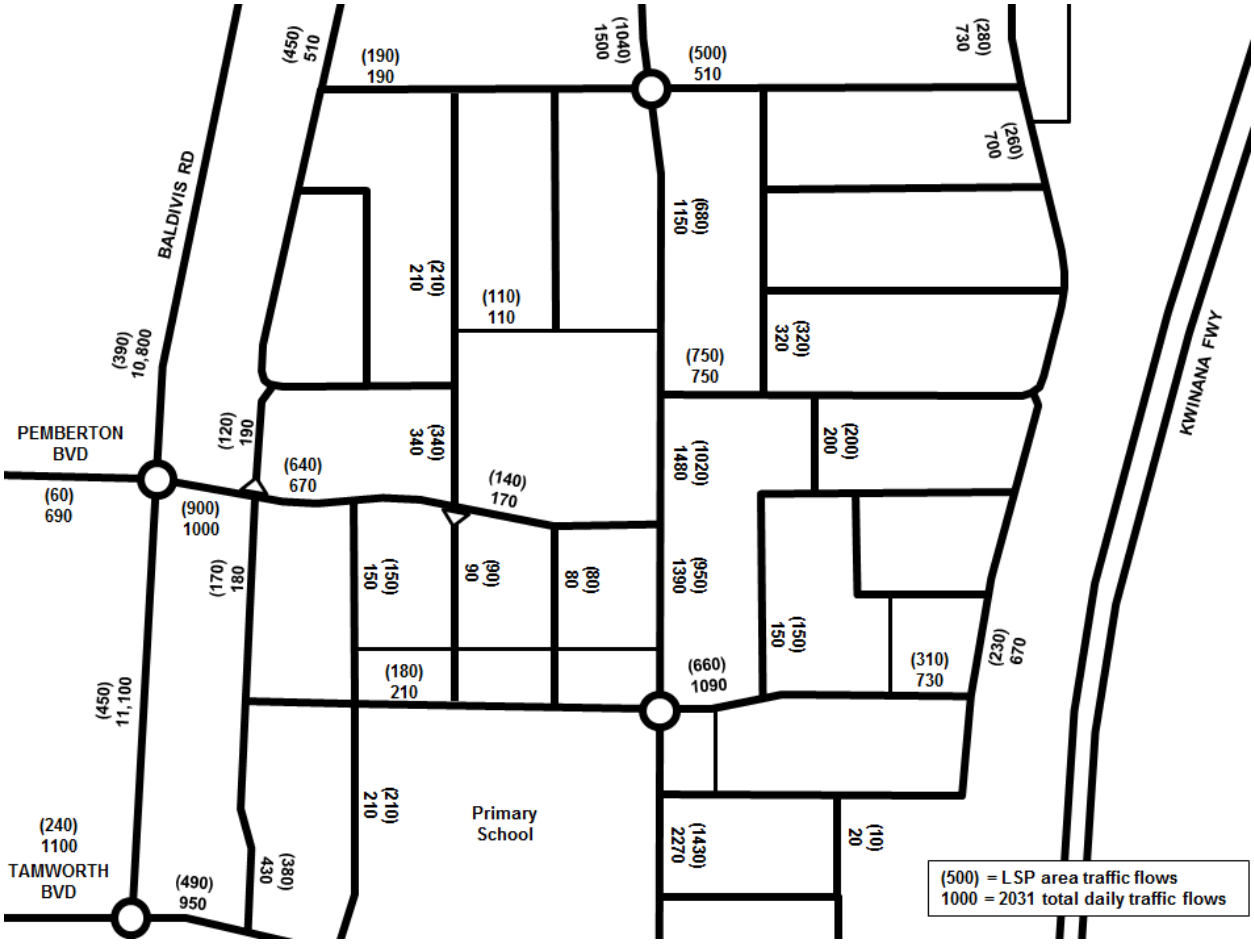

Figure 9: Future Daily Traffic Volumes

6.4 Roads and Intersections

The proposed road network to accommodate these traffic volumes has been detailed in section 4 of this transport assessment, including the details of the proposed road hierarchy in section 4.1.

Figure 10 details the proposed intersection controls for intersections within the LSP area.

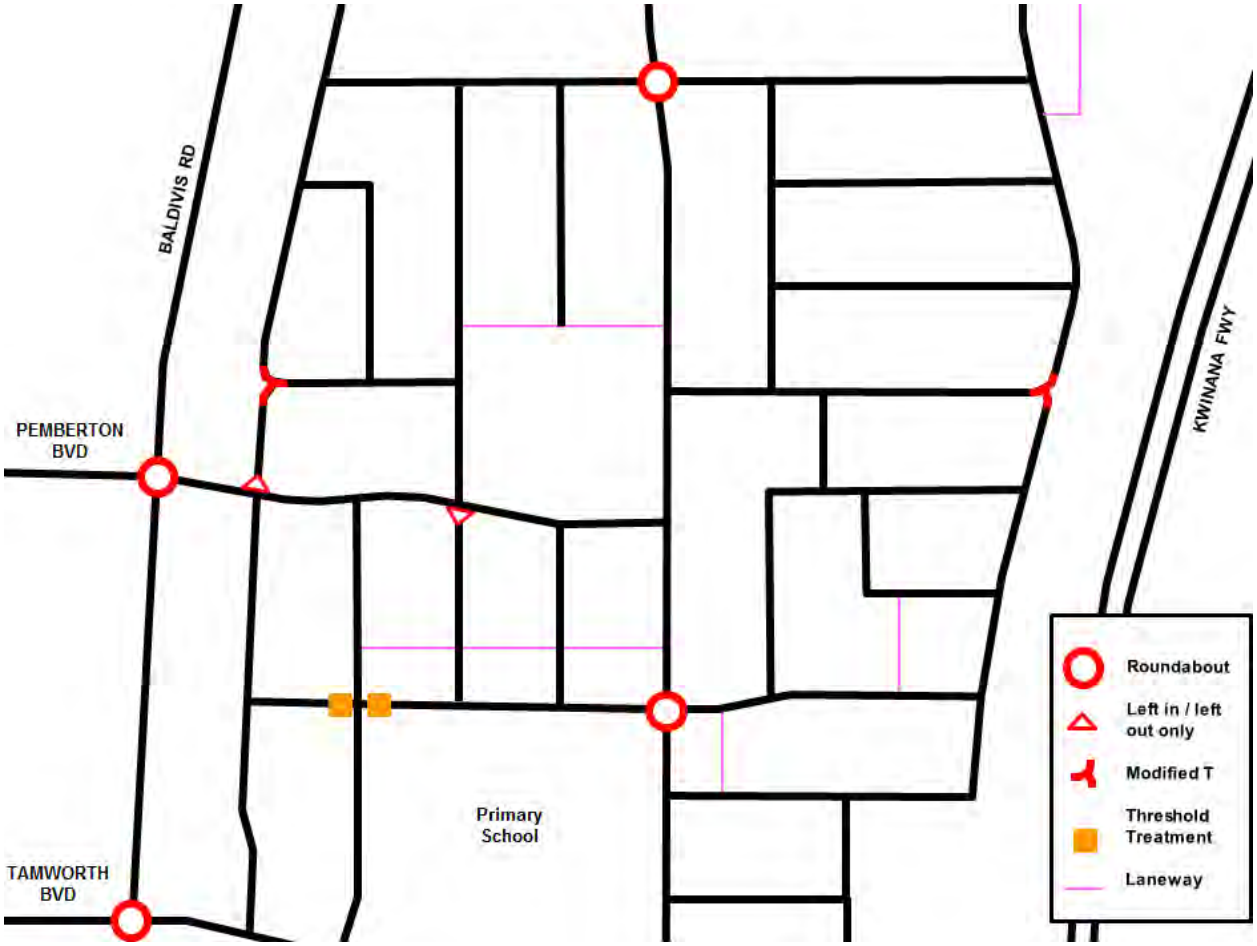

Figure 10: Intersection treatments

Baldivis Road Intersections

The future planning for Baldivis Road assumes it will be upgraded to a two-lane boulevard as has already been constructed on some sections south of the LSP area. The future traffic volume of approximately 11,000vpd adjacent to the LSP area modelled in this transport assessment is consistent with this road standard.

Access to the LSP area will be provided by a 4-way intersection on Baldivis Road at Pemberton Bvd, which is proposed to be constructed as a single-lane roundabout similar to those constructed at the Baldivis Rd/Amazon Dr and Baldivis Rd/Tamworth Bvd intersections.

Internal Intersections

Within the structure plan area there are several proposed four-way intersections. Two of these on the north south Neighbourhood Connector B road are recommended to be constructed as roundabouts, as shown in Figure 10. This will help manage crossing traffic flows and assist with speed management on this long neighbourhood connector road.

Two other four-way intersections on the east west Neighbourhood Connector B road are proposed to be treated to prevent the through movements straight

across the neighbourhood connector. This will completely eliminate the perceived potential for those vehicles to enter the intersection without slowing down first, which could potentially happen if drivers are careless or not paying attention. It is proposed that one side road at each intersection will be restricted to left in / left out by installing a triangular 'seagull island' treatment on that approach at these intersections as illustrated in Figure 10.

One other proposed four-way intersection is recommended to be constructed as priority-controlled intersections with give way signs on the minor road approaches as suggested in Liveable Neighbourhoods (LN Element 2 pages 31-33). Appropriate entry treatments will be provided on the side roads to help to alert drivers to the presence of the intersection and that traffic on the major road has priority. Existing threshold treatments on side roads crossing Amazon Drive west of Baldivis Road are a suitable example of the type of treatment that could be implemented at these 4-way intersections.

Two T-intersections within the LSP area are planned to be constructed as "modified T-intersections", where the major road route bends around the corner and the other approach connects in on the bend, as illustrated on Figure 10. In both cases this is to reinforce the higher order road route or the route without access restrictions at the next intersection, to improve legibility of the local road network in the LSP area.

6.5 Intersection Analysis

Intersection capacity analysis has been undertaken for the key intersection on Baldivis Road for the AM and PM peak hour flows that correspond to the modelled 2031 daily traffic flows in Figure 9.

The location analysed is:

- Baldivis Rd / Pemberton Bvd intersection (roundabout)

Capacity analysis of this intersection has been undertaken using the SIDRA computer software package. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics 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 zero for infrequent traffic flow up to one 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 (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).

- Average Delay is the average of all travel time delays for vehicles through the intersection.
- 95% Queue is the queue length below which 95% of all observed queue lengths fall.

The results of the SIDRA analysis are summarised in Appendix A.

The SIDRA analysis at Tables A1a and A1b in Appendix A indicates that the Baldivis Rd / Pemberton Bvd roundabout will operate satisfactorily in the AM and PM peak periods with the forecast traffic flows for full development of Baldivis. All movements will be at level of service A or B (very good). The longest traffic queues will occur on Baldivis Road in the peak direction of flow in each peak hour. The longest 95th percentile queues are anticipated to extend approximately 40m north of the Pemberton Bvd roundabout, which should be considered quite satisfactory as there will be around 480m and 330m queuing distance available before the existing roundabouts to the north and south, respectively, on Baldivis Road. Queue lengths on the side roads are anticipated to be much shorter (generally only one or two vehicles at a time).

6.6 Access to Frontage Properties

The WAPC Liveable Neighbourhoods policy 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."

There will be no direct driveway access from abutting residential development to Baldivis Road and all of the other roads in the LSP area are expected to carry less than 3000 vpd, so no restriction on vehicular access is required.

6.7 Pedestrian / Cycle Networks

The proposed network of shared paths for pedestrians and cyclists is described in section 4.3 of this transport assessment. This network of paths will provide an excellent level of accessibility and permeability for pedestrians and cyclists within the LSP area, and connections to neighbouring precincts at strategic locations.

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.

Future traffic volumes on Baldivis Road could potentially be up to 11,000 vpd adjacent to the LSP area. If Baldivis Road is designed as a two-lane boulevard as has been constructed on the section adjacent to the northern part of the LSP area this would satisfy the guidance in the Transport Assessment Guidelines.

6.8 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 future bus route shown east of Baldivis Road on Figure 6 would be routed on the north south Neighbourhood Connector B road shown on Figure 7. Residential development within the LSP area will extend approximately 300m east and west from this future bus route, so this 400m guideline is clearly satisfied.

7.0 Conclusions

The main findings of the transport assessment for the Local Structure Plan (LSP) for Lots 545 & 746-750 Baldivis Rd, East Baldivis are outlined below.

The LSP area is anticipated to accommodate approximately 530 dwellings and the northern half of a primary school site.

This residential area is anticipated to generate traffic flows of approximately 4240 vehicles per day and the primary school could attract traffic flows up to 1160 vehicles per day.

The road network of the LSP area has been designed based on WAPC Liveable Neighbourhoods guidelines to accommodate the future traffic flows that will be generated in this area.

The future planning for Baldivis Road assumes it will be upgraded to a two-lane boulevard (one lane each way, separated by a central median island) and the future traffic volumes adjacent to the LSP area modelled in this transport assessment are consistent with this road standard.

Access to the LSP area will be served by a four-way intersection on Baldivis Road at Pemberton Boulevard, which is recommended to be constructed as a single-lane roundabout similar to the existing Baldivis Road / Amazon Drive and Baldivis Road / Tamworth Bvd intersections. These proposed roundabout has been analysed for future traffic flows when Baldivis is fully developed and the analysis indicates that it will operate satisfactorily during weekday AM and PM peak periods.

Roundabouts are also recommended at two other 4-way intersections along the planned neighbourhood connector road running north south through the LSP area. Other intersection treatments are recommended in the report to ensure safe operation of three other four-way intersections within the LSP area.

The proposed road network provides three road links at the northern boundary and four at the southern boundary to integrate with future development planned in the local structure plans of neighbouring landholdings north and south of this site within the wider East Baldivis District Structure Plan.

The proposed north south neighbourhood connector is an appropriate alignment for a planned future bus route east of Baldivis Road, which will provide satisfactory public transport access in future.

The proposed LSP also provides for a comprehensive network of shared paths and footpaths to encourage and facilitate non-motorised travel as well.

Appendix A

SIDRA Intersection Analysis

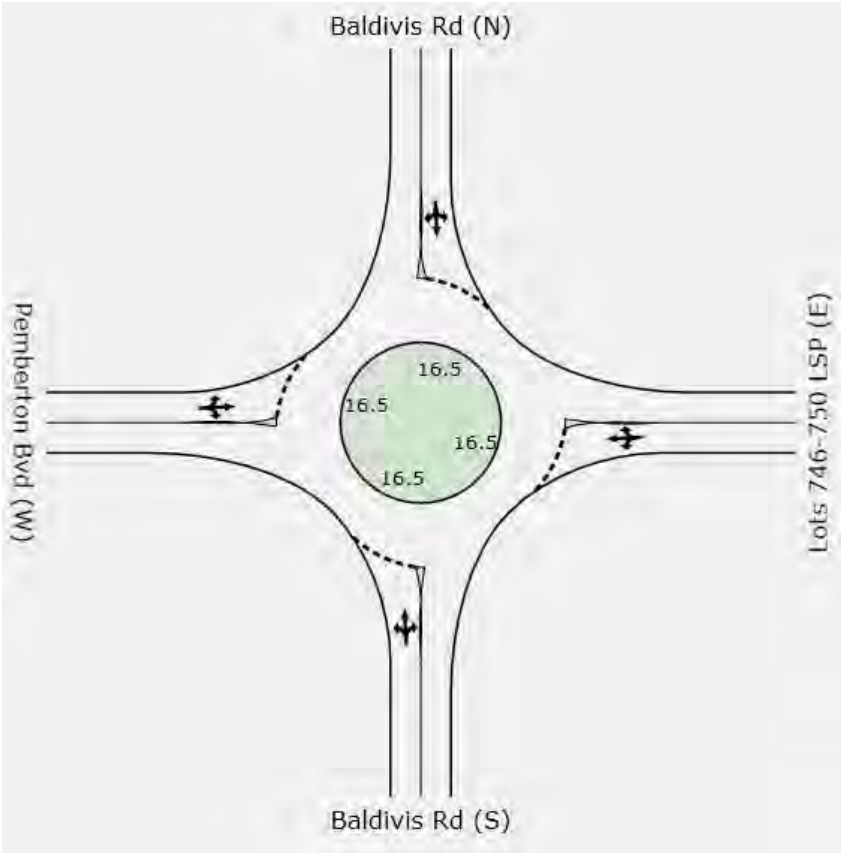

Figure A1. Baldivis Rd / Pemberton Bvd roundabout layout analysed in SIDRA

Table A1a. SIDRA results – Baldivis Rd / Pemberton Bvd roundabout – 2031 AM peak with full development

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: Baldivis Rd (S)								
1	L	15	1.0	0.416	7.6	LOS A	3.2	22.4
2	T	588	2.0	0.416	7.9	LOS A	3.2	22.4
3	R	17	1.0	0.416	11.6	LOS B	3.2	22.4
Approach		620	1.9	0.416	8.0	LOS A	3.2	22.4
East: Lots 746-750 LSP (E)								
4	L	34	1.0	0.068	8.1	LOS A	0.3	2.4
5	T	4	1.0	0.068	5.8	LOS A	0.3	2.4
6	R	28	1.0	0.068	12.7	LOS B	0.3	2.4
Approach		66	1.0	0.068	9.9	LOS A	0.3	2.4
North: Baldivis Rd (N)								
7	L	12	1.0	0.263	7.5	LOS A	1.6	11.7
8	T	358	2.0	0.263	7.8	LOS A	1.6	11.7
9	R	11	1.0	0.263	11.5	LOS B	1.6	11.7
Approach		381	1.9	0.263	7.9	LOS A	1.6	11.7
West: Pemberton Bvd (W)								
10	L	4	1.0	0.036	9.5	LOS A	0.2	1.4
11	T	3	1.0	0.036	7.3	LOS A	0.2	1.4
12	R	22	1.0	0.036	14.2	LOS B	0.2	1.4
Approach		29	1.0	0.036	12.9	LOS B	0.2	1.4
All Vehicles		1096	1.9	0.416	8.2	LOS A	3.2	22.4

Table A1b. SIDRA results – Baldivis Rd / Pemberton Bvd roundabout – 2031 PM peak with full development

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: Baldivis Rd (S)								
1	L	35	1.0	0.225	7.5	LOS A	1.3	9.4
2	T	252	2.0	0.225	7.8	LOS A	1.3	9.4
3	R	39	1.0	0.225	11.5	LOS B	1.3	9.4
Approach		326	1.8	0.225	8.2	LOS A	1.3	9.4
East: Lots 746-750 LSP (E)								
4	L	15	1.0	0.047	11.9	LOS B	0.3	2.0
5	T	2	1.0	0.047	9.7	LOS A	0.3	2.0
6	R	12	1.0	0.047	16.6	LOS B	0.3	2.0
Approach		29	1.0	0.047	13.7	LOS B	0.3	2.0
North: Baldivis Rd (N)								
7	L	27	1.0	0.598	7.8	LOS A	5.6	39.9
8	T	836	2.0	0.598	8.1	LOS A	5.6	39.9
9	R	25	1.0	0.598	11.8	LOS B	5.6	39.9
Approach		888	1.9	0.598	8.2	LOS A	5.6	39.9
West: Pemberton Bvd (W)								
10	L	2	1.0	0.018	7.4	LOS A	0.1	0.6
11	T	7	1.0	0.018	5.2	LOS A	0.1	0.6
12	R	10	1.0	0.018	12.2	LOS B	0.1	0.6
Approach		19	1.0	0.018	9.1	LOS A	0.1	0.6
All Vehicles		1262	1.9	0.598	8.3	LOS A	5.6	39.9