Maddington Kenwick Strategic Employment Area
Precinct 3A

Taylor Burrell Barnett

STRUCTURE PLAN

Prepared for **Linc Property Pty Ltd**
Prepared by **Taylor Burrell Barnett**

LINC PROPERTY

August 2017

DOCUMENT HISTORY AND STATUS

	Revision	Reviewer	Date Issued
MKSEA Precinct 3A Structure Plan	15/073-2	JR	Aug 2017

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ENDORSEMENT

This Structure Plan is prepared under the provision of the **City of Gosnells Town Planning Scheme No. 6**

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

……………………………. 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:

………………………………………… Witness

……………………………. Date

……………………………. Date of Expiry

TABLE OF AMENDMENTS

Each time a Structure Plan is amended, the amendment is to be recorded in the table of amendments at the front of the Structure Plan, including the amendment type (minor or major).

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

EXECUTIVE SUMMARY

This structure plan has been prepared to provide guidance to subdivision and development for industrial purposes within the majority of Precinct 3A of the Maddington Kenwick Strategy Employment Area (MKSEA). The structure plan has been prepared in accordance with the Western Australian Planning Commission's (WAPC) *Structure Plan Framework* (August 2015) and the provisions of the *Planning and Development (Local Planning Schemes) Regulations 2015 ('The Regulations').* Once the necessary procedures and requirements for advertising and consideration have been met the Structure Plan is to be approved by the WAPC in accordance with Schedule 2 Part 4 Cl.22 of the Regulations.

The Structure Plan area is located within the suburb of Kenwick and is bound by the City of Gosnells municipal boundary to the northeast, Coldwell road to the southeast, Roe Highway / Freight Rail alignment to the northwest and by Lot 2008 Grove Road to the southwest. The structure plan area has a total area of 72.61ha, and at the time of preparing this report consisted of 29 individual parcels of land.

The Structure Plan area is zoned 'Rural' under the Metropolitan Region Scheme (MRS) at the time of preparing this report, and abuts land reserved 'Railway' for the freight rail alignment to the northwest, land zoned 'Rural' for the Wattle Grove area to the east and for the MKSEA Precinct 3B area to the south. In 2015 the Western Australian Planning Commission, at the request of the City of Gosnells, initiated an amendment to the MRS to rezone the structure plan area from 'Rural' to 'Industrial' (Ref 1302/57). The amendment was initiated on the basis of its consistency with the *Economic and Employment Lands Strategy* and the Indicative Structure Plan for MKSEA, and is an important first step in realising the vision for MKSEA as an industrial precinct. The proposed amendment was advertised for a period of 60 days and adopted by the WAPC in May 2016, and is anticipated to be approved and published in the *Government Gazette* by mid 2016.

The Structure Plan area is currently zoned 'General Rural' under *Town Planning Scheme No. 6* (TPS6) at the time of preparing this report, and abuts land reserved 'Railways' for the freight rail alignment to the northwest and west, land zoned 'General Rural' to the south and southeast and land zoned 'Special Rural' under the Shire of Kalamunda's *Local Planning Scheme No. 3* to the northeast. In March 2016 the City of Gosnells initiated an amendment to the TPS6 to rezone the structure plan area from 'General Rural' to 'General Industrial' (Amendment 165) with the creation of a 'Special Control Area' under clause 6.10 of the Scheme to require that a structure plan be prepared for the precinct. The amendment was initiated on the basis of its consistency with the proposed MRS amendment and the Indicative Structure Plan for MKSEA, and the desire to facilitate priority development within Precinct 3A as the unconstrained development area.

The Structure Plan proposes that the majority of the land is to be used for 'General Industrial' purposes with subdivision and development to generally accord with WAPC and City of Gosnells requirements. The Structure Plan also includes reference to land area proposed to be acquired by the Public Transport Authority for a Rail Infrastructure Facility to replace the existing PTA facility in Bellevue.

In order to facilitate development and subdivision some infrastructure upgrades will be required, including:

- Upgrade and widening of Coldwell Road to accommodate industrial vehicle movements and a drainage swale;
- Reconfiguration of the Coldwell Road and Grove Road intersection to ensure safety and legibility;
- Realignment and widening of Grove Road to accommodate a drainage swale, ensure improved circulation of traffic and orderly lot creation;
- The closure of Edward Street to facilitate orderly creation of lots fronting the realigned Grove Road; and

- The construction and ceding of a drainage retention basin to accommodate storage of stormwater runoff within the precinct.

These infrastructure upgrades are to be undertaken by landowners as conditions of subdivision and development approval.

There are also a number of infrastructure upgrades that are required to facilitate development of both Precincts 3A and 3B. These infrastructure upgrades include:

- Upgrade the intersection of Welshpool Road East and Coldwell Road;
- Modification to the intersection of Welshpool Road East and Brook Road;
- Upgrade the intersection of Grove Road, and Welshpool Road East;
- Provision of sewer outlet infrastructure to support the development area; and
- Land acquisition and construction costs for local road connection between realigned Grove Road and Welshpool Road East.

As these infrastructure upgrades are necessary to facilitate development within both Precincts they have been incorporated within a proposed Development Contributions Plan as part of Amendment 167 to *Town Planning Scheme No. 6.*

Table 1 below outlines summary information as it applies to the structure plan area.

Table 1: Structure Plan Summary Table

Item	Date		Structure Plan Ref. (Section No.)
Total area covered by the Structure Plan	72.61 hectares		Plan 1
Approximate area of each land use proposed: • General Industry • PTA Rail Infrastructure Facility	**Hectares** 53.00 ha 19.26 Ha	**Lot Yield** Undetermined Undetermined	Plan 1
Total Estimated Lot Yield	Undetermined		NA
Estimated Commercial Floor Space	Undetermined		NA

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PART ONE
IMPLEMENTATION

1 STRUCTURE PLAN AREA

This structure plan applies to the majority of the area known as 'Maddington Kenwick Strategic Employment Area – Precinct 3A' as delineated in proposed amendment 165 of the *Town Planning Scheme No. 6* maps and described by clause 6.10 of the same amendment.

The structure plan area is located within the suburb of Kenwick and is bound by the municipal boundary to the northeast, Coldwell road to the southeast, Roe Highway / Freight Rail alignment to the northwest and Lot 2008 Grove Road to the southwest (**Figure 2**). The structure plan area has a total area of 72.61ha, and at the time of preparing this report consisted of 29 individual parcels of land which are described in **Table 3**.

2 OPERATION

This structure plan comes into effect on the date it is approved by the Western Australian Planning Commission pursuant to section 16 of the *Planning and Development Act 2005.*

The structure plan is to be read in conjunction with the Development Contributions Plan (DCP) and Development Contributions Plan Report (DCPR) for the Development Contribution Plan 12 (DCP12) as approved by the Western Australian Planning Commission.

3 STAGING

While actual development within the structure plan area will be subject to private developer intent, it is anticipated that initial development will occur between Coldwell Road and the realigned Grove Road, and thereafter expand to the area west of the realigned Grove Road. Further information on the proposed staging is outlined within **Section 3.7** of the Explanatory Report.

4 SUBDIVISION AND DEVELOPMENT REQUIREMENTS

4.1 ZONING AND LAND USE

The zoning and land use permissibility for the structure plan area are to be prescribed by the provisions of *Town Planning Scheme No. 6*, which under Amendment 165 is to incorporate the entire area within the 'General Industry' zone. Due regard shall be given to the following provisions in the assessment of applications for land within the structure plan area.

4.1.1 GENERAL INDUSTRY

The subject area is proposed to be zoned 'General Industry' zone under Amendment 165 to *Town Planning Scheme No. 6* and land use permissibility shall be in accordance with Table 1 for that zone.

4.1.2 LOCAL RESERVE – INFRASTRUCTURE SERVICES (DRAINAGE)

The structure plan identifies two indicative areas proposed for drainage detention basins that will accommodate storage of stormwater. Basin A is to be designed, constructed and ceded to the Crown and vested with the City of Gosnells as a condition of subdivision approval, and it is anticipated it will ultimately be reserved for the purpose of 'Local Reserve – Infrastructure Services (Drainage)' by the City of Gosnells as part of a future amendment to *Town Planning Scheme No. 6.* Basin B is intended to account for the drainage of the PTA Rail Infrastructure Facility and may be a private basin or may be ceded to the City of Gosnells.

4.2 SUBDIVISION

Due regard shall be given to the following provisions in the preparation, assessment and determination of subdivision applications.

4.2.1 LOT DESIGN

A Plan of Subdivision should generally demonstrate all proposed lots are of a size and shape that makes them fit for purpose for a variety of land uses that may be considered under the 'General Industry' zone.

4.2.1.1 LANDSCAPE MASTERPLAN

A Plan of Subdivision is to be accompanied by a Landscape Masterplan which identifies the design standards applicable to the local road network, stormwater basin/swales and open spaces, including entry statements, public art and other built form and landscape features.

4.2.2 LOCAL ROADS

4.2.2.1 ROAD WIDENING AND INTERSECTION UPGRADES

Grove Road and Welshpool Road East

The final configuration and design of this intersection is to be agreed with Main Roads Western Australia.

Coldwell Road and Welshpool Road East

The final configuration and design of this intersection is to be agreed with Main Roads Western Australia.

Coldwell Road

It is proposed that Coldwell Road is widened from its existing 20m road reserve to a 30m road reserve to accommodate a drainage swale of approximately 8m wide. Subdivision or development on lots that abut or rely upon Coldwell Road should be required, as a condition of approval, to:

1. Cede the land required for the road widening; and

2. Construct the drainage swale and road upgrading to a standard suitable for industrial use.

It is noted that landowners may be entitled to seek reimbursement from other landowners abutting Coldwell Road in accordance with Part 10 Division 4 of the *Planning and Development Act 2005.*

It is also proposed that the intersection of Coldwell Road and Grove Road is ultimately modified (after the Grove Road connection to Welshpool Road East is complete) to provide Grove Road with priority and Coldwell Road terminates at the intersection. It is anticipated that the realignment of the section of Coldwell Road will be undertaken as a land transfer arrangement between the subdividing landowner and the Department of Lands, with the redundant portion of Coldwell Road being formally closed and transferred to the subdividing landowner in exchange for the new portion of road to be ceded.

Edward Street

It is proposed that Edward Street is formally closed via the required process and the land area transferred to the primary subdivider in exchange for the widening and realignment of Grove Road and the PTA Access, which will replace the current Edward Street and Grove Road north of Coldwell Street. The road will only be closed upon undertaking of the necessary procedures and should be informed by a suitable plan of subdivision that ensures all lots have dedicated access to a gazetted road.

Grove Road

It is proposed that Grove Road be realigned north of Coldwell Road to run generally parallel with the proposed PTA Rail Infrastructure Facility, and widened from 20m to 30m to accommodate a drainage swale.

It is anticipated that the realignment of the road will be undertaken as a land transfer arrangement between the subdividing landowner and the Department of Lands, with the redundant portion of Grove Road being formerly closed and transferred to the subdividing landowner in exchange for the new portion of Grove Road to be ceded.

The location of the realigned road will be further refined at the subdivision application stage, and the design of the road will be subject to the consideration and approval of the City of Gosnells as a condition of subdivision approval.

Proposed PTA Access

It is proposed that a new connection of 20m in width will be created that connects the realigned Grove Road through to the PTA Rail Infrastructure Facility. This connection will be subject to consideration as a component of a subdivision application, and may take the form of an easement, Right of Carriageway or dedicated road dependent on the PTA requirements.

4.2.2.2 SUBDIVISIONAL ROADS

The introduction of additional roads within the precinct may occur at the subdivision application stage and in accordance with Part 10 of the *Planning & Development Act 2005*. These roads are to be designed to an industrial standard in accordance with the requirements of the City of Gosnells.

4.2.3 LOCAL DRAINAGE

In accordance with the Local Water Management Strategy the local drainage network is to be constructed to transfer 1:100 year event surface water drainage to detention basins in the south-east of the structure plan area. The proposed drainage network, as defined by the proposed Local Water Management Strategy, is outlined in Section 3.3 and **Appendix 4** of this report.

The majority of the drainage network is to be accommodated as drainage swales within the local road reserves, and as such no further land will be required to be transferred to the City of Gosnells for the retention of drainage for the majority of lots within the structure plan area. The exception will be the proposed detention Basin A depicted on **Plan 1**, which will be ceded to the Crown and vested with the City of Gosnells as a condition of subdivision and designed in accordance with the City's required standards, inclusive of a connection to a public road.

4.2.4 WASTEWATER DISPOSAL INFRASTRUCTURE

The subdivision of lots within the structure planning area will be provided with a suitable wastewater disposal service.

A condition(s) of subdivision will be included on relevant subdivision approvals requiring that the applicant must demonstrate adequate provision of wastewater disposal infrastructure to suitably service the proposed lots. Measures may, subject to the approval of relevant Government Agencies, include:

a) The installation of local sewerage reticulation infrastructure; or

b) The installation of Aerobic Treatment Units as a component of a future development approval for any development prior to the availability of the connection to the reticulated sewerage network, with dormant sewer reticulation infrastructure or other suitable provision to be made within road reserves sufficient to allow connection to the Water Corporation's ultimate sewerage infrastructure and subject to the request and approval of the Water Corporation; and/or

c) Any other design solution as may be approved by the relevant Government Agencies.

The proposed method of wastewater disposal will be subject to negotiation and compliance with the requirements of the Water Corporation and the Department of Health as a component of satisfying the above which may require a temporary method of wastewater disposal, such as tankering, until such time as a connection to the broader reticulated sewerage network is available.

4.2.5 CONDITIONS OF SUBDIVISION

The table below outlines additional information that will be required at future approval stages. Additional information requirements may not be limited to those listed; the City or WAPC may require other information in relation to particular proposals.

Table 2: Proposed conditions of subdivision

Additional information	Approval stage	Approving Authority
Water Management		
Urban Water Management Plan	Condition of subdivision	WAPC, City, DoW
Environment		
Environmental Assessment Report	Documented in Appendix 1 Implementation via Subdivision	WAPC, City, OEPA,
Fire Management Plan	Documented in Appendix 2 Condition of subdivision	WAPC, City
Engineering		
Servicing Report	Documented in Appendix 5 Condition of Subdivision	City, Water Corporation, Western Power

Additional information	Approval stage	Approving Authority
Road Widening and Upgrade	Condition of Subdivision	City
Acid Sulphate Soils	Condition of Subdivision	City
Geo-technical	Condition of Subdivision	City
Other		
Development Contributions	Condition of Subdivision	City
Local Development Plan(s)	Condition of subdivision (if required in accordance with section 6 of Part 1)	City

4.3 DEVELOPMENT

Development of land within the subject area is to be generally in accordance with the standards and requirements of *Town Planning Scheme No. 6*. Proposed variations to these standards are to be outlined within a development application and will be considered by the determining authority with due regard to the intent and purpose of the standards.

4.3.1 DESIGN GUIDELINES

Where deemed appropriate, the City and/or landowners may prepare design guidelines which identify the proposed built form standards that are to replace or supplement those standards outlined within the Scheme provisions. The design guidelines should be prepared and considered by the City as a Local Planning Policy under Section 2.4 of *Town Planning Scheme No. 6.*

4.3.2 SEPARATION FROM SENSITIVE USES

The structure planning area includes and sits adjacent to a number of existing dwellings which will maintain a non-conforming use right after their land is rezoned for industrial purposes. The introduction of some industrial uses within the structure plan may require the establishment of a separation distance between the use and the existing dwelling.

Appendix 1 of the Environmental Protection Authority's *'Guidance for the Assessment of Environmental Factors: Separation Distances between Industrial and Sensitive Land Uses'* identifies a large number of uses that have potential to impact upon amenity of adjacent uses. A development application that proposes a use specified in Appendix 1 of the EPA Guidance Statement shall generally be guided by the statement, inclusive of the need for a separation distance from the identified sensitive use.

Where the proposed use is to be situated less than the recommended separation distance, further justification and design consideration is likely to be required by the City of Gosnells, including mapping of the location of each of the effected dwellings and identification of amelioration methods to be employed.

4.3.3 WASTEWATER DISPOSAL INFRASTRUCTURE

If a lot proposed for development has not been provided with wastewater infrastructure as a component of a previous subdivision application outlined in Section 4.2.4 an applicant must demonstrate adequate provision of wastewater disposal infrastructure to suitably service the proposed development. Measures may, subject to the approval of relevant Government Agencies, include:

a) The installation of local sewerage reticulation infrastructure; or

b) The installation of Aerobic Treatment Units with dormant sewer reticulation infrastructure or other provision to be made within road reserves sufficient to allow connection to the Water Corporation's ultimate sewerage infrastructure and subject to the request and approval of the Water Corporation; and / or

c) Any other design solution as may be approved by the relevant Government Agencies.

The proposed method of wastewater disposal will be subject to negotiation and compliance with the requirements of the Water Corporation and the Department of Health as a component of satisfying the above which may require a temporary method of wastewater disposal until such time as a connection to the broader reticulated sewerage network is available.

5 LOCAL DEVELOPMENT PLANS

Local Development Plans are not proposed to be required as a condition of subdivision unless a subdivision proposes irregularly shaped lots, very large lots or a site specific constraint is identified that is deemed unsuitable to be addressed at a development application stage.

6 ADDITIONAL INFORMATION

6.1 PUBLIC TRANSPORT AUTHORITY RAIL INFRASTRUCTURE FACILITY

In early 2016 landowners within the structure plan area were notified by the Public Transport Authority that a portion of their land has been identified for public acquisition to accommodate the relocation of the freight rail infrastructure facility currently located at Bellevue near Midland.

The area proposed for acquisition is generally in accordance with that shown in **Plan 1**. It is understood that the Public Transport Authority will negotiate acquisition of land within the identified area during 2016, and the land will thereafter be transferred to the Crown.

6.2 PARMELIA GAS PIPELINE

The Parmelia Gas Pipeline traverses the structure plan area along the north-western boundary, running parallel with the freight rail alignment. The pipeline is protected by a 15m wide easement along its full extent which constrains the development and subdivision of land within which the pipeline is located.

Development and subdivision of land within proximity to the pipeline easement will be required to have regard to the advice provided by the WAPC's *Planning Bulleting 87: High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region*, and may be required to undergo a risk assessment in accordance with the requirements outlined and in collaboration with the pipeline operator, the APA Group.

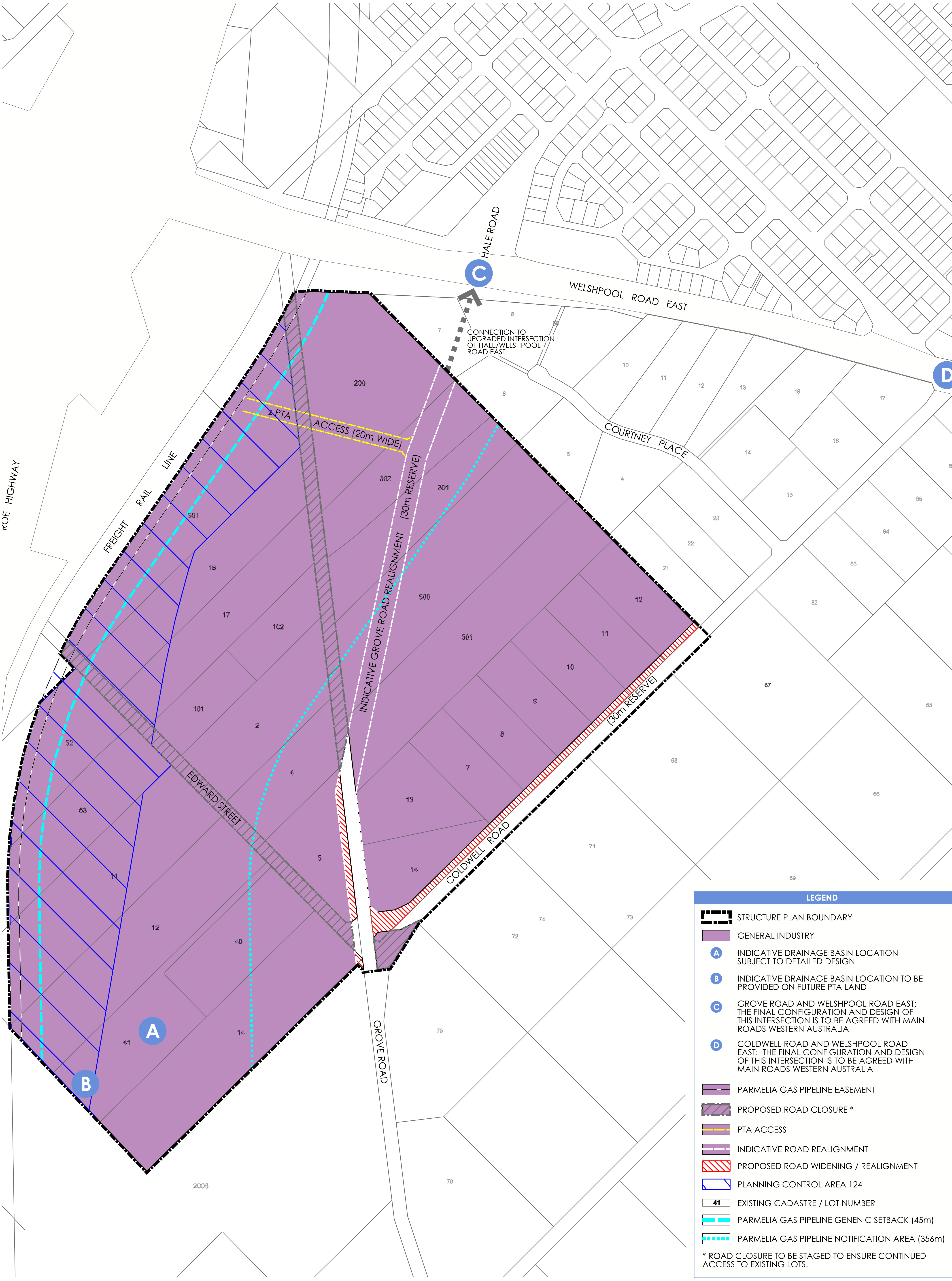
At the time of preparing this report Planning Bulletin 87 identified that:

- A generic 45m buffer zone would be applied to the pipeline easement where it traverses the structure plan area (Plan 1). APA Group has advised that industrial development and subdivision within this buffer area can be considered and approved based on a risk assessment which considers the risks to the operation and maintenance of the gas pipeline, and proposals within the buffer area should be discussed with the APA Group prior to submission.

- A requirement for notification of land use, development and/or subdivision proposals within 356m of the pipeline easement will be applied (Plan 1). This notification will occur through referral by the City of Gosnells or the WAPC of any subdivision or development application within 356m of the pipeline easement in accordance with the Planning Bulletin.

6.3 LOT 2008 GROVE ROAD

The structure plan area includes the majority of Precinct 3A with the exception of a portion of Lot 2008 Grove Road. This lot is proposed to be partially zoned 'General Industry' and partially zoned 'Business Development' under Amendment 165 and 166 to *Town Planning Scheme No. 6*, and the current landowner has expressed a desire to undertake their own structure plan separate to the current exercise.



LEGEND

- STRUCTURE PLAN BOUNDARY
- GENERAL INDUSTRY
- A INDICATIVE DRAINAGE BASIN LOCATION SUBJECT TO DETAILED DESIGN
- B INDICATIVE DRAINAGE BASIN LOCATION TO BE PROVIDED ON FUTURE PTA LAND
- C GROVE ROAD AND WELSHPOOL ROAD EAST: THE FINAL CONFIGURATION AND DESIGN OF THIS INTERSECTION IS TO BE AGREED WITH MAIN ROADS WESTERN AUSTRALIA
- D COLDWELL ROAD AND WELSHPOOL ROAD EAST: THE FINAL CONFIGURATION AND DESIGN OF THIS INTERSECTION IS TO BE AGREED WITH MAIN ROADS WESTERN AUSTRALIA
- PARMELIA GAS PIPELINE EASEMENT
- PROPOSED ROAD CLOSURE *
- PTA ACCESS
- INDICATIVE ROAD REALIGNMENT
- PROPOSED ROAD WIDENING / REALIGNMENT
- PLANNING CONTROL AREA 124
- 41 EXISTING CADASTRE / LOT NUMBER
- PARMELIA GAS PIPELINE GENERIC SETBACK (45m)
- PARMELIA GAS PIPELINE NOTIFICATION AREA (356m)

* ROAD CLOSURE TO BE STAGED TO ENSURE CONTINUED ACCESS TO EXISTING LOTS.

PLAN 1 | STRUCTURE PLAN

Maddington - Kenwick Strategic Employment Area - Precinct 3A

A LINC PROPERTY PROJECT

0m 25 50 75 100m

s: 1:2,500@A1
d: 24 August 2017
p: 15/073/024P

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PART TWO EXPLANATORY INFORMATION

1 PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

The structure plan area forms part of the wider Maddington Kenwick Strategic Employment Area, which is identified by the Western Australian State Government and the City of Gosnells as a strategic industrial development area.

The purpose of this document is to fulfil the requirements of proposed clause 6.10 of *Town Planning Scheme No. 6* which will require that prior to subdivision or development being undertaken within the subject area a structure plan is required to be prepared and approved for the purpose of Schedule 2 Part 4 clause 15 (a) (ii) of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

1.2 LAND DESCRIPTION

1.2.1 LOCATION

The subject land is situated within the suburb of Kenwick as shown in **Figure 1**. The structure plan area is located within the suburb of Kenwick and is bound by the municipal boundary to the northeast, Coldwell Road to the southeast, Roe Highway / Freight Rail alignment to the northwest and by Lot 2008 Grove Road to the southwest.

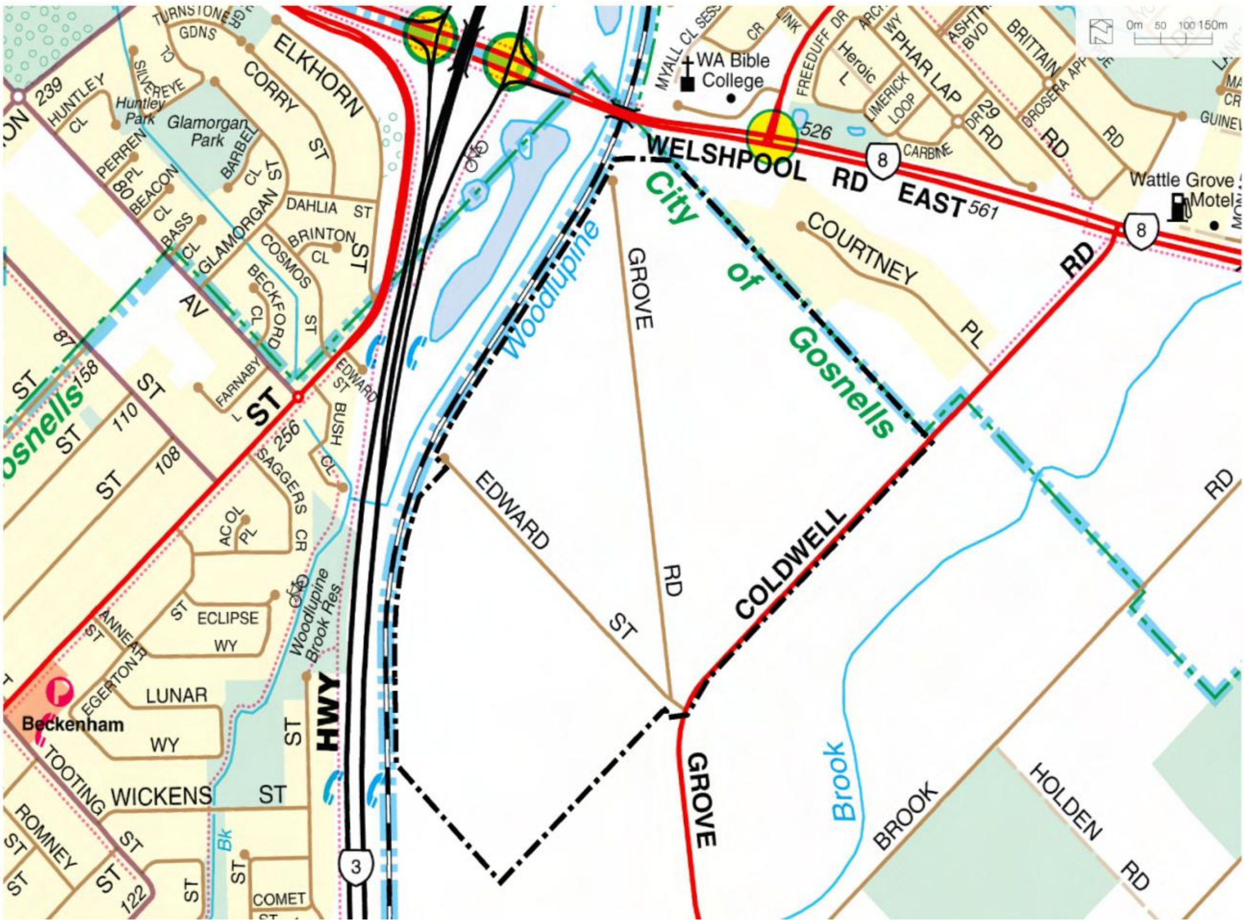

Figure 1: Location Plan

1.2.2 AREA AND LAND USE

The structure plan area is currently used primarily for general rural activities and rural living, with 23 dwellings throughout the precinct and several small commercial vehicle parking and transport depot type operations. The structure plan area totals 72.61 hectares in size, with individual lot areas outlined in **Figure 2**.

Figure 2: Area and Land Use

1.2.3 LEGAL DESCRIPTION AND OWNERSHIP

The subject land is wholly within private ownership with the exception of existing local road reserves. The land ownership details are shown in **Figure 3** below and described within **Table 2**.

Figure 3: Legal Description and Ownership

TABLE 3: LEGAL DESCRIPTION AND OWNERSHIP OF LOT PARCELS WITHIN THE STRUCTURE PLAN AREA.

HOUSE	LOT	STREET	AREA (ha)	LAND OWNER
	52	Edward Street	1.9986	ZURICH BAY HOLDINGS PTY LTD
49	53	Edward Street	2.4946	CARUSO, CHRISTOPHER VICTOR & CARUSO, SUZANNE FRANCENE
31	11	Edward Street	4.135	CURNOW, GARRY FREDERICK & CURNOW, ROSEMARIE
29	12	Edward Street	4.1893	WILLIAMS, ROSEMARIE ANN
15	40	Edward Street	2.0401	HAYES, JANICE KAYE & HAYES, TREVOR JOHN
17	41	Edward Street	2.4397	DOWNING, BEVERLY RUTH; DOWNING, COLIN RAYMOND & DOWNING, DEREK JOHN
3	14	Edward Street	4.5	MAZZA, FRANCESCO & MAZZA, PASQUALINA
58	16	Edward Street	2.786	RAPHAEL ROAD PTY LTD
54	17	Edward Street	2.5133	SMITH, JENNIFER ANNE & SMITH, COLIN LINDSAY
64	501	Edward Street	3.2597	BALSTON, RICHARD WILLIAM
48	101	Edward Street	1.012	KARU, SANDRA CAROLYN
111	102	Grove Road	1.012	BEGG, LISA-KIM MARGARET IRENE & MOSS, SCOTT EDWARD
26	4	Edward Street	1.5115	LOVEGROVE, ANN MARGARET & LOVEGROVE, RICHARD ANTHONY
16	5	Edward Street	1.5051	ZHAO, SHANSHAN
141	2	Grove Road	1.2869	HOLOWAY, JENNIFER KAY
78	13	Grove Road	1.5982	HICKS, ANDREW & HICKS, HELENA
76	14	Grove Road	1.6338	MCMANUS, ALEXANDRA & MCMANUS, GORDON JOSEPH
102	500	Grove Road	4.6764	BUCKLAND, JUDITH ANNE
92	501	Grove Road	4.4898	LOVEGROVE, ANN MARGARET & LOVEGROVE, RICHARD ANTHONY
	200	Grove Road	4.2908	BUCKLAND, JUDITH ANNE
118	301	Grove Road	2.291	CRAMPTON, SUSAN
	302	Grove Road	2.601	BUCKLAND, JUDITH ANNE
38	2	Edward Street	2.4288	DOWNE, PATRICIA MAY & LLOYD, PETER
25	7	Coldwell Road	1.2809	FARR, GARY FREDERICK
35	8	Coldwell Road	1.2809	WHITE HOLDINGS PTY LTD
45	9	Coldwell Road	1.2809	HOPKINS, MATTHEW & CASSIDY, SHANE JOSEPH
49	10	Coldwell Road	1.2809	SIMEON, BRIAN WILLIAM
57	11	Coldwell Road	1.2809	HARVEY, ROSS
63	12	Coldwell Road	1.2809	NEWITT, MARIAN & NEWITT, PETER CHARLES

1.3 PLANNING FRAMEWORK

1.3.1 ZONING AND RESERVATIONS

1.3.1.1 METROPOLITAN REGION SCHEME

The structure plan area is zoned 'Rural' under the Metropolitan Region Scheme (MRS) (**Figure 4**) at the time of preparing this report, and abuts land reserved 'Railway' for the freight rail alignment to the northwest, land zoned 'Rural' for the Wattle Grove area to the east and for the MKSEA Precinct 3B area to the south.

In 2015 the Western Australian Planning Commission, at the request of the City of Gosnells, initiated an amendment to the MRS to rezone the structure plan area from 'Rural' to 'Industrial' (Ref 1302/57). The amendment was initiated on the basis of its consistency with the *Economic and Employment Lands Strategy* and the Indicative Structure Plan for MKSEA, and is an important first step in realising the vision for MKSEA as an industrial precinct.

The proposed amendment was advertised for a period of 60 days and adopted by the WAPC in May 2016, and is anticipated to be approved and published in the *Government Gazette* by mid 2016.

Figure 4: Current and proposed MRS Zoning of structure plan area

1.3.1.2 TOWN PLANNING SCHEME NO. 6

The structure plan area is currently zoned 'General Rural' under *Town Planning Scheme No. 6* (TPS6) (**Figure 5**) at the time of preparing this report, and abuts land reserved 'Railways' for the freight rail alignment to the northwest and west, land zoned 'General Rural' to the south and southeast and land zoned 'Special Rural' under the Shire of Kalamunda's *Local Planning Scheme No. 3* to the northeast.

In 2016 the City of Gosnells initiated an amendment to the TPS6 to rezone the structure plan area from 'General Rural' to 'General Industrial' (Amendment 165) with the creation of a 'Special Control Area' under clause 6.10 of the Scheme to require that a structure plan be prepared for the precinct. The amendment was initiated on the basis of its consistency with the proposed MRS amendment and the Indicative Structure Plan for MKSEA, and the desire to facilitate priority development within Precinct 3A as the unconstrained development area.

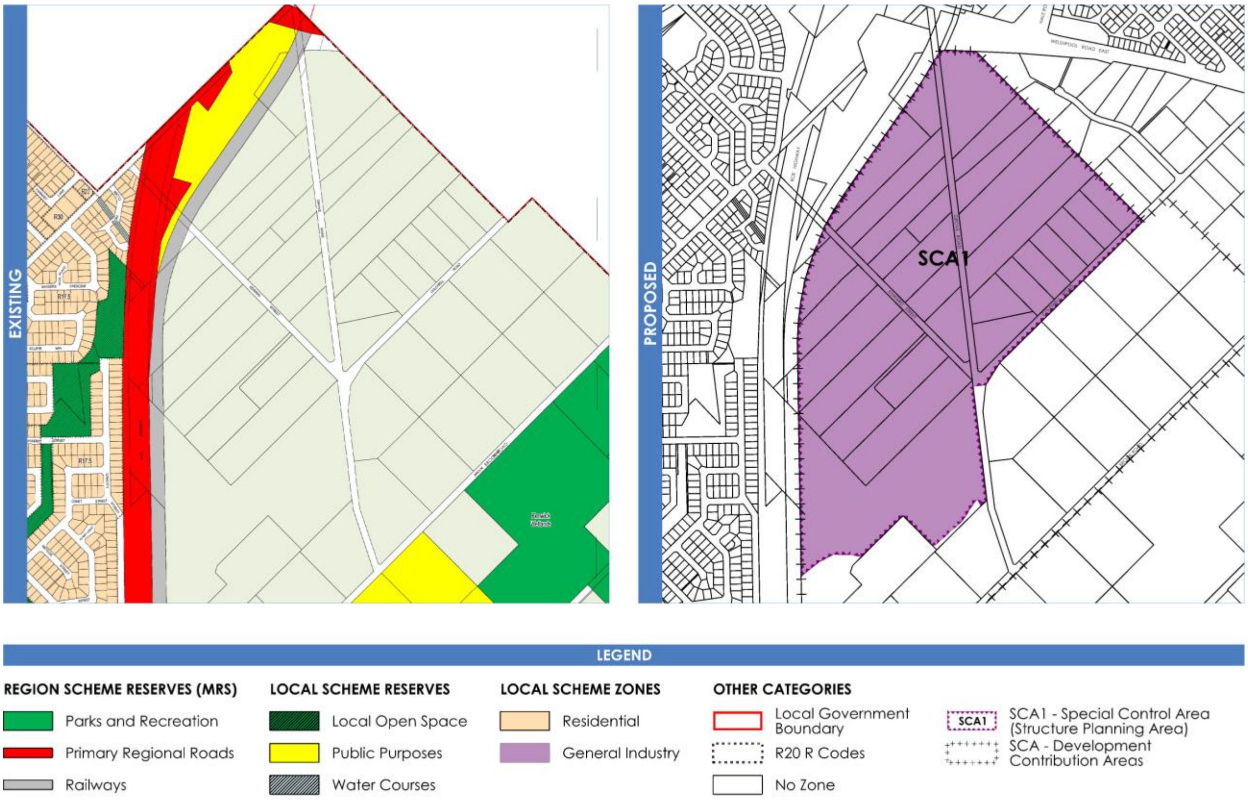

Figure 5: Current and proposed TPS6 Maps of structure plan area

1.3.2 REGIONAL AND SUB-REGIONAL STRUCTURE PLAN

1.3.2.1 PERTH AND PEEL @ 3.5 MILLION

The most recent Regional Planning Framework for Perth, Perth and Peel @ 3.5 Million, identifies that economic modelling predicts a requirement for jobs to grow within the south-eastern sector of Perth by more than double to approximately 113,000 by 2050.

The growth sectors are predicted to focus on Armadale and Maddington as the key centres within the precinct, but *'will require a steady supply of developable land including into the Forrestfield industrial area and Maddington Kenwick Strategic Employment Area'* (pg 37).

1.3.2.2 SOUTH METROPOLITAN PEEL SUB-REGIONAL PLANNING FRAMEWORK

The *South Metropolitan Peel Sub-Regional Planning Framework*, which incorporates the structure plan area, identifies that the future economy and employment opportunities within the sub-region will focus on manufacturing, construction, retail, healthcare and social assistance, in addition to education, training, public administration and safety.

The plan identifies the MKSEA precinct (**Figure 6**), including the structure plan area, as 'Industrial Expansion' (page 25) and describes the MKSEA precinct as *'an area of expansion of the existing industrial re in proximity to the Kewdale intermodal transfer facilities and freight routes linking with Fremantle, Kwinana and Perth Airport'* (Page 29).

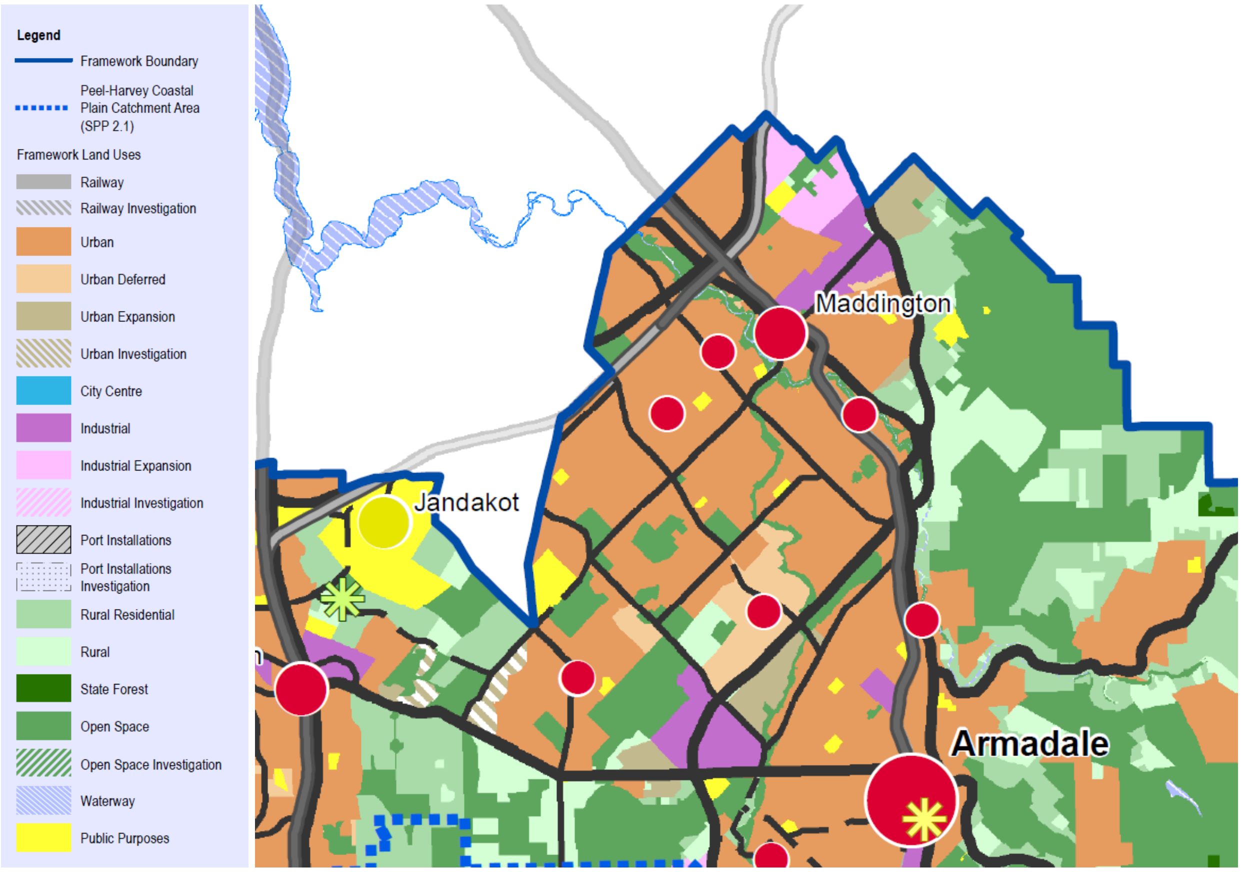

Figure 6: Extract from the draft South Metropolitan Peel Sub-Regional Planning Framework (May 2015) identifying the structure plan area as 'Industrial Expansion'.

1.3.3 PLANNING STRATEGIES

1.3.3.1 ECONOMIC AND EMPLOYMENT LAND STRATEGY: NON HEAVY INDSUTRIAL

The *Economic and Employment Land Strategy: Non Heavy Industrial* (EELS) was endorsed by the State Government in 2012 as a long-term strategy to identify strategic industrial sites within the Perth Metropolitan and Peel Region that require comprehensive planning and development to ensure they achieve their potential.

The Strategy identifies the MKSEA area as a potential industrial area, with Precinct 1 identified as a short-term priority, Precinct 3A identified as a medium-term priority (Figure 7) and Precinct 2 and Precinct 3B identified as long-term priorities. It is understood that the prioritisation is based on the known environmental and service infrastructure constraints at the time and the proposed staging of development identified by the City of Gosnells.

The Strategy indicates that Precincts 3A is capable of accommodating industrial development subject to further investigation as part of detailed structure planning and site investigation, including fragmented ownership and service infrastructure availability.

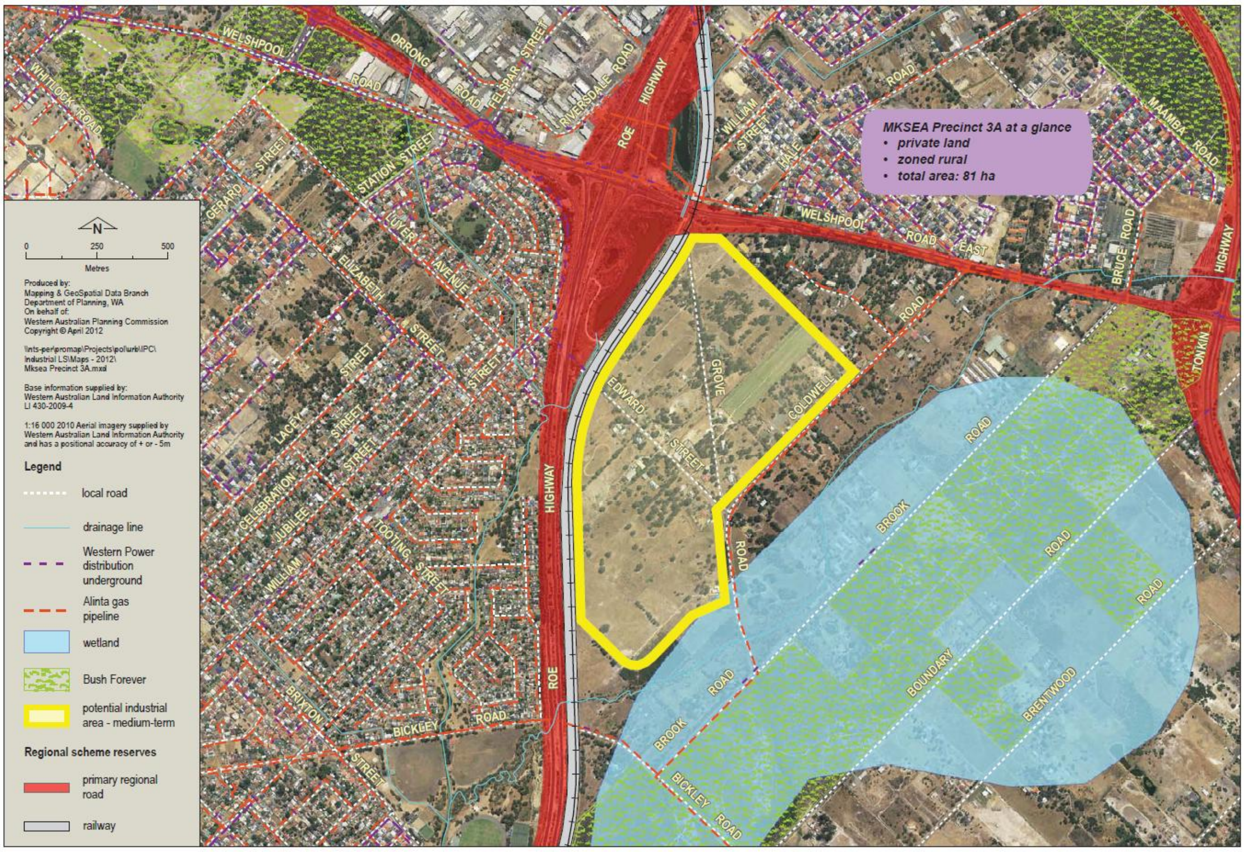

Figure 7: Extract from the Economic and Employment Lands Strategy: Non-Heavy Industrial (WAPC 2012) identifying the structure plan area as 'Potential Industrial Area: Medium Term'.

1.3.4 PLANNING POLICIES

1.3.4.1 DEVELOPMENT CONTROL POLICY 4.1 – INDUSTRIAL SUBDIVISION

The WAPC's *Development Control Policy 4.1*, adopted in July 1988, is likely to be a relevant consideration in the assessment of subdivision applications within the structure plan area. The policy provides general guidance on the subdivision of land within industrial areas, including lot size and shape, staging of subdivision, access and road layout and service infrastructure requirements.

1.3.4.2 CITY OF GOSNELLS LOCAL PLANNING POLICY 5.8 – MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA

The City of Gosnells Local Planning Policy 5.8 (LPP5.8) was prepared to guide development within the Maddington Kenwick Strategic Employment Area. The stated project intent is to:

> *'Ensure that development of the MKSEA will be well-coordinated and provide a high level of efficiency, utility and functionality for business in a manner that protects and where possible enhances the unique environmental characteristics of the area, and the amenity of nearby established communities'.*

In outlining the necessary planning framework it was recognised that the amendments to the MRS and TPS6 would be required together with the preparation of local structure plans / outline development plans and development contribution arrangements.

1.3.4.3 MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA INDICATIVE STRUCTURE PLAN

For the purpose of providing context to the preparation of local structure plans / outline development plans and to inform the preparation of a District Water Management Strategy, the City of Gosnells prepared an Indicative Structure Plan for the Maddington Kenwick Strategic Employment Area (**Figure 8**).

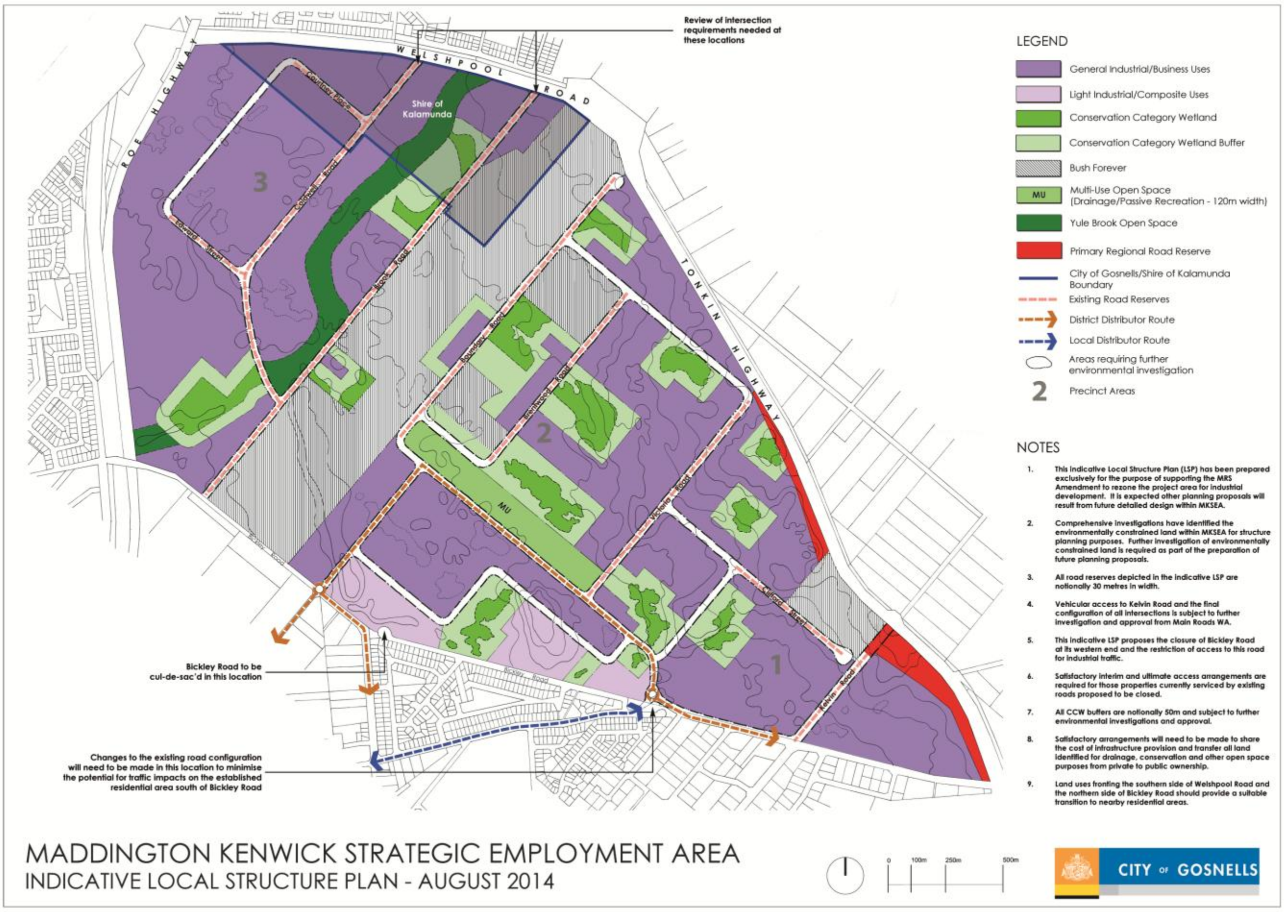

Figure 8: Maddington Kenwick Strategic Employment Area Indicative Local Structure Plan (August 2014)

The indicative structure plan identifies that:

- The entirety of Precinct 3A is proposed to be developed for 'General Industrial/Business Uses';
- The existing road network requires modification to ensure that a more logical movement pattern and future subdivision pattern can be achieved. The Structure Plan shows Grove Road north of Coldwell Road being realigned to run between Edward Street and Courtney Place;
- Precinct 3B contains the Yule Brook and two Conservation Category Wetlands with associated buffers;
- The area to the north falls within the Shire of Kalamunda, and planning and development within this area will need to be undertaken in consultation with the Shire and under the provisions of their *Local Planning Scheme No. 3*; and
- Bush Forever Site No. 387 sits adjacent to the eastern boundary of the Precinct 3, and will need to be considered in the context of development proposals within the precinct.

1.3.5 PRE LODGEMENT CONSULTATION

Linc Property Group and Taylor Burrell Barnett have undertaken a large amount of pre-lodgement consultation with key stakeholders: A summary of the outcome of the discussions is outlined below, as it relates to the structure plan:

1.3.5.1 LANDOWNERS

Linc Property Pty Ltd has entered into contractual arrangements to purchase the majority of lots within the structure plan area and has formed a good working relationship with those landowners not currently under contract. The landowners within the precinct are aware of the preparation of the MRS and TPS6 amendments and the requirement for a development contributions plan, along with the preparation of this structure planning document. To our knowledge all landowners are supportive of the measures outlined within this structure plan.

1.3.5.2 CITY OF GOSNELLS

Linc Property Pty Ltd and Taylor Burrell Barnett have been in regular consultation with the City of Gosnells throughout the process of amendments to TPS6 and the preparation of this structure plan. The City will have an ongoing role in the implementation of the structure plan through the assessment and determination of applications and the management of the development contributions fund for the wider MKSEA Precinct 3. The City supports the preparation of this structure plan consistent with TPS6 Amendments 165 and 167.

Separate meetings with City officers have been held to discuss drainage management and design requirements. The City's feedback and input on drainage management has been considered in the preparation of this structure plan and the Local Water Management Strategy for the precinct.

1.3.5.3 SHIRE OF KALAMUNDA

Linc Property Pty Ltd and Taylor Burrell Barnett have met with the Shire of Kalamunda to confirm their support for industrial development within Precinct 3A and for the upgrade to the road network within their Shire, including the proposed intersection upgrades for Coldwell Road / Welshpool Road East and Grove Road / Welshpool Road East. The Shire has indicated officer level support for these upgrades on the basis that the entire area is proposed to be redeveloped for industrial purposes.

1.3.5.4 DEPARTMENT OF PLANNING

Linc Property Pty Ltd and Taylor Burrell Barnett have met with the Department of Planning to confirm direction on both the amendments to TPS6 and the preparation of this structure plan. At these meetings it was confirmed that the Department was satisfied that a structure plan was to be prepared for the subject area and, in the absence of a requirement to prepare one under the Scheme, the Department would issue notification that a structure plan is to be prepared for the purpose of Schedule 2 Part 4 Clause 15c) of the *Planning and Development (Local Planning Scheme) Regulations 2015.*

1.3.5.5 PUBLIC TRANSPORT AUTHORITY

Linc Property Pty Ltd has been in regular liaison with the Public Transport Authority regarding their proposed acquisition of land for the Rail Infrastructure Facility. The PTA have provided support to the preparation of the structure plan and are supportive of the proposed access arrangement to the Rail Infrastructure Facility via the realigned Grove Road and the upgrade of the Grove Road / Welshpool Road East intersection.

1.3.5.6 MAIN ROADS WA

The project team has met with Main Roads WA on a number of occasions to discuss the proposed access arrangements to the precinct via Welshpool Road East. Main Roads WA has provided indicative support to the upgrade of the intersections of Grove Road / Welshpool Road East and Coldwell Road /Welshpool Road East, and to the modification of the intersection of Welshpool Road East with Brook Road, subject to detailed design.

1.3.5.7 DEPARTMENT OF TRANSPORT

The project team has met with the Department of Transport to discuss the proposed structure plan and officers provided support to the proposal for access along Welshpool Road East as outlined in the structure plan and development contributions plan report.

1.3.5.8 WATER CORPORATION

Linc Property Group, Taylor Burrell Barnett, Cossill and Webley & Emerge have met with the Water Corporation on two occasions to discuss the servicing requirements, detailed drainage strategy (as per the draft LWMS) and Yule Brook. The Water Corporation provided indicative support to the proposed drainage strategy and the infrastructure development, subject to receiving more detailed information as part of the LWMS and infrastructure strategy included as appendices to this structure plan.

2 SITE CONDITIONS AND CONSTRAINTS

2.1 BIODIVERSITY AND NATURAL AREA ASSETS

2.1.1 FLORA AND VEGETATION

The flora and vegetation values of the site have been determined based on a number of flora and vegetation assessments undertaken within the broader area and the site, including:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)
- *MKSEA Precinct 3A Flora and Vegetation Assessment* (Emerge Associates 2016).

The majority of the site has been historically cleared to support agricultural land uses, with existing vegetation primarily comprised of planted, non-endemic species, in addition to small areas of remnant vegetation and scattered trees. In summary:

- The site has been subject to extensive historical disturbance and clearing, resulting in the condition of vegetation within the site ranging from 'Completely Degraded' to 'Degraded'.
- The site contains six plant communities, including native remnants in addition to areas of cleared or planted vegetation, all of which are highly disturbed, absent of native understorey species and are subject to weed invasion.
- None of the identified plant communities within the site are representative of any Threatened Ecological Communities or Priority Ecological Communities, nor are they representative of the Guildford or Southern River complexes (as mapped by Heddle *et al* (1980)), which would have been found historically within the site.
- No Threatened (Declared Rare) or Priority Flora species have been recorded or are likely to occur within the site.

Further information regarding the flora and vegetation characteristics of the site is provided in the *Environmental Assessment and Management Strategy* (Emerge Associates 2016), provided in **Appendix 1**.

2.1.2 FAUNA

A number of fauna investigations have been undertaken across the broader area and the site, including:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *Black Cockatoo Survey MKSEA* (360 Environmental 2012)
- *Fauna Assessment MKSEA Precinct 3* (Harewood 2016)

Based on the findings of these investigations, the overall fauna habitat values within the site have been severely compromised by the almost total clearing of vegetation. The limited fauna habitat values remaining in the site are represented by remnant vegetation comprised of individual trees and small groups of marri (*Corymbia calophylla*), flooded gum (*Eucalyptus rudis*) and paperbark *(Melaleuca rhaophiophylla*), in addition to various endemic, non-endemic and exotic trees planted throughout the site. Native understorey flora species of any type were not observed within the site.

On this basis, the site is considered to be generally utilised by common and widespread fauna species with non-specific habitat requirements which generally persist in highly disturbed areas. The overall fauna biodiversity within the site is considered to be well below pre-disturbance levels.

Notwithstanding, the site does contain some isolated areas of habitat suitable for two Threatened species of black cockatoo (primarily in the form of mature marri trees), namely Carnaby's black cockatoo and Forest Red-tailed black cockatoo. Foraging evidence of both species was observed within the site, however the available foraging habitat is not considered to represent quality habitat as it is degraded, scattered and limited in representation of known foraging habitat species.

Further information regarding the fauna habitat characteristics of the site is provided in the *Environmental Assessment and Management Strategy* (Emerge Associates 2016), provided in **Appendix 1**.

2.2 LANDFORM AND SOILS

The site is generally flat and low-lying, with elevation ranging from approximately 9 m Australian Height Datum (AHD) in the south west to 13 m AHD in the north east (DoW 2008). The site has a gentle south-westerly aspect.

The majority of the site is situated on the Guildford soil-landform formation, which is broadly described as "flat plain with medium textured deposits and yellow duplex soils". The remainder of the site (an area of approximately 9 ha intersecting the northern corner) is situated on the Southern River formation, which is described as "sandplain with low dunes and many intervening swamps" (Churchward and McArthur 1980).

The environmental geology of the site has been mapped by the Geological Survey of Western Australia (Jordan 1986), which indicates the site is comprised of areas of sand and clayey sand.

Available information from the Department of Environment Regulation indicates that the site has been generally classified as having a 'Moderate to Low' risk of Acid Sulfate Soils (ASS) occurring within three metres of the natural soil surface. ASS is only likely to be a potential risk where civil construction works extend below the seasonally dry soils (i.e. where deep sewer is installed), and can be appropriately managed at future planning stages in accordance with the WAPC's *Acid Sulfate Soils Planning Guidelines* (2008).

Further information regarding the landform and soil characteristics of the site is provided in the *Environmental Assessment and Management Strategy* (Emerge Associates 2016), provided in **Appendix 1**.

2.3 GROUNDWATER AND SURFACE WATER

There are no wetlands or water courses of significance within Precinct 3A. The surface hydrology of the site is characterised by low permeability sandy clay soils and an overall very flat gradient. This results in generally low infiltration within the site and low runoff rates.

Surface runoff is guided by existing man made surface water drains/channels which either align with road reserves or minor existing site low points. Surface runoff leaving the site discharges from Precinct 3A to Precinct 3B, where it is conveyed to Yule Brook. Yule Brook floodplain is entirely within Precinct 3B and the approach to surface water management is affected by the maximum flood heights in the Yule Brook, but not the spatial extent of it's floodplain.

Groundwater beneath the site has been characterised as being shallow, and for much of Precinct 3A it is at or near the surface. This is consistent with the observed soils onsite which are low permeability, and therefore groundwater is largely seasonally perched.

The future development of the site will need to be undertaken in a way which does not create artificial mounding of groundwater within any fill brought in to the site. Given there are no sensitive wetlands or watercourses with riparian vegetation there should be no impediment to modification of groundwater levels to achieve sustainable environmental outcomes during development of the site i.e. groundwater can be lowered, and minimum clearances do not necessarily need to be achieved by import of fill in isolation of other measures.

2.4 HERITAGE

In January 2016 an aboriginal heritage consultant from Horizon Heritage undertook a review of the Aboriginal Heritage Inquiry System (AHIS), along with a site visit, and confirmed that there are no Aboriginal heritage values considered to occur within the site.

A desktop search of the State Heritage Office database, Australian Heritage Database and the City of Gosnells Heritage Inventory did not identify any registered heritage sites as occurring within the site.

2.5 BUSHFIRE HAZARD

The site is regionally mapped as a 'Bushfire Prone Area' in the state-wide *Map of Bush Fire Prone Areas* (Office of Bushfire Risk Management 2015) and as such statutory requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) apply to development within the site. On this basis, a *Bushfire Management Plan* (BMP) (Emerge Associates 2016) has been prepared for the site and is included as **Appendix 2.**

In accordance with the vegetation classifications set out in *Australian Standard 3959: Construction of buildings in bushfire-prone areas* (AS 3959) (Standards Australia 2009), the site is predominantly characterised by grasslands, with managed and unmanaged areas. In addition, areas of woodland are scattered across the site and areas of scrub occur within and adjacent to the Roe Highway road reserve and Woodlupine Brook Reserve north-west of the site.

Based on the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2015), the associated bushfire hazard rating of each AS 3959 vegetation classification was determined as either 'low', 'moderate' or 'extreme'. Areas within 100m of 'moderate' or 'extreme' bushfire hazards are considered to be bushfire prone. On this basis, the vast majority of the site was determined to be bushfire prone, generally aligning with the Map of Bush Fire Prone Areas (OBRM December 2015).

Given the vast majority of the site is considered to be bushfire prone, further consideration of bushfire risk management in relation to the proposed industrial development of the site is required, as discussed in **Section 3.5**. The post development fire hazard is assessed as generally low.

2.6 CONTEXT AND OTHER LAND USE CONSTRAINTS AND OPPORTUNITIES

2.6.1 PARMELIA GAS PIPELINE CONSTRAINTS

The Parmelia Gas Pipeline traverses the structure plan area along the north-western boundary, running parallel with the freight rail alignment (**Plan 1**). The pipeline is protected by a 15m wide easement along its full extent which restricts the development and subdivision of land within which the pipeline is located.

The WAPC's *Planning Bulletin 87: High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region* provides guidance to the requirements for subdivision and development within proximity to high pressure gas pipelines, including the Parmelia Gas Pipeline, including requirements to refer applications received within a radius of 356m from the edge of the corridor/easement, and a risk assessment and prepare a management plan where subdivision or development is considered to pose a risk to the management and operation of the pipeline infrastructure.

At the time of preparing this report Planning Bulletin 87 identified that:

- A generic 45m buffer zone would be applied to the pipeline easement where it traverses the structure plan area (Plan 1). APA Group has advised that industrial development and subdivision within this buffer area can be considered and approved based on a risk assessment which considers the risks to the operation and maintenance of the gas pipeline, and proposals within the buffer area should be discussed with the APA Group prior to submission.

- A requirement for notification of land use, development and/or subdivision proposals within 356m of the pipeline easement will be applied (Plan 1). This notification will occur through referral by the City of Gosnells or the WAPC of any subdivision or development application within 356m of the pipeline easement in accordance with the Planning Bulletin.

2.6.2 PTA RAIL INFRASTRUCTURE FACILITY

In early 2016 landowners within the structure plan area were notified by the Public Transport Authority that a portion of their land has been identified for public acquisition to accommodate the relocation of the freight rail facility currently located at Bellevue near Midland.

The area proposed for acquisition has not yet been finalised by the Public Transport Authority, but is generally in accordance with that shown in **Plan 1**. It is understood that the Public Transport Authority will negotiate acquisition of land within the identified area during 2016, and the land will thereafter be transferred to the Crown.

3 LAND USE AND SUBDIVISION REQUIREMENTS

3.1 LAND USE

The structure plan area is intended to accommodate general industrial type activities, including warehousing, distribution centres, transport depots, manufacturing and logistics.

The permissibility of uses within the precinct is subject to the 'General Industry' zone under TPS6 and the provisions of Table 1 within the Scheme.

The Rail Infrastructure Facility may contain rail infrastructure, a flash butt welding facility, maintenance aggregate storage and loading, mechanical workshop and other support buildings, depot, general storage and hardstand areas all associated with the operations and maintenance of the freight rail.

3.2 MOVEMENT NETWORKS

The Transport Assessment included in **Appendix 3** has been prepared in accordance with the Western Australia Planning Commission (WAPC) *Transport Assessment Guidelines for Developments: Volume 2 – Structure Plan (2006)* and outlines the transport aspects of Precinct 3 (incorporating Precincts 3A, 3B and Welshpool Road East Industrial Precinct) for the Maddington Kenwick Strategic Employment Area (MKSEA) and focuses on the traffic operations, access arrangements and road reservation widths within the area **(Figure 9).**

The following conclusions have been made in regard to the proposed Precinct 3 which includes the Precinct 3A Structure Plan:

- The Transport Assessment has been prepared based on the assumptions and data adopted for the entire MKSEA.
- Precinct 3 comprises a gross area of approximately 200ha of land, including 147ha of general industrial land use, 15ha for drainage and natural reserve (including Yule Brook) 17ha of road reservation and 20ha for Rail Infrastructure Facility to be utilised by the Public Transport Authority (PTA).
- Consistent with the Traffic Assessment undertaken for the entire MKSEA area, the land uses within the Precinct 3 will generate an estimated 603 trips during the AM peak hour period and 501 trips for the PM peak hour period upon full build-out of Precinct 3.
- Analysis of AIMSUN micro-simulation results for the scenarios evaluated suggest that the access options described in Scenario 2 (left-in, left-out and right-in access via intersection of Welshpool Road / Grove Road, and signalised intersection at Welshpool Road / Coldwell Road) and Scenario 3 (left-in, left-out, right-in and right-out access via intersection of Welshpool Road / Grove Road, with the intersection of Welshpool Road / Coldwell Road retaining its existing priority form but banned right-out movements), will result in acceptable LOS for all turning movements at the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road and are the most efficient operation of the entire model network.
- Scenario 3 was found to have several advantages over Scenario 2 in terms of practical considerations and is therefore the preferred access configuration to the area.

- The proposed road cross-sections will allow for the provision of on-road cycle facilities and pedestrian facilities on the verge.
- In order to facilitate the development of the proposed industrial land uses within MKSEA, it is recommended to permit RAV4 vehicles (as a minimum) on all internal MKSEA roads.

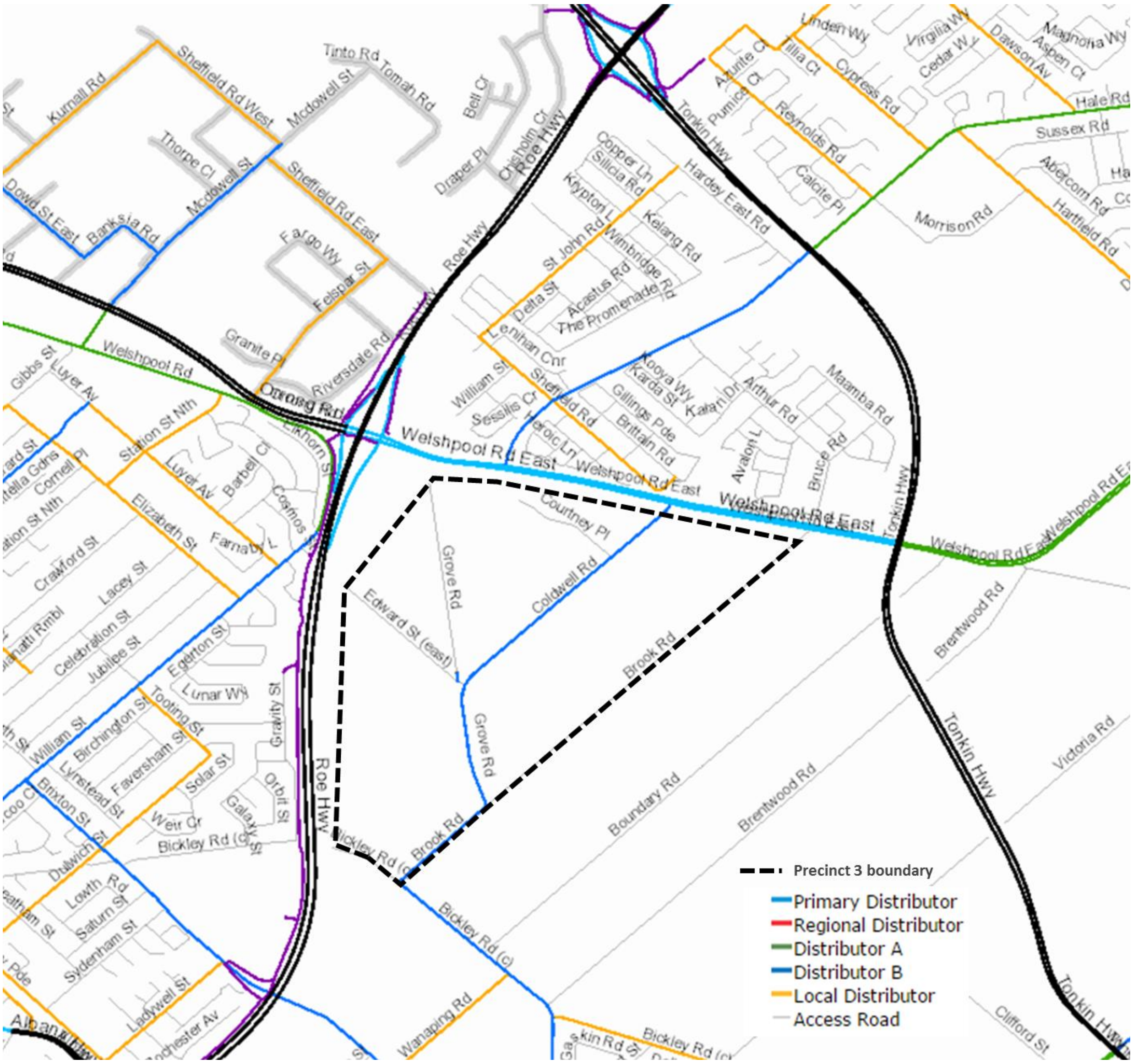

Figure 9: MKSEA Precinct 3 existing road network

3.3 WATER MANAGEMENT

The water management approach at the site aims to achieve:

- **Maintenance of the existing hydrology of the site:** Open swales are proposed that will convey upstream flows through the site as per the existing environment. These will be generally consistent with current alignments with minor amendments proposed to one discharge location to Yule Brook.

- **A sustainable approach to earthworks:** The use of open swales which generally align with the existing site hydrology allows minimal grades to be adopted within stormwater infrastructure, which is most consistent with the existing environment. While imported fill will still be required, this approach allows the import of fill to be minimised.

- **Providing adequate flood protection for future lot owners:** The earthworks approach considers the tailwater (top water level) conditions provided by the Yule Brook, existing site grades and the need to tie in with surrounding areas/landowners. Lots will all achieve appropriate separation from 100 year ARI flood levels.

- **Protecting water quality onsite and within downstream environments:** Given the flat grades across the site and low permeability underlying soils, a typical approach of retaining a nominated volume within the site is not proposed. The approach proposed was suggested by the City and discussed with DoW, and involves appropriate at source treatment with lots and in-line detention within roadside swales, rather than bio-retention areas that could cause undue groundwater mounding and create mosquito breeding habitat. Water quality treatment will be achieved by slow filtration through vegetation which will remove sediments and nutrients.

- **Avoiding impacts to groundwater levels and quality:** Groundwater quality beneath the site is varied and displays some measure of nutrients. The change of land use from agriculture to industrial will see most lots become largely impervious, and nutrient inputs will be almost entirely removed. Nutrients within the soil profile will be encapsulated by the large impervious areas, and any groundwater infiltration will have been treated via extended detention and contact with vegetation. The treatment measures proposed will protect the underlying groundwater resource. Surface conveyance swales will be set at approximately the existing surface. The elevations of these swales are driven by consideration of both predevelopment groundwater levels and the downstream discharge elevation to Yule Brook. Groundwater within road reserves and beneath lot scale treatment measures will be addressed by localise use of subsoil drains as required, however these will be more aimed at pavement integrity and will not seek to lower groundwater, but will seek to ensure that drainage infrastructure dries in an appropriate timeframe.

The above measures have been developed in consideration of the feedback provided by the Water Corporation, City of Gosnells and Department of Water, and are fully detailed in the LWMS outlined as **Appendix 4**.

3.4 UTILITY INFRASTRUCTURE

The project's civil engineering consultant, Cossill & Webley, has prepared a comprehensive engineering report outlining the existing utility infrastructure and the proposed upgrades to this infrastructure to service the structure plan area to an industrial standard. This report is included as **Appendix 5**, and a summary of the utility infrastructure advice is outlined as follows:

3.4.1 WASTEWATER

The site is located within the Water Corporation's Wattle Grove district, for which long term scheme planning has recently been updated. This planning allows for the extension of the 750mm diameter Main Sewer from the west of Roe Highway to the south of the site to collect sewer flows from the entire MKSEA area. This will then ultimately discharge into an existing sewer main downstream on Bickley Road.

Reticulated sewerage is considered an important component for the development of MKSEA which is a large strategically located industrial estate and would allow for, over time, the estate to evolve to cater for a broad range of industrial uses. The provision of reticulated sewerage would also ensure that there was no adverse impact by leaching, or other unforseen events, of contaminants into the surrounding wetlands.

The timeframes for delivery of the Water Corporation's connection to the main sewer network within the region is understood to be approximately ten (10) years away at the time of preparing this Structure Plan. An interim solution will be required to ensure that individual developers within the precinct can proceed to develop land for industrial purposes without requiring the ultimate wastewater infrastructure to be in place.

The interim solution will require that developers provide sufficient servicing for the proposed development in addition to providing reticulation infrastructure to individual lots such that connection to the main sewer, once available, can be completed quickly and without significant further cost from landowners.

The interim solution will be achieved via condition(s) of subdivision or a condition(s) of development approval (whichever comes first) to require that applicants proposing a subdivision or development likely to create additional demand for wastewater infrastructure must demonstrate adequate provision of wastewater disposal infrastructure to suitably service the proposed lots/development, preferably through:

a) The installation of local sewerage reticulation infrastructure; or alternatively

b) The installation of Aerobic Treatment Units as a component of a future development approval for any development; and / or

c) Any other design solution as may be approved by the relevant Government Agencies.

The proposed method of wastewater disposal will be subject to negotiation and compliance with the requirements of the Water Corporation and the Department of Health as a component of complying with the condition(s) referred to above which may require a temporary method of wastewater disposal, such as tankering, until such time as a connection to the broader reticulated sewerage network is available.

3.4.2 WATER RETICULATION

Water supply to the area will be via the existing infrastructure within and adjacent to Precinct 3A. It is likely that existing mains will need to be upgraded to cater for the proposed development. Standard Water Corporation water headworks will apply to the development.

3.4.3 ELECTRICAL POWER SUPPLY

There is existing high voltage overhead power running along Welshpool Road abutting the site. Initial investigations indicate that there is sufficient capacity within this network to cater for the proposed development.

Undergrounding of the existing internal overhead power supply network along Coldwell Road and a portion of Grove Road will be required. Existing overhead power lines in Edwards Road and portion of Grove Road to be closed will be relocated. In addition a series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements.

3.4.4 GAS SUPPLY

The existing 225mm diameter high pressure gas main along Coldwell Road may require to be raised to coincide with the developed earthworks levels.

It is not intended to provide a gas supply to the development. However, future investigations into connecting to the Coldwell Road gas main may determine a supply is possible if it is deemed to be required.

3.4.5 TELECOMMUNICATIONS

The site is within NBN Co's fixed line footprint, and hence can be serviced with optic fibre under their roll-out scheme for greenfield developments.

Under the Federal Government's new Telecommunications in New Developments Policy, developers are responsible for contributing to the cost of delivering the nbn™ network in new developments. This includes contributing to part of the costs of the build (civils and any backhaul required) as well as a per lot deployment change.

The current design practice for road reserves, pavement and verge provisions will make adequate allowance for services including broadband in accordance with the agreed Utilities Service Providers handbook. There will be some local land requirements for equipment sites, similar to current provisions which will be accommodated at detailed subdivision stage.

3.5 BUSHFIRE REQUIREMENTS

As outlined in **Section 2.4**, areas within and adjacent to the site are identified as bushfire prone. The implementation of the Structure Plan will result in the removal of the majority of vegetation within the site, and as such reduce the bushfire hazard of the site to 'low'. Areas of vegetation within the Roe Highway road reserve and Woodlupine Brook Reserve are not expected to be cleared as such, maintain an 'extreme' bushfire hazard.

In order to mitigate the bushfire risk within the site, the Structure Plan has been designed to address the bushfire protection criteria set out in Appendix 4 of the *Guidelines for Planning in Bushfire Prone Areas*. This is discussed in detail in the BMP (**Appendix 2**) and includes the following considerations:

- **Location**. Future industrial development within the site can be located and designed in such a way that bushfire hazard within 20 m of a future industrial facility will be low.
- **Vehicular access**. The proposed road network provides two access points to the site at all times in the form of public roads, for use by the public and emergency personnel. The requirement for the preparation of an Emergency Evacuation Plan is also likely to be imposed for industrial facilities as part of the building licence process, which should consider the bushfire considerations outlined in the BMP.
- **Water**. The site will be supplied with scheme water for potable and non-potable uses, in addition to fire hydrants. This will provide a suitable water source for fire response services in the event of a bushfire emergency within the site.
- **Siting and design of development**. Bushfire hazards will be mitigated through the provision of a minimum 20m Asset Protection Zone (APZ) adjacent to areas of permanent classified vegetation, which is

accommodated within the adjacent freight railway reserve. As such, no spatial requirement to accommodate an APZ within the site is required. Based on the industrial land use proposed in the Structure Plan, increased construction standards detailed in AS 3959 are not applicable and as such no Bushfire Attack Level considerations are required for the site.

By considering bushfire hazard management elements detailed in SPP 3.7 and the *Guidelines for Planning in Bushfire Prone Areas* in the early stage of planning process, the Structure Plan has been able to incorporate bushfire hazard management considerations into the design of the development. This ensures that bushfire risk to life, property and emergency response personnel is reduced.

3.6 PARMELIA GAS PIPELINE INFRASTRUCTURE

As outlined in Section 2.6.1, the Parmelia Gas Pipeline traverses the north-west of the subject area within a 15m wide easement immediately abutting the freight rail alignment. In preparing applications for subdivision and development applicants should note the WAPC's *Planning Bulleting 87: High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region*, along with advice provided by the APA Group which is summarised as follows:

a) A Quantitative Risk Assessment is not likely to be required to support development applications that propose development outside of the easement area.

b) A Qualitative Risk Assessment will be required to support subdivision or development of land for industrial or commercial purposes within a 45m buffer of the easement area. This buffer distance may be amended where a proposed development or subdivision is of an intensity or use that is considered to pose a risk to the operation of pipeline.

c) Subject to the outcome of the Qualitative Risk Assessment, the easement area may be approved for specified uses provided that:

    i) A subterranean reinforced concrete cover is installed to the specifications and satisfaction of the APA Group; and

    ii) Uses do not restrict direct access or line of sight to the easement area.

d) Surface water drainage infrastructure, either for the purpose of conveyance or storage, will not be permitted within the easement area.

3.7 INFRASTRUCTURE COORDINATION, SERVICING AND STAGING

While actual development within the structure plan area will be subject to private developer intent, it is anticipated that initial development will occur between Coldwell Road and the realigned Grove Road, and thereafter expand to the area west of the realigned Grove Road, as shown in **Figure 10.** Each stage will require subdividers/developers to upgrade necessary service infrastructure and roads and provide drainage in accordance with their conditions of approval.

The staging of upgrades to intersections of Grove Road / Welshpool Road East, Coldwell Road / Welshpool Road East and provision of sewer outlet infrastructure to support the development area will be in accordance with the Development Contributions Plan.

3.8 DEVELOPER CONTRIBUTIONS ARRANGEMENTS

A development contributions plan has been prepared in accordance with amendment 167 to *Town Planning Scheme No. 6.*

Once this amendment is approved and published in the *Government Gazette* landowners will become liable for payment of development contributions upon subdivision or development of their land in accordance with the provisions of clause 6.4.13 of *Town Planning Scheme No. 6.*

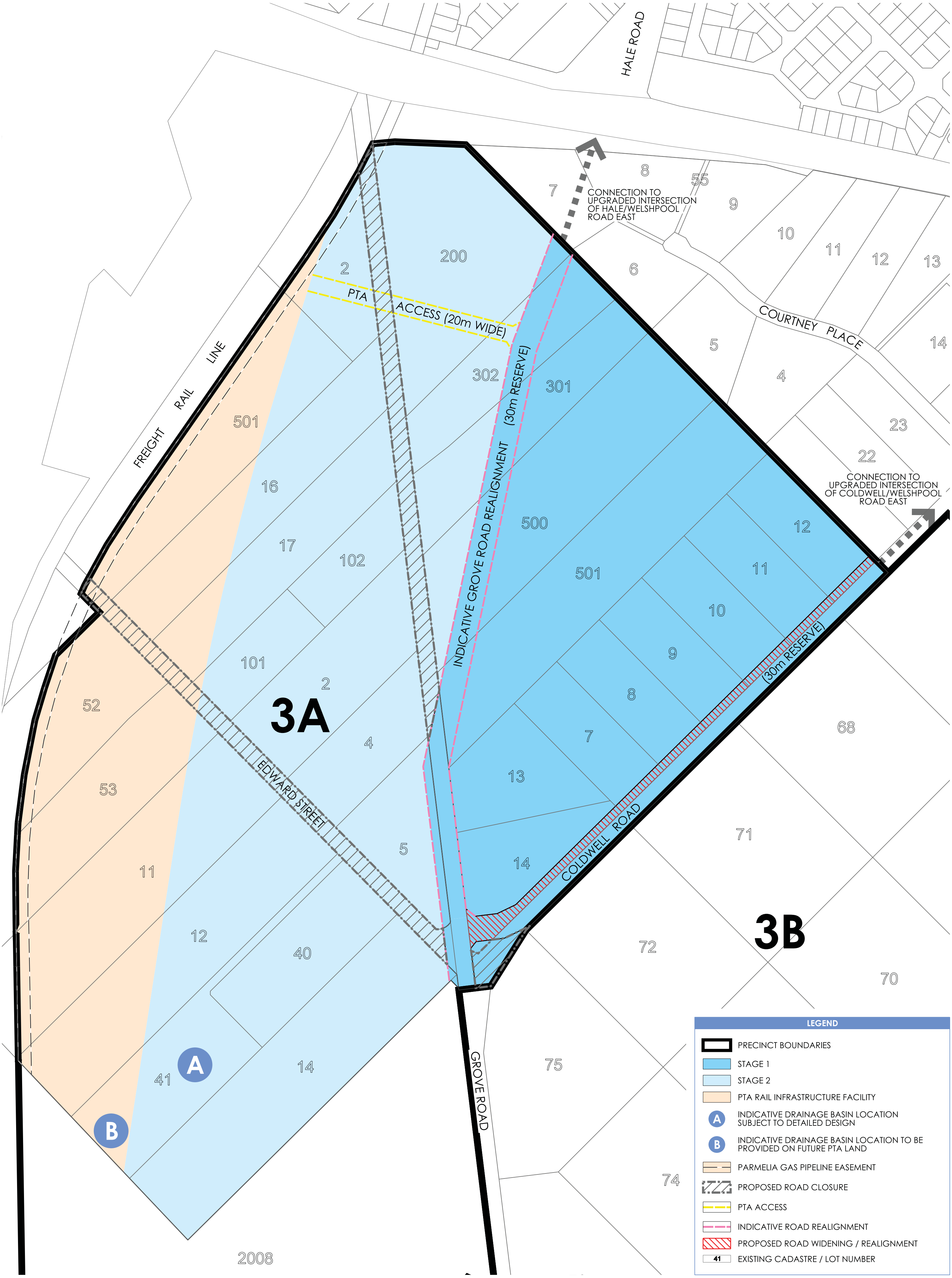

FIGURE 10 - INDICTIVE STAGING PLAN - PRECINCT 3A

Maddington - Kenwick Strategic Empolyment Area - Precinct 3A

A Linc Property Project

N 0m 20 40 60m

s: 1:4000@A3
d: 6 July 2016
p: 15/073/054A

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APPENDIX 1
ENVIRONMENTAL ASSESSMENT AND MANAGEMENT STRATEGY

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT STRATEGY

MKSEA PRECINCT 3A STRUCTURE PLAN

Project Number EP14-056(05)

Prepared for Linc Property Pty Ltd
June 2016

Document Control

DOC NAME	ENVIRONMENTAL ASSESSMENT AND MANAGEMENT STRATEGY MKSEA PRECINCT 3A STRUCTURE PLAN				
DOC NO.	EP14-056(05)--008				
REVISION	DATE	AUTHOR		REVIEWER	
1	December 2015	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Draft sent to client for review.				
A	January 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Updated following comments from client.				
B	March 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised to align with updated Structure Plan.				
C	April 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Updated following comments from client.				
D	May 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised to align with updated Structure Plan.				
E	June 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised address City of Gosnells comments.				

Executive Summary

Linc Property Pty Ltd (Linc Property) have prepared a Structure Plan to guide industrial development across Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA) (herein referred to as 'the site'). Emerge Associates were engaged to provide a suite of environmental consultancy services to support the preparation of the Structure Plan.

The site incorporates an area of 72.6 hectares and is located approximately 12 km south east of the Perth Central Business District. The site is zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and City of Gosnells (CoG) Town Planning Scheme No. 6 respectively. The site is currently being rezoned to 'Industrial' under the MRS concurrently with adjoining areas, and is proposed for industrial development through the implementation of the Structure Plan. This is in accordance with the strategic planning framework, specifically the *Economic and Employment Lands Strategy: non-heavy industrial* (WAPC 2012), the *Draft Perth and Peel@3.5 Million* (WAPC 2015b) and the associated *Draft South Metropolitan Peel Sub-regional Planning Framework* (WAPC 2015a), all of which identify the MKSEA for future industrial development.

This EAMS provides a synthesis of information from a range of sources regarding any potential environmental features, attributes and values of the site. It is based on publically available information, in addition to site specific assessments and investigations. Based on this information, the environmental attributes and values identified within the site have been outlined in **Section 2** and are summarised as follows:

- The site is currently used for a combination of general rural, rural residential and light industrial land uses.
- The site is generally flat and low-lying, with elevation ranging from approximately 9 m Australian Height Datum (AHD) in the south-west to 13 m AHD in the north-east.
- Regional ASS risk mapping indicates that the site is classified as having a moderate to low risk of ASS occurring within three metres of the natural soil surface.
- The majority of the site was historically cleared to support agricultural land uses. Existing vegetation within the site is primarily comprised of planted, non-endemic species, in addition to small areas of remnant vegetation and scattered trees.
- The vast majority of vegetation is in 'Completely Degraded' condition, with some remnant areas in 'Degraded' condition. Identified plant communities within the site are highly disturbed, absent of native understorey species and are subject to weed invasion.
- Based on current and historic surveys, no conservation significant flora or ecological communities have been recorded as occurring within the site.
- Given the degraded nature of vegetation within the site, fauna habitat values within the site are generally limited. Notwithstanding, the site does contain some limited areas of black cockatoo habitat. Foraging evidence of two threatened species of black cockatoo was observed within the site, however the foraging habitat is not considered to represent quality habitat as it is degraded, scattered and limited in representation of known foraging habitat species.
- Minimal separation between surface levels and groundwater occurs across the site, with the majority of the site mapped as a Multiple Use Wetland (DPaW 2015).
- No natural surface water features occur within the site. Yule Brook is located approximately 150 m south east of the site, however will not directly impact upon development within the site.
- One 'Lodged' Aboriginal heritage site (scatter) is mapped by the Department of Aboriginal Affairs as occurring within the site. Based on a review of the original survey report, it was determined that the actual location of the heritage site and associated heritage values occurs outside of the site.

- The Dongara-Pinjarra regional gas pipeline occurs along the north-western boundary of the site.
- The site is regionally mapped as a 'Bushfire Prone Area' in the state-wide *Map of Bush Fire Prone Areas* (OBRM 2015) and as such statutory requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* apply to development within the site.

The environmental attributes and values identified within the site have been outlined in **Section 2**. The proposed Structure Plan has responded to the environmental attributes and values of the site, as discussed in **Section 4**, through specific provisions for the:

- Accommodation of the Dongara-Pinjarra regional gas pipeline easement along the western boundary of the Structure Plan.
- Preparation of a *Local Water Management Strategy* to address the stormwater management requirements of the proposed development.
- Preparation of a *Bushfire Management Plan* to demonstrate how the proposed development meets the established bushfire protection criteria.

In addition to the above, the structure planning process has accommodated the requirements of the local environmental planning framework, set out in *Local Planning Policy 5.8 Maddington Kenwick Strategic Employment Area Planning Framework*, as detailed in **Table 1**.

Table 1: MKSEA environmental planning framework, adapted from Table 1 of LPP 5.8 (CoG 2014)

REQUIRED INFORMATION TO SUPPORT A STRUCTURE PLAN	HOW THIS REQUIREMENT HAS BEEN ADDRESSED
Preparation of a Local Water Management Strategy in accordance with Better Urban Water Management Principles.	A *Local Water Management Strategy* (Emerge Associates 2016) has been prepared for Precinct 3A.
Wetland studies and management strategies.	The wetland characteristics of the site are detailed in this EAMS, with management strategies specified in **Section 4.5**.
Buffer definition studies for wetlands, threatened ecological communities (TECs) and other conservation assets.	No environmental assets of conservation significance are identified as occurring within the site and as such no buffers are required. This is discussed further in this EAMS.
TEC and other conservation value vegetation management plans.	No vegetation of conservation value is identified as occurring within the site, notwithstanding vegetation management strategies for the site are discussed in **Section 4.2**.
Odour, noise and dust management strategy to address appropriate separation distances between proposed industrial development and sensitive land uses, including the intended approach to removal of sensitive land uses within the MKSEA to avoid land use conflict and constraints to development.	**Section 4.7** of this EAMS addresses how potential impacts on adjacent sensitive land uses as a result of industrial development within the site will be managed through the development process.
Fire Management Planning for the protection and management of natural assets, and the protection of the adjoining built environment.	Addressed through the preparation of a *Bushfire Management Plan* (Emerge Associates 2016), provided as **Appendix D**.
A Structure Plan that clearly provides for the conservation and protection of important natural assets, and incorporates recommended initiatives from the above studies and plans, including ecological linkages.	**Section 4** of this EAMS discusses how the Structure Plan has responded to the identified environmental values within the site.

This document outlines the proposed environmental management framework to manage environmental values of the site as part of future planning stages. The key future management considerations are discussed in **Section 4** and include:

- Preparation of an *Urban Water Management Plan(s)* or a *Stormwater Management Plan* to support subdivision or development respectively, to demonstrate how groundwater and surface water are appropriately managed in accordance with the framework set out in the LWMS.
- Importation of clean sand fill across the site to achieve suitable clearance between final surface levels and groundwater.
- If it is deemed to be required, consideration of acid sulfate soils risk through the completion of an *Acid Sulfate Soils Self-Assessment Form* as part of subdivision.
- Updating of the *Bushfire Management Plan* prepared to support the Structure Plan as required, to support future subdivision or development.

Overall, the Structure Plan provides for the proposed industrial development of the site in accordance with the established strategic planning framework. The spatial considerations of the Structure Plan and proposed management measures set out in this EAMS, in addition to the established statutory planning framework, ensures that future development within the site suitably accommodates the existing environmental values of the site and will not incur any significant environmental impacts.

Based on the findings of the EAMS, the following recommendations are made in relation to the finalisation of the Structure Plan and subsequent subdivision and development:

- There are no significant environmental values that would constrain the proposed industrial uses.
- Future subdivision and development should accommodate the Dongara-Pinjarra regional gas pipeline easement, including the undertaking of qualitative risk assessment(s) to identify any required easement setback.
- The implementation of bushfire mitigation strategies in accordance with the *Bushfire Management Plan,* including consideration of any changes to the plan through the subdivision and development process as required.

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Appendices

1 Introduction

1.1 Background

Linc Property Pty Ltd (Linc Property) have prepared a Structure Plan to guide industrial development across Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA). Precinct 3A of the MKSEA, herein referred to as 'the site', forms the north-western portion of the MKSEA, which incorporates three precincts covering a total area of over 600 ha, as shown in **Figure 1**. The site incorporates 29 individual lots, the cadastral boundaries of which are shown in **Figure 2**.

The site is currently zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and City of Gosnells (CoG) Town Planning Scheme (TPS) No. 6 respectively, as shown in **Figure 3**. An amendment to the MRS (no. 1302/57) is currently being progressed by the Western Australian Planning Commission (WAPC) to rezone the site to 'Industrial'. A local scheme amendment to rezone the site to 'General Industry' has recently been initiated by the CoG.

The proposed industrial development set out in the proposed Structure Plan is in accordance with the strategic, regional and local planning frameworks, which identify the MKSEA for future industrial land uses, discussed further in **Section 1.4**.

1.2 Scope of work

Linc Property commissioned Emerge Associates (Emerge) to undertake an environmental assessment to document the existing environmental attributes and values of the site and ensure any relevant environmental values can be accommodated within the Structure Plan, as well as through the future stages of development within the site.

In addition to the preparation of this *Environmental Assessment and Management Strategy* (EAMS), Emerge have prepared or commissioned the following documents to support the proposed Structure Plan:

- *Flora and Vegetation Assessment* (Emerge Associates 2016) (**Appendix A**)
- *Fauna Assessment* (Harewood 2016) (**Appendix B**)
- *Bushfire Management Plan* (Emerge Associates 2016) (**Appendix D**)
- *Local Water Management Strategy* (Emerge Associates 2016)

1.3 Purpose of this report

This report provides a synthesis of information regarding the environmental attributes and values of the site. It is based on a range of information sources including local and regional reports, databases and publically available mapping, and where existing or required, site specific investigations. Together, this information has been used to inform the layout of the Structure Plan and the preparation of the supporting documentation for the development of the site.

Specifically, this EAMS provides a summary of the environmental attributes and any values found within the site and addresses the proposed development of the site as defined by the Structure Plan. It specifies the environmental management framework for the future development process.

The EAMS is the key supporting environmental document for the Structure Plan process, to ultimately facilitate the consideration of any environmental issues by the various state government agencies and authorities. It is consistent with the Environmental Protection Authority's (EPA) current *Guidance Statement No. 33 Environmental Guidance for Planning and Development* and the *Structure Plan Framework* (WAPC 2015d) and includes:

- Identification of any potentially significant environmental features (**Section 2**).
- Management strategies specific to any identified environmental feature within the Structure Plan area (**Section 4**).
- Opportunities for enhancement of the environmental features and issues to address at later stages of development (**Section 4**).

1.4 Planning and environmental assessment context

1.4.1 Regional planning framework

The State Government has identified the MKSEA for future industrial development through the strategic land use planning framework. Specifically, the *Economic and Employment Lands Strategy: non-heavy industrial* (WAPC 2012), which guides non-heavy industrial development across the Perth and Peel regions, outlined the MKSEA as being suitable as a 'potential non-heavy industrial area'. On this basis, the recently released *Draft Perth and Peel@3.5 Million* (WAPC 2015b) and the associated *Draft South Metropolitan Peel Sub-regional Planning Framework* (WAPC 2015a), which are intended to act as a strategic plan for future land use development across the region, identified the MKSEA for 'industrial expansion'. As such, the proposed development of the site for industrial land uses is consistent with the regional planning framework.

In order to facilitate the proposed industrial development of the MKSEA, three MRS amendments have been concurrently initiated to rezone various portions of the MKSEA from 'Rural' to 'Industrial':

- MRS amendment 1300/57 – portion of MKSEA within the Shire of Kalamunda.
- MRS amendment 1301/57 – MKSEA Precinct 2.
- **MRS amendment 1302/57 – MKSEA Precincts 3A and 3B.**

MRS amendment 1302/57 is applicable to the site and was initiated in 2015. The WAPC referred the three proposed scheme amendments to the Environmental Protection Authority (EPA) to determine whether environmental assessment under Part IV of the *Environmental Protection Act 1986* (EP Act) was required. In Western Australia, all proposed amendments to local and regional planning schemes are required to be referred to the EPA for this determination pursuant to Section 38 of the *Planning and Development Act 2005*. The EPA advised the WAPC that the proposed scheme amendments did not require formal assessment, however provided advice and recommendations regarding the following environmental factors:

- Flora and vegetation
- Inland waters environmental quality.

This advice was provided primarily in relation to natural areas adjacent to Yule Brook, which is not located within the site and such are generally not applicable to the proposed industrial development of the site. Notwithstanding this, the advice and recommendations provided by the EPA have been considered during the preparation of the Structure Plan, discussed in **Sections 3** and **4**.

1.4.2 Local planning framework

The CoG have coordinated the initial phases of the planning and development process across the MKSEA, undertaking a range of preliminary studies and investigations to demonstrate the feasibility of the proposed industrial development. Based on the outcomes of these investigations, the CoG prepared an Indicative Local Structure Plan (LSP) in August 2014 to provide a conceptual spatial framework to guide industrial development across the MKSEA.

Local Planning Policy 5.8 Maddington Kenwick Strategic Employment Area Planning Framework (LPP 5.8) has been prepared by the CoG to guide the future phases of the planning and development process within the MKSEA. In accordance with LPP 5.8, a Structure Plan is to be prepared for each precinct of the MKSEA, which should be informed by the Indicative LSP design. Following the approval of a Structure Plan, industrial development will be achieved through subdivision approvals and/or development applications, in accordance with the approved Structure Plan layout.

Section 3 discusses how the requirements of LPP 5.8 have been considered during the preparation of the proposed Structure Plan and those which will be addressed at future stages of the development process.

2 Description of Existing Environment

The CoG have previously commissioned a range of studies and investigations across the broader MKSEA to support the MRS rezoning process, in order to understand the environmental attributes and values of the area and to ensure the acceptability of any industrial development that is planned for. These included consideration and investigation of Precinct 3A. The various reports associated with these investigations include:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *MKSEA Engineering Feasibility Study* (GHD 2005)
- *MKSEA Preliminary Transport Study* (Cardno BSD 2006)
- *MKSEA Surface Water and Groundwater Investigation and Monitoring Program* (Aquaterra 2008)
- *Preliminary Investigation of Aboriginal Heritage – City of Gosnells MKSEA* (ACHM 2009)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)
- *Black Cockatoo Survey - MKSEA* (360 Environmental 2012)
- *MKSEA Surface Water and Groundwater Monitoring and Investigation Report* (Endemic 2012)
- *District Water Management Strategy MKSEA Precincts 2 and 3* (TME 2014)
- *MKSEA Bushfire Hazard Assessment* (Eco Logical 2014)

The outcomes of these investigations, in addition to further site-specific targeted investigations undertaken by Emerge, have informed the identification and assessment of the existing environmental attributes and values within the site and are discussed further below.

2.1 Local context

The site is situated in the eastern portion of the Swan Coastal Plain, within the locality of Kenwick approximately 4 km west of the Darling Escarpment. The locality is characterised by a mixture of residential, industrial and rural land uses, in addition to regionally and locally significant environmental values within the Greater Brixton Street Wetlands.

The site is located within the CoG approximately 12 km south-east of the Perth Central Business District, as shown in **Figure 1**. The site comprises a total area of 72.6 ha and is generally bound by Coldwell Road, rural-residential land uses along Courtney Place, Roe Highway and the adjacent freight railway line, as shown in **Figure 2**.

The site is currently used for a combination of general rural, rural residential and light industrial land uses. The majority of the site was historically cleared to support agricultural land uses. Existing vegetation within the site is primarily comprised of planted, non-endemic species, in addition to small areas of remnant vegetation and scattered trees.

2.2 Climate

The climate of the site (which applies to the wider Perth metropolitan region) is described as Mediterranean, with hot, dry summers and moderately wet, mild winters. The majority of rainfall within the region occurs between May and October each year, and is generally between 600 to 1000 millimetres annually. However, in the last 40 years there has been a marked decrease in rainfall, with a noticeable shift to a drier climate across the south-west of Western Australia (CSIRO 2009).

The closest weather station to the site which records rainfall and temperature data is located within the CoG (Bureau of Meteorology (BoM) station number 9106) approximately 3 km south of the site. Based on weather data collected from 1961 to 2015, the area receives an average of 825 mm of annual rainfall, as detailed in **Table 2** below. Temperature data is also recorded, indicating a mean annual maximum temperature of 25.6˚C and a mean annual minimum temperature of 13.4˚C (BoM 2015).

Table 2: Mean annual rainfall from 1961-2015 in the City of Gosnells (BoM 2015)

CITY OF GOSNELLS	MONTH												
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Mean rainfall (mm)	11.6	14.6	16.8	43.7	104.3	169.0	160.7	125.8	82.7	45.8	29.7	11.4	**824.9**

2.3 Topography, landforms and soils

2.3.1 Topography

The site is generally flat and low-lying, with elevation ranging from approximately 9 m Australian Height Datum (AHD) in the south west to 13 m AHD in the north east (DoW 2008). On this basis, the site has a gentle south-westerly aspect.

Topographical contours are shown in **Figure 4**, indicating the elevation characteristics of the site.

2.3.2 Regional geomorphology

The Swan Coastal Plain is generally flat and is approximately 20 to 30 km wide, consisting of a series of geomorphic entities aligned parallel to the coast. These geomorphic entities consist of three dunal formations of aeolian origin, followed by an alluvial zone known as the Pinjarra Plain, which consists of clayey alluvium that has been transported by rivers and streams from the adjacent Darling Escarpment (McPherson and Jones 2005). The site is situated on the Pinjarra Plain, in the eastern extent of the Swan Coastal Plain, close to the Darling Escarpment.

2.3.3 Landforms and soils

The majority of the site is situated within the Guildford soil-landform formation, which is described as a flat plain with medium textured deposits and yellow duplex soils. The northern-most portion of the site is mapped as the Southern River soil-landform formation, which is described as a sandplain with low dunes and many intervening swamps (Churchward and McArthur 1980).

2.3.4 Surface soils and geology

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986), indicates the site is comprised of:

- Clayey sand (Sc): silty in part, pale grey-brown, medium to coarse, poorly sorted, sub-angular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin.
- Sand (S_{10}): white to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin, over other units.

The mapped extent of the above soils units across the site is shown in **Figure 5**.

As part of preliminary groundwater investigations across the wider area, Endemic (2012) observed occurrences of sub-cropping calcrete at shallow depths during bore installations, in addition to occurrences of exposed calcrete within roadside drains. These observations were made within the adjacent Precinct 3B of the MKSEA, south-east of the site. Endemic hypothesised that the occurrence of sub-cropping calcrete was concentrated within Precinct 3B of the MKSEA in proximity to the Greater Brixton Street Wetlands, outside of the site.

2.3.5 Acid sulfate soils

Acid sulfate soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide materials. In their natural state ASS are generally present in waterlogged anoxic conditions and do not present any risk to the environment. When oxidised, ASS produce sulphuric acid, which can present risks to the environment, infrastructure and human health.

Regional ASS risk mapping (DER 2006) indicates that the site is classified as having a moderate to low risk of ASS occurring within three metres of the natural soil surface, as shown in **Figure 6**.

2.4 Biodiversity and natural assets

2.4.1 Flora and vegetation

2.4.1.1 Regional context

The site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by Beard (1990). This region is characterised by *Banksia* low woodlands on leached sands, woodlands of *Eucalyptus gomphocephala* (tuart), *Eucalyptus marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils and *Melaleuca* spp. swamps.

At a finer scale, vegetation complex mapping undertaken by Heddle *et al.* (1980) for the Swan Coastal Plain, indicates that the site primarily occurs within the Guildford complex (Pinjarra Plain). Some of the northern most lots are mapped as comprising the Southern River complex, which is a transitional complex between the Bassendean dunes and the Pinjarra Plain. The descriptions of both vegetation complexes are detailed in **Table 3**.

Table 3: Regional vegetation complex descriptions (Heddle et al. 1980)

COMPLEX	DESCRIPTION
Guildford	Vegetation is characterised by a mixture of open forest to tall open forest of marri, *Eucalyptus wandoo* (wandoo), jarrah and woodland of wandoo (with rare occurrences of *Eucalyptus lane-poolei*). Minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla*
Southern River	Vegetation includes open woodland of marri, jarrah and *Banksia* spp. with fringing woodland of *Eucalyptus rudis - Melaleuca rhaphiophylla* along creek beds.

The EPA's *Guidance Statement No. 10 Level of Assessment for Proposals Affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region* (2006) identifies a target for native vegetation retention of at least 10% of the original extent of each vegetation complex within 'constrained areas' of the Swan Coastal Plain. 'Constrained areas' may include lands zoned for urban, urban deferred or industrial development (EPA 2006).

Recently released statistics from the EPA indicate that approximately 5.9% of the original extent of the Guildford complex and 19.7% of the original extent of the Southern River complex remains across the Swan Coastal Plain. The high clearing rate of the Guildford complex is associated with its geographical distribution within the Pinjarra Plain, as this eastern portion of the Swan Coastal Plain has been subject to extensive historical clearing to support agricultural land uses. Consequently, vegetation complexes occurring within this physiographic region are generally poorly represented.

Whilst the site is mapped within the boundary of the Guildford complex, vegetation within the site is not considered to be representative of this vegetation complex given the extent of historical disturbance, which has led to a significant reduction in the condition and extent of intact vegetation, discussed in detail further below.

The eastern extent of the Swan Coastal Plain is known to contain a range of conservation significant values, including conservation significant intact remnant plant communities and flora species. The local and regional significance of these values has been further accentuated by the extensive historical clearing undertaken across the region. This regional context has informed the surveying and assessment of flora and vegetation values within the site, discussed further below.

2.4.1.2 Previous surveys and site-specific investigations

Two flora and vegetation surveys incorporating the site have previously been undertaken, both of which surveyed the entirety of the MKSEA, including:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)

The findings of both surveys are summarised below and have been considered during the preparation of the Structure Plan. This informed the decision to undertake an additional site specific flora and vegetation survey in order to gain a thorough understanding of such values within the site, and to address any ambiguity and/or perceived data gaps of the previous surveys.

An additional survey was undertaken by Emerge Associates in December 2015 and involved the assessment of all flora and vegetation values within the site. Where access to some lots was not available, flora and vegetation values were assessed from adjacent properties, fence-lines and road reserves, and is discussed further in the *Flora and Vegetation Assessment* (Emerge Associates 2015). The findings of the survey have been summarised for the purpose of this EAMS, as discussed below.

2.4.1.3 Vegetation condition

Vegetation condition within the site was assessed in accordance with the Keighery (1994) scale, as detailed in **Table 4**, a vegetation condition scale commonly used within the Perth Metropolitan Region, which is also appropriate for other urbanized and agricultural areas.

Table 4: Vegetation condition scale (Keighery 1994)

VEGETATION CONDITION	DEFINITION
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.

VEGETATION CONDITION	DEFINITION
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

The vast majority of the site is considered to be in 'Completely Degraded' condition as a result of historical clearing of vegetation to facilitate historical and existing land uses. Some isolated patches of remnant vegetation in the south east of the site are considered to be in 'Degraded' condition, which have been subject to partial clearing, have low species diversity and high levels of weed invasion. Vegetation condition across the site is shown in **Figure 7**.

A number of invasive weeds, mostly grasses, were identified within the site. One 'declared pest', *Echium plantagineum* (Paterson's curse), as listed pursuant to the *Biosecurity and Agriculture Management Act 2007* was recorded. This species was observed to be scattered throughout the site in low densities.

No native understorey species were observed to occur within any of the plant communities identified within the site. The effects of weed invasion are evident across the site in areas of native vegetation where disturbance to the understorey has resulted in replacement with invasive species. Grasses such as *Ehrharta calycina* and *Cynodon dactylon* may invade disturbed areas quickly and out compete native species.

2.4.1.4 Significant flora

At a Commonwealth level, flora species can be considered 'threatened' pursuant to Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the EPBC Act, threatened species are listed as 'critically endangered', 'endangered' or 'vulnerable'. Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment.

At a state level, plant species are classed 'threatened' ('declared rare') or 'priority' conservation status where populations are restricted geographically or threatened by local processes. DPaW recognise these threats and subsequently considers population protection and species conservation. DPaW enforces the *Wildlife Conservation Act 1950* (WC Act) to conserve threatened flora and protect populations. Priority flora species are potentially rare or threatened and are classified in order of threat, but are not afforded statutory protection.

Based on a review of historical records provided in Commonwealth and state flora databases, the eastern margin of the Swan Coastal Plain is known to support a range of populations of threatened and priority flora species. On this basis, targeted searches for such species have been undertaken across the MKSEA and specifically within the site to ensure no such values occur.

No occurrences of threatened or priority flora were recorded within the site by Cardno BSD (2005) during their flora and vegetation survey of the MKSEA. The results of the Tauss and Weston (2010) survey relating to identified threatened and priority flora occurrences were withheld from the publically available report. As a result, Emerge Associates liaised directly with the City of Gosnells in February 2016 to review the full report in person, which confirmed that Tauss and Weston (2010) did not record any occurrences of threatened or priority flora within the site.

Prior to the undertaking of the December 2015 field survey, Emerge Associates also completed a detailed review of previous studies and federal and state threatened and priority flora databases to understand which flora species of conservation significance are known to occur in the wider region, and there may potentially occur within the site. Based on this process, 70 conservation significant taxa (i.e. listed as threatened or priority species) were identified as occurring in the wider region, as specified in the *Flora and Vegetation Assessment* (**Appendix A**).

The December 2015 field survey of the site conducted by Emerge Associates did not record any occurrences of threatened or priority flora species.

2.4.1.5 Plant communities

Cardno BSD (2005) did not identify any remnant plant communities as occurring within the site, and broadly described the vegetation within the site as cleared or mostly cleared.

The additional field survey undertaken by Emerge Associates in December 2015 involved the assessment of vegetation to identify any plant communities occurring within the site. Six plant communities were identified, including native remnants in addition to areas of cleared or planted vegetation. The identified plant communities are described in **Table 5** and their extent across the site is shown in **Figure 8**.

Table 5: Plant communities identified within the site.

PLANT COMMUNITY	DESCRIPTION	AREA	CONDITION
BmNf	Emergent *Corymbia calophylla* over open woodland of *Banksia menziesii* and *Nuytsia floribunda* over open shrubland of *Xanthorrhoea preissii, Macrozamia riedlei* and *Eremaea pauciflora* subsp. *pauciflora* over grassland of pasture weeds	0.06 ha	Degraded
Cc	Open woodland to open forest of *Corymbia calophylla* over closed grassland of pasture weeds	3.68 ha	Completely Degraded
Er	Open woodland to woodland of *Eucalyptus rudis* over closed grassland of pasture weeds	0.39 ha	Completed Degraded
Mr	Shrubland to low woodland of *Melaleuca rhaphiophylla* (with opportunistic *Eucalyptus rudis*) over grassland of pasture weeds	0.25 ha	Degraded
XpM	Shrubland of *Xanthorrhoea preissii* over low shrubland of *Melaleuca* sp., *Eremaea pauciflora* subsp. *pauciflora* and *Stirlingia latifolia* over grassland of pasture weeds	0.03 ha	Degraded
Cleared/planted	Parkland cleared or planted vegetation over pasture weeds	68.16 ha	Completely Degraded

2.4.1.6 Threatened and Priority Ecological Communities

Generally, ecological communities can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole provide many of the processes which support a specific ecosystem. Threatened Ecological Communities (TECs) are recognised as specific ecological communities that are rare or under threat.

Selected TECs are afforded statutory protection at a federal level under section 181 of the EPBC Act. TECs nominated for listing under the EPBC Act are considered by the Threatened Species Scientific Committee and a final decision is made by the Minister of the Environment. Once listed under the EPBC Act, communities are categorised as either 'critically endangered' (CE), 'endangered' (EN) or 'vulnerable' (VU). Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment.

Within Western Australia, TECs are determined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee and endorsed by the Minister for the Environment. While TECs are not afforded direct statutory protection at a state level (unlike threatened flora under the WC Act) their significance is acknowledged through other state environmental approval processes such as the Environmental Impact Assessment pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the Part V of the EP Act and associated clearing regulations.

In addition to listing as a TEC, a community may be listed as a 'Priority Ecological Community' (PEC). This is an ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined.

Based on historical records provided in federal and state threatened and priority ecological community databases, the eastern margin of the Swan Coastal Plain is known to support a range of TECs and PECs. On this basis, targeted searches for such communities have been undertaken across the MKSEA and specifically within the site to ensure no such values occur.

Cardno BSD (2005) did not identify any remnant plant communities as occurring within the site, and as such no TECs or PECs were inferred to occur. The results of the Tauss and Weston (2010) survey relating to occurrences of TECs and PECs was withheld from the publically available report. As a result, Emerge Associates liaised directly with the City of Gosnells in February 2016 to review the full report in person, which confirmed that Tauss and Weston (2010) did not record any occurrences of TECs or PECs within the site.

Prior to the undertaking of the December 2015 field survey, Emerge Associates also completed a detailed review of previous studies and Commonwealth and state TEC and PEC databases to understand which TECs and PECs are known to occur in proximity to the site, and as such could potentially occur within the site. Based on this process, seven TECs and two PECs were identified as occurring in the wider local area, as detailed in **Table 6**.

Table 6: TECs and PECs known to occur within the wider local area.

COMMUNITY CODE	COMMUNITY NAME	TEC/PEC	LEVEL OF SIGNIFICANCE	
			STATE	EPBC ACT LISTED
SCP3a	*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain	TEC	CE	E
SCP3c	*Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	TEC	CE	E
SCP20c	Shrublands and woodlands of the eastern side of the Swan Coastal Plain	TEC	CE	E
Muchea Limestone	Shrublands and woodlands on Muchea Limestone	TEC	E	E
SCP2	Southern wet shrublands, SCP	TEC	E	-
SCP10a	Shrublands on dry clay flats	TEC	E	CE
SCP20a	Eastern shrublands and woodlands	TEC	E	-
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the SCP	TEC	E	-
SCP07	Herb rich saline shrublands in clay pans	TEC	V	CE
SCP08	Herb rich shrublands in clay pans	TEC	V	CE
SCP09	Dense shrublands on clay flats	TEC	V	CE
SCP3b	*Corymbia calophylla – Eucalyptus marginata* woodlands on sandy slay soils of the southern SCP	TEC	V	-
Coastal Saltmarsh	Subtropical and Temperate Coastal Saltmarsh	TEC	-	V
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	PEC	P3	-
SCP23a	Central *Banksia attenuata – B. menziesii* woodlands	PEC	P3	-
Central Granite Shrublands	Central Northern Darling Scarp Granite Shrubland Community	PEC	P4	-

Note; CE = Critically Endangered, E = Endangered, V = Vulnerable, P3 = Priority Three, P4 = Priority Four

The December 2015 survey of the site recorded plant communities to determine whether or not any communities were likely to be representative of identified TECs or PECs. Each of the plant communities identified as occurring within the site, as described in **Section 2.4.1.5** were observed to have been subject to significant historical disturbances and contained very limited numbers of native species remaining. On this basis, these communities were not considered to be representative of any Floristic Community Types (FCTs) to a high degree in their current condition, based on comparison with to the Gibson *et al.* (1994) study and dataset.

As PECs and TECs are generally associated with known FCTs, no plant communities within the site are representative of any PEC or TEC.

2.4.1.7 Summary of flora and vegetation values

Based on the findings of a range of desktop and field investigations undertaken across the MKSEA and specifically within the site to date, which have extensively considered the regional and local context of the area, the flora and vegetation values within the site are summarised as follows:

- The site has been subject to extensive historical disturbance and clearing, resulting in the condition of vegetation within the site ranging from 'Completely Degraded' to 'Degraded'.
- No threatened or priority flora species have been recorded or are likely to occur within the site.
- The site contains six plant communities, including native remnants in addition to areas of cleared or planted vegetation, which are not representative of any TECs or PECs.

2.4.2 Bush Forever

The Government of Western Australia's *Bush Forever Policy* is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10 % of each vegetation complex for protection (Government of WA 2000). Bush Forever Sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

No Bush Forever Sites are mapped as occurring within or immediately adjacent to the site. *Bush Forever Site 387: Greater Brixton Street Wetlands* (BF 387) is situated approximately 500 m south east of the site, as shown in **Figure 9**.

2.4.3 Ecological linkages

Ecological linkages allow the movement of fauna, flora and genetic material between areas of fragmented remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances (i.e. fire) and assists in maintaining the genetic diversity of plant communities and populations. Ecological linkages are often continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

These identified linkages reflect the on-ground linkages throughout the Perth Metropolitan area and are published by the Perth Biodiversity Project (PBP). No ecological linkages are identified as occurring within the site. The Greater Brixton Street Wetlands, situated approximately 500 m south east of the site, are identified as part of an ecological linkage as shown in **Figure 9**.

2.4.4 Environmentally Sensitive Areas

The south-western portion of the site intersects the extent of a declared Environmentally Sensitive Area (ESA), as shown in **Figure 9**. The environmental values from which this ESA is based upon are inferred to be associated with remnant vegetation and wetland values located within Lot 4 Bickley Road to the south of the site.

ESAs are identified to protect native vegetation values of areas surrounding significant threatened or scheduled flora, vegetation communities, wetlands or ecosystems and are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. No such values occur within the site and specifically in the area mapped within the extent of the declared ESA.

The clearing of native vegetation for general management purposes as outlined in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, including for example the construction of fence-lines, the reduction of fire hazards and the collection of firewood, is not permitted within ESAs.

Clearing is only permitted within an ESA where a Clearing Permit is approved under Part V of the EP Act or a valid exemption under Schedule 6 of the EP Act applies, which includes any clearing in accordance with a subdivision or development approval under the *Planning and Development Act 2005*.

This is discussed further in **Section 4**.

2.4.5 Terrestrial fauna

2.4.5.1 Regional context

The site is located in the eastern margin of the Swan Coastal Plain, which is typically characterised by areas largely cleared of remnant vegetation. Notwithstanding, the region does generally contain some areas of remnant vegetation in addition to other environmental features such as waterways and wetlands, which provide fauna habitat values particularly given the close proximity to the less disturbed Darling Range.

A range of conservation significant species are also known to occur within the broader region as it applies to the site. This includes three species of threatened black cockatoo, namely Carnaby's black cockatoo (CBC), Forest Red-tailed black cockatoo (FRTBC) and Baudin's black cockatoo (BBC). Potential habitat mapping provided by the DoP (2011) has used available data to map likely habitat of the CBC used for feeding, night roosts and breeding across the Swan Coastal Plain and Jarrah Forest IBRA regions, at a regional scale. This mapping indicates that the MKSEA and wider locality contain areas of potential black cockatoo foraging habitat, and is located in proximity to a number of roosting and breeding areas, the majority of which are located within the Darling Range.

2.4.5.2 Previous surveys and site specific investigations

Given the regional context with regard to fauna occurrences, the City of Gosnells undertook a Level 1 fauna assessment of the site (Cardno BSD 2005). This involved the identification of all fauna species which could potentially occur within the site based on existing habitat values, in addition to the recording of opportunistic fauna observations. The report identified the potential for three threatened species of black cockatoo to potentially utilise the site based on the identified habitat values.

Given this, the City of Gosnells commissioned 360 Environmental (2012) to undertake a Level 2 targeted black cockatoo survey across the entirety of the MKSEA. The survey identified known foraging and potential roosting and breeding habitat for the CBC and FRTBC as occurring within the site, primarily in the form of mature marri trees.

In consideration of the regional fauna context, in addition to the findings of previous surveys undertaken within the site, an additional fauna assessment of the site was undertaken by Linc Property in December 2015 to support the preparation of the Structure Plan. This survey was completed by qualified zoologist Greg Harewood and a copy is provided in **Appendix B**.

The survey included both a Level 1 fauna assessment, in addition to a targeted Level 2 black cockatoo habitat assessment. The specific survey methodology included:

- (Level 1) desktop investigations to compile a list of vertebrate fauna potentially occurring within the site. This involved searches of state and federal government fauna databases, a review of existing publications relevant to the area and a review of previous fauna surveys undertaken in the region.
- (Level 1) daytime reconnaissance field survey, conducted on 9 December 2015, in order to identify and assess fauna habitat values within the site and record any opportunistic observations of fauna species. This involved traversal of the site by vehicle and foot.
- (Level 2) targeted black cockatoo habitat assessment of the site given the known occurrence of the Threatened black cockatoo species generally across the wider region.

The results of the fauna assessment have been summarised below.

2.4.5.3 Fauna assessment

A total of 30 native fauna species were observed (or positively identified through foraging evidence, scats, tracks, skeletons or calls) within the site during the reconnaissance survey. Six introduced species were also confirmed as being present. The majority of the recorded fauna species are common, widespread bird species. Further detail on species observations is provided in the fauna assessment report (**Appendix B**).

Fauna habitat values within the site, whilst limited, are represented by remnant vegetation comprised of individual trees and small groups of marri (*Corymbia calophylla*), flooded gum (*Eucalyptus rudis*) and paperbark *(Melaleuca rhaophiophylla*), in addition to various endemic, non-endemic and exotic trees planted throughout the site. Native understorey species of any type were not observed within the site.

Based on the findings of the fauna assessment, it was concluded that the overall fauna habitat values within the site were severely compromised by the almost total clearing of vegetation. The site is considered to be generally utilised by common and widespread fauna species with non-specific habitat requirements which generally persist in highly disturbed areas. Overall, fauna biodiversity within the site is considered to be well below pre-disturbance levels.

2.4.5.4 Species of conservation significance

The conservation status of fauna species in Western Australia is assessed under the state administered WC Act. The WC Act utilises a set of schedules to define Threatened fauna species and DPaW also produces a list of Priority fauna species which, while not considered Threatened under the WC Act, there is some concern over their long-term survival. The Federal government also maintains a list of protected species under the EPBC Act, including migratory bird species.

Based on the results of the fauna assessment (Harewood 2015), four fauna species of conservation significance were opportunistically observed within the site, including:

- *Calyptorhynchus latirostris* (CBC, threatened) – foraging evidence observed.
- *Calyptorhynchus banksii naso* (FRTBC, threatened) – foraging evidence observed.
- *Merops ornatus* (Rainbow bee-eater, migratory) – A single individual was observed foraging in paddock areas. This species is common seasonal visitor to the south west.

- *Isoodon obesulus* subsp. *fusciventer* (southern brown bandicoot, priority 4) – One dead individual was found in a lot to the south of the site, but diggings attributed to this species were also noted within cleared and weed dominated vegetation within Lot 200. The majority of fauna habitat within the site is unsuitable for this species to persist.

In addition to the above, the following species are considered to possibly utilise the site for some purpose at times, based on the habitats present and the current document distributions of these species:

- *Ardea ibis* (Cattle Egret, migratory) – the site contains very marginal habitat, however the species may occur very occasionally in paddocks areas with livestock. The species would not breed onsite.
- *Calyptorhynchus baudinii* (BBC, vulnerable) – potential habitat values within the site are discussed further below.
- *Falco peregrinus* (Peregrine Falcon) – this species may potentially utilise some sections of the site as part of a much large home range. No evidence of nesting within the site was observed, and it is very unlikely the species would breed onsite.

The fauna habitat values within the site are not considered suitable to support a large number of the species identified in the Level 1 desktop assessment as potentially occurring within the wider region. On this basis, these species are not considered likely to utilise the site.

2.4.5.5 Black cockatoo habitat assessment

The Level 2 targeted black cockatoo habitat assessment of the site was undertaken to identify potential and known black cockatoo habitat and to attain an understanding of to what extent the site is known or likely to be utilised by black cockatoos. This targeted assessment considered the findings of previous surveys, including 360 Environmental (2012). The identified black cockatoo habitat values within the site have been summarised below.

<u>Foraging habitat</u>

Black cockatoo foraging habitat within the site is primarily represented by marri trees, with additional components including small numbers of scattered individuals of tuart (*Eucalyptus gomphocephala*), pine (*Pinus pinaster*) and banksia (*Banksia menziesii*). These species are generally contained within the **BmNf** and **Cc** plant communities. Foraging evidence was observed during the 2015 fauna survey in the form of chewed marri (attributed to CBC and FRTBC) in addition to chewed pine cones (attributed to CBC only).

On this basis, the site contains approximately 3.7 ha of black cockatoo foraging habitat. The quality of this vegetation is considered to be limited by the disturbed nature of plant communities identified within the site, which are not considered to be intact. In addition, marri trees within the site are dispersed in scattered groups and do not form a continuous area of woodland, which would provide greater fauna habitat value for black cockatoos. The inferred extent of black cockatoo foraging habitat within the site is shown in **Figure 10**.

Areas previously identified as black cockatoo foraging habitat by 360 Environmental (2012) were assessed as part of the black cockatoo habitat assessment (Harewood 2015). Some areas of foraging habitat recoded by 360 Environmental (2012) were not considered to be representative of such values, including vegetation within Lot 2 Grove Road (all planted non-endemic eucalypts) and vegetation at the rear of Lot 7, 9 and 10 Coldwell road (almost all paperbark trees with a small number of flooded gums).

Approximately 9,913 ha of potential foraging habitat is mapped as occurring within 12 km of the site, based on mapping published by the former Department of Environment and Conservation (DEC 2011). Foraging habitat within the site contributes to approximately 0.02% of the total potential foraging habitat located within 12 km.

Potential foraging habitat exists within scattered small patches, Bush Forever Site No. 387 and a large area of intact vegetation on the Darling Range to the east of the site (comprising 956 ha of the total foraging habitat within 6 km). This is associated with Regional Parks, other Parks and Recreation Reserves and water supply catchments. These areas contain large intact jarrah, marri and wandoo woodlands which would provide high quality foraging habitat.

Roosting habitat

Groves of large native trees within the site provide potential roosting opportunities for black cockatoos, although no evidence of such activities were observed during the fauna assessment. 360 Environmental (2012) did not observe any evidence of black cockatoo roosting within the site. However, three areas south of the site were observed by 360 Environmental to contain large amounts of black cockatoo scat, small broken branches and evidence of FRTBC foraging. These observations could be an indication of FRTBC roosting activity, however no direct observations of black cockatoo roosting were made (i.e. through dusk or night time surveys).

At a regional scale, potential roosting habitat areas are likely to occur within 12 km of the site, based on available vegetation mapping. These are particularly likely to the east of the site on the Darling Range in intact marri, jarrah and wandoo woodlands and forests.

Six confirmed roosting locations occur within 12 km of the site based upon DEC (2011) mapping. The largest of these confirmed roost sites is located approximately 8 km to the west of the site over the Collier Park Golf Course and adjacent area (DEC 2011). In addition, two unconfirmed roost habitat areas occur within 12 km of the site based upon DEC (2011) mapping, located to the south and west of the site.

Breeding habitat

A total of 116 potential black cockatoo breeding habitat trees (with a diameter at breast height greater than 500 mm) are identified as occurring within the site, based on surveys by 360 Environmental (2012) and Harewood (2015). The majority of the identified potential black cockatoo breeding habitat trees are intermittently dispersed across the site within small patches of the **Cc** plant community.

Table 7: Potential black cockatoo habitat trees (DBH > 500 mm) observed within the site.

HABITAT TREE SPECIES	360 ENVIRONMENTAL (2012)	HAREWOOD (2015) (IN ADDITION TO 360 ENVIRONMENTAL)	TOTAL
Marri	78	16	**94**
Tuart (planted)	0	7	**7**
Flooded gum	0	15	**15**
TOTAL	**78**	**38**	**116**

Only one of the total identified 116 potential black cockatoo breeding habitat trees was observed to contain hollows, however was not considered to be suitably sized to allow for entrance of a black cockatoo. The hollows present appeared to be of a size suitable for medium sized parrots (such as galahs or corellas) but not for larger species. The locations of observed potential black cockatoo habitat trees within the site are shown in **Figure 10**.

At a regional scale, potential breeding habitat occurs within 12 km of the site based on available vegetation mapping. These are located primarily on the Darling Range which contains large areas of intact marri, jarrah and wandoo woodlands and forests with potential nesting trees associated with foraging and roosting habitat.

A confirmed breeding habitat site is recorded approximately 11 km south east of the site by DEC mapping (2011). Surrounding this confirmed breeding habitat, the site contributes a very small proportion of the foraging habitat within 12 km of this location that could be utilised by breeding cockatoos. Another confirmed breeding location is located approximately 11 km north east of the site. Both of these confirmed breeding areas are centered upon the Darling Range, which contains large areas of remnant vegetation likely to be utilised by black cockatoos.

2.4.5.6 Summary of fauna values

The overall fauna habitat values of the site are considered to be low, given vegetation within the site is heavily disturbed as a result of historical clearing and agricultural land uses with limited areas of quality remnant vegetation. The site supports limited areas of black cockatoo habitat, primarily in the form of remnant marri trees.

2.5 Hydrology

This section provides a summary of the hydrological characteristics of the site, further detail is provided in the *District Water Management Strategy* (TME 2014) and the *Local Water Management Strategy* (Emerge Associates 2015).

2.5.1 Groundwater

Information on groundwater from the DoW online *Water Register* (DoW 2015) indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan unconfined aquifer
- Perth – Leederville confined aquifer
- Perth – Yarragadee North confined aquifer.

Groundwater data from the *Perth Groundwater Atlas* show that maximum groundwater levels across the site range between 7 m AHD and 12 m AHD (DoW 2015b).

Groundwater monitoring was carried out by Endemic for 18 months commencing in July 2009 (Endemic 2012). Maximum groundwater levels (MGL) recorded range between approximately 9 m AHD in the south west and 13 m AHD in the north east of the site. The site is subject to the seasonal perching of groundwater and is highly responsive to rainfall (Endemic 2012).

The depth to water across the site has been calculated based on the recorded MGL data and existing topography, and is shown in the *District Water Management Strategy* (TME 2014). The mapping indicates that groundwater clearance is shallowest in the southern and eastern portions of the site (0 m – 0.25 m) with the greatest clearance occurring in the north west of the site (1.2 m – 2.0 m).

2.5.2 Surface water

No natural surface water features occur within the site. The site is situated within the Yule Brook catchment with the Yule Brook watercourse located approximately 150 m south east of the site, as shown in **Figure 11**.

The existing drainage network within the site is comprised of a number of drainage swales situated within road reserves, which convey runoff from the road network downstream and ultimately to Yule Brook. The Yule Brook conveys flows west and ultimately to the Canning River and is part of the Water Corporation drainage network.

2.5.3 Wetlands

Wetlands are areas which are permanently, seasonally or intermittently waterlogged or inundated with water. Naturally occurring wetland features are common across the Swan Coastal Plain and can contain fresh or salty water, which may be flowing or still. DPaW classifies wetland types based on their inundation characteristics and physical structure, as outlined in **Table 8**.

Table 8: Wetland classifications used by DPaW (adapted from Hill et al. 1996)

	BASIN	FLAT	CHANNEL	SLOPE	HIGHLAND
PERMANENTLY INUNDATED	Lake	-	River	-	-
SEASONALLY INUNDATED	Sumpland	Floodplain	Creek	-	-
INTERMITTENT INUNDATION	Playa	Barlkarra	Wadi	-	-
SEASONALLY WATERLOGGED	Dampland	Palusplain	Trough	Paluslope	Palusmont

In order to provide an indication of the relative condition and conservation value of mapped geomorphic wetlands on the Swan Coastal Plain, each wetland has been evaluated and assigned one of three management categories, as detailed in **Table 9**.

Table 9: Geomorphic wetlands of the Swan Coastal Plain management categories (Hill et al. 1996)

MANAGEMENT CATEGORY	DESCRIPTION OF WETLAND	MANAGEMENT OBJECTIVES
Conservation (CCW)	Support high levels of attributes	Preserve wetland attributes and functions through reservation in national parks, crown reserves and state owned land. Protection provided under environmental protection policies.
Resource Enhancement (REW)	Partly modified but still supporting substantial functions and attributes	Restore wetland through maintenance and enhancement of wetland functions and attributes. Protection via crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple Use (MUW)	Few wetland attributes but still provide important hydrological functions	Use, development and management considered in the context of water, town and environmental planning through land care.

DPaW maintains the *Geomorphic Wetlands of Swan Coastal Plain* spatial dataset, which specifies the classifications and management categories of all wetland features across the Swan Coastal Plain.

Based on a review of this dataset, three geomorphic wetlands are identified as occurring within the site, including areas of palusplain, dampland and sumpland, all of which are classified as 'Multiple Use' wetlands.

Palusplain, dampland and sumpland Multiple Use wetlands are characterised by areas of seasonal inundation or waterlogging and do not typically exhibit permanent or significant surface water features. The presence of these wetlands generally indicates minimal separation between expressions of groundwater and natural surface levels, which is known to occur across the site. The three classified geomorphic wetlands mapped as occurring within the site are shown in **Figure 11** and detailed in **Table 10**.

Table 10: Geomorphic wetlands identified within the site

UNIQUE FEATURE IDENTIFIER (UFI)	WETLAND TYPE	MANAGEMENT CATEGORY
15254	Palusplain	Multiple Use
7632	Dampland	Multiple Use
7633	Sumpland	Multiple Use

2.5.4 Public Drinking Water Source Areas

The site is not located within or in proximity to any proclaimed or proposed Public Drinking Water Source Areas (PDWSAs).

PDWSAs are proclaimed by the DoW to protect identified drinking water sources, which can be surface water or groundwater sources (DoW 2009). They are proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947* as Water Reserves, Catchment Areas or Underground Water Pollution Areas. PDWSAs provide the community of Western Australia with the majority of its drinking water supplies and can be vulnerable to contamination from a range of land uses and water based activities. Once an area is identified as a PDWSA, consideration needs to be given to the intended land use and associated activities to ensure that they are appropriate in meeting the water protection quality objectives of the area.

2.6 Heritage

2.6.1 Indigenous heritage

The Aboriginal Heritage Inquiry System (AHIS) is maintained pursuant to Section 38 of the *Aboriginal Heritage Act 1972* by the Department of Aboriginal Affairs (DAA), containing information on Registered Aboriginal Heritages Sites and Other Heritage Places throughout Western Australia. In accordance with the *Aboriginal Heritage Due Diligence Guidelines* (DAA 2013), a search of the AHIS online database (DAA 2015) was undertaken. One 'Lodged' Other Heritage Place is mapped as occurring within the south west portion of the site, the details of which are outlined in **Table 11** below.

Table 11: Aboriginal heritage sites mapped by the DAA as occurring within the site

NAME	DAA ID	STATUS	LOCATION DATA	TYPE
Edward/Grove Streets	4340	Lodged	Unreliable	Artefacts/scatter

A *Preliminary Investigation of Aboriginal Heritage* was conducted by Australian Cultural Heritage Management (ACHM) in May 2009. The scope of this desktop investigation extended across the entirety of the MKSEA and involved an assessment of all available information on Aboriginal heritage values, including a review of previously completed archaeological and ethnographic surveys.

ACHM (2009) noted that DAA 4340 was identified in 1973 and was recorded to comprise 52 quart artefacts, however the spatial accuracy of the mapped location of the heritage site is considered unreliable.

Based on a review of the original heritage survey report, DAA 4340 was originally described as occurring on an area of exposed sand on high ground. The original sketch plan depicts the location of DAA 4340 as occurring approximately 100 m south-east of its current mapped location, and therefore outside of the site. This information was reviewed by an Aboriginal heritage consultant from Horizon Heritage in January 2016, which included a site visit to verify the originally mapped location. On this basis, the Aboriginal heritage values associated with DAA 4340 are not considered to occur within the site.

No other records of Aboriginal heritage values occurring within the site were identified by ACHM (2009), who noted that it is likely the entirety of the MKSEA was surveyed for Aboriginal heritage values in the 1970s.

2.6.2 Non-indigenous heritage

A desktop search of the State Heritage Office database (Heritage Council 2015), Australian Heritage Database (Department of the Environment 2015) and the CoG Heritage Inventory (CoG 2015) did not identify any registered heritage sites as occurring within the site.

2.7 Land use considerations

2.7.1 Historic and existing land uses

A review of historic aerial photography indicates that the site has been predominately used for rural and agricultural land uses, although recently some areas have been subject to other agricultural and light industrial uses such as turf farming and small freight haulage facilities. The majority of the site was cleared of remnant vegetation prior to 1953 to support such land uses.

A search of the Department of Environment Regulation (DER) Contaminated Sites Database (DER 2015) did not identify any registered contaminated sites within or in close proximity to the site.

2.7.2 Surrounding land uses

2.7.2.1 Regional gas pipelines

The Dongara-Pinjarra regional gas pipeline (Parmelia Mainline) easement is located within the western boundary of the site, directly adjacent to the freight railway line. APA Group operate and manage the Parmelia Mainline.

2.7.2.2 Sensitive land uses

The site is situated in proximity to residential land uses, including suburban areas in Beckenham (west of Roe Highway) and Wattle Grove (north of Welshpool Road).

In addition, rural-residential properties along Courtney Place are situated adjacent to the north eastern boundary of the site. This land is currently being rezoned 'Industrial' under the MRS concurrently with the site, and as such is expected to be developed for industrial uses. Similarly, land to the south-east of the site in proximity to Yule Brook is currently being rezoned 'Industrial' under the MRS and is also expected to be developed for industrial uses in the short to medium term. This is discussed further in **Section 1.4.1**.

2.8 Bushfire hazard

The majority of the site was historically cleared to support agricultural land uses. Existing vegetation within the site is primarily comprised of planted, non-endemic species, in addition to small areas of remnant vegetation and scattered trees. Within 100 m of the site, existing vegetation occurs within private lots, road reserves and open space areas.

The Office of Bushfire Risk Management (OBRM) has prepared the *Map of Bush Fire Prone Areas* (OBRM December 2015) which designates bushfire prone areas within Western Australia. Existing vegetation within and immediately adjacent (within 100 m) to the site, as described above, has been identified as bushfire prone.

In order to further understand the bushfire hazards within and surrounding the site, a *Bushfire Management Plan* (BMP) (**Appendix D**) has been prepared by Emerge Associates.

As part of preparing the BMP, the existing vegetation within and immediately adjacent to the site was classified into vegetation types set out in Table 2.3 of the *Australian Standard 3959: Construction of buildings in bushfire-prone areas* (AS 3959) (Standards Australia 2009), the results of which are shown in **Figure 12**. Vegetation within the site was identified as predominantly grasslands, with managed and unmanaged areas. In addition, areas of woodland are scattered across the site and areas of scrub occur within and adjacent to Roe Highway north west of the site.

Based on the AS3959 vegetation classifications, the associated bushfire hazard rating of each vegetation type was determined as either 'low', 'moderate' or 'extreme' in accordance with Appendix 2 of the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2015).

The inferred bushfire hazard ratings were then used to identify bushfire prone areas within the site, which are areas within 100 m of 'moderate' or 'extreme' bushfire hazards. This vast majority of the site was determined to be bushfire prone, generally aligning with the *Map of Bush Fire Prone Areas* (OBRM December 2015).

Given the vast majority of the site is considered to be bushfire prone, further consideration of bushfire risk management in relation to the proposed industrial development of the site is required, as discussed in **Section 4**.

3 The Proposed Landuse, Planning and Approval Framework

3.1 Structure Plan

TBB have prepared a Structure Plan for the site, as shown in **Figure 14** and provided in **Appendix E**, which outlines the proposed land uses across the site, including:

- Areas to be developed for 'General Industry'
- A Public Transport Authority rail infrastructure facility
- The Parmelia Mainline gas pipeline easement
- Indicative drainage basin locations
- The proposed internal road network.

The land uses set out in the proposed Structure Plan generally align with those shown in the Indicative LSP prepared by CoG, allowing for the progression of industrial development within Precinct 3A of the MKSEA in accordance with the established planning framework.

This has been discussed with key stakeholders, including the Parmelia Mainline operator (APA Group) and the Public Transport Authority, to ensure the proposed Structure Plan is appropriate and addresses the requirements of all parties.

The environmental planning framework set out in LPP 5.8 details a number of requirements to be addressed as part of structure planning. These have been considered and addressed through the preparation of this EAMS and other management strategies and plans, discussed further in **Section 4**. These requirements include:

- The preparation of a Local Water Management Strategy in accordance with Better Urban Water Management Principles.
- Wetland studies and management strategies.
- Buffer definition studies for wetlands, TECs and other conservation assets.
- TEC and other conservation value vegetation management plans.
- An odour, noise and dust management strategy to address appropriate separation distances between proposed industrial development and sensitive land uses, including the intended approach to the removal of sensitive land uses within the MKSEA to avoid land use conflict and constraints to development.
- Fire management planning for the protection and management of natural assets, and the protection of the adjoining built environment.
- A Structure Plan that clearly provides for the conservation and protection of important natural assets, and incorporates recommended initiatives from completed studies and plans, including ecological linkages.

3.2 Future planning approvals process

MRS amendment number 1302/57 is currently being progressed to rezone the site to 'Industrial' concurrently with adjoining areas. An amendment to the CoG TPS No. 6 will also be required to allow for industrial development of the site in accordance with the proposed Structure Plan.

Following the approval and endorsement of the Structure Plan by the CoG and the WAPC, industrial development of the site will be progressed either through subdivision, amalgamation or development approvals (collectively referred to herein as 'future planning stages').

The WAPC generally impose conditions on subdivision applications (which incorporate both subdivisions and amalgamations) to ensure development considers all the appropriate management measures. These conditions are usually determined in accordance with WAPC's *Model Subdivision Conditions Schedule 2012*.

Where subdivision or amalgamation of the site is not applicable, development approval(s) will be sought to progress industrial development in accordance with the proposed Structure Plan. The local government is generally responsible for the imposition of conditions on development approvals.

As part of the future planning stages to support development of the site, LPP 5.8 stipulates that the following documentation must be provided where applicable environmental values occur:

- Urban Water Management Plan
- Wetland Management Plan
- TEC and Conservation-value Vegetation Management Plan
- Odour, Noise and Dust Buffers
- Fire Management Plan
- Aboriginal Heritage Assessment
- Solid and Liquid Waste Management Plan.

The requirement for these documents will be determined during the preparation of subdivision or development applications on a case by case basis. Given the site does not generally contain extensive environmental values, it is likely a number of these documents will not be applicable to the site and therefore not required.

3.3 Relevant environmental factors and considerations

Table 12 summarises the environmental factors that have been considered for the site during structure planning to date, and outlines the factors which will require specific consideration as part of the future development process, as discussed in **Section 4**.

Table 12: Relevant environmental factors and considerations

ENVIRONMENTAL FACTOR	RELEVANT CONSIDERATIONS
Climate	No further consideration of this factor is required.
Topography	No further consideration of this factor is required.
Geology	No further consideration of this factor is required.
Landforms and soils	No further consideration of this factor is required.
Acid sulfate soils	The site is identified as having a moderate to low risk of ASS occurrence. This factor may require further consideration and is addressed in **Section 4**.
Flora and vegetation	The site contains limited flora and vegetation values. This factor is considered further in **Section 4**.
Bush Forever	No Bush Forever Sites occur within or interface with the site and therefore no further consideration of this factor is required.
Ecological linkages	Vegetation within the site does not contribute to any identified ecological linkage and therefore no further consideration of this factor is required.

ENVIRONMENTAL FACTOR	RELEVANT CONSIDERATIONS
Environmentally Sensitive Areas	A portion of the site falls within a declared ESA. This factor may require further consideration and is addressed in **Section 4**.
Terrestrial fauna	The site contains remnant vegetation representing known and potential fauna habitat for species of conservation significance. This factor may require further consideration and is addressed in **Section 4**.
Groundwater	There is low clearance to groundwater from the natural soil surface across the site. This factor requires further consideration and is addressed in **Section 4**.
Surface water	The management of stormwater in the proposed industrial development is addressed in **Section 4**.
Wetlands	No further consideration of this factor is required.
Public Drinking Water Source Areas	No PDWSAs are located within the site and therefore no further consideration of this factor is required.
Indigenous heritage	One Other Heritage Place is mapped as occurring within the site, however it was determined that the heritage place does not occur within the site. No further consideration of this factor is required.
Non-indigenous heritage	No further consideration of this factor is required.
Historic and existing land uses	No further consideration of this factor is required.
Surrounding land uses	The site is situated in proximity to sensitive land uses, in addition to a regional gas pipeline. This factor may require further consideration and is addressed in **Section 4**.
Bushfire hazard	The vast majority of vegetation within the site is considered to be bushfire prone. Bushfire risk management is considered further in **Section 4**.

4 Environmental Assessment and Future Environmental Management Framework

This section outlines the spatial response of the Structure Plan to the environmental attributes and values associated with the site and the future environmental management considerations that will be required for the relevant environmental factors as part of future planning stages. This section discusses only those environmental values and attributes that require specific consideration based on their presence within the site, and/or applicable legislation and policy requirements, as identified in **Table 12**.

It should be noted that in addition to environmental management considerations implemented through the statutory planning process (generally pursuant to Part IV of the EP Act), the establishment and ongoing operation of certain industrial uses within the site may also be regulated under Part V of the EP Act. This involves the management and regulation of “prescribed premises” which are certain industrial land uses identified in the *Environmental Protection Regulations 1987.* The EP Act requires the DER to assess, monitor, audit and manage the impacts that industry may have on the surrounding environment. These operational approvals associated with Part V of the EP Act will be dealt with by future landowners and operators following the statutory planning and development process. This is discussed further in **Section 4.6**.

4.1 Acid sulfate soils

4.1.1 Policy framework and management objectives

The DER, through the WAPC, ensures ASS are adequately managed during the subdivision process. The objective of the WAPC’s *Acid Sulfate Soils Planning Guidelines* (2008) is to manage ASS appropriately to prevent the release of metals, nutrients and acidity into the soil and groundwater system that may adversely affect the natural and built environment and human health.

4.1.2 Structure Plan considerations for acid sulfate soils

The management of ASS within the site does not require a specific spatial consideration within the Structure Plan.

4.1.3 Future acid sulfate soils management requirements

For subdivision applications where the subject land is identified as having a high to moderate risk of ASS occurring within 3 m of the natural soil surface (based on regional ASS risk mapping), the WAPC imposes model subdivision condition EN8 (WAPC 2012b), which states:

“An acid sulfate soils self-assessment form and, if required as a result of the self-assessment an acid sulfate soils report and an acid sulfate soils management plan shall be submitted to and approved by the Department of Environment Regulation before any subdivision works are commenced. Where an acid sulfate soils management plan is required to be submitted, all subdivision works shall be carried out in accordance with the approved management plan (Department of Environment Regulation).”

The site is mapped as having a moderate to low risk of ASS occurring within 3 m of the natural soil surface. In such areas, model subdivision condition EN8 may only be imposed by the WAPC if activities with a high risk of encountering ASS are proposed, including extensive excavation below seasonally dry soils, dewatering or installation of deep sewer.

The importation of sand fill is likely to be required as part of the proposed industrial development set out in the Structure Plan, which will increase the separation distance to any potential ASS. This will contribute to reducing any risk of encountering ASS within the site.

4.1.4 Predicted environmental outcomes

Any future ASS considerations can be identified and suitably managed at future planning stages in accordance with the WAPC's *Acid Sulfate Soils Planning Guidelines* (2008) and does not impact upon the proposed Structure Plan.

4.2 Flora and vegetation

4.2.1 Policy framework and management objectives

The EPA's *Guidance Statement No. 33 Environmental Guidance for Planning and Development* (2008) states their broad objective for flora and vegetation biodiversity conservation 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."*

As part of their informal advice provided in response to the referred scheme amendment, the EPA noted that the site is mapped within the regional area comprising the Guildford complex.

LPP 5.8 details the environmental planning framework for development within the MKSEA. In regard to flora and vegetation considerations, LPP 5.8 sets out the following requirements to support a Structure Plan:

- Buffer definition studies for TECs and other conservation assets.
- TEC and other conservation value vegetation management plans.
- The Structure Plan is to provide for the conservation and protection of important natural assets, and incorporate recommended initiative from the above plans, including ecological linkages.

4.2.2 Structure Plan considerations for flora and vegetation

Based on outcomes of various flora and vegetation surveys and assessments, vegetation values within the site are considered to be highly degraded as a result of historical and existing disturbances. Identified plant communities were assessed to be in 'Degraded' or 'Completely Degraded' condition and are characterised by low native species diversity, with paddock grasses and weed species dominant, in addition to planted non-native trees.

On this basis, vegetation within the site is not considered to represent intact vegetation communities and is not representative of the Guildford vegetation complex. No vegetation of conservation value was identified as occurring within the site and as such the requirements of LPP 5.8 outlined above are not considered to be applicable to the preparation of the Structure Plan.

Given the highly degraded nature of vegetation within the site, in addition to the fill requirements to achieve suitable separation to expressions of groundwater, the majority of vegetation within the site is likely to be cleared as part of implementing the proposed industrial land uses set out in the Structure Plan.

4.2.3 Future flora and vegetation management requirements

The clearing of any vegetation within the site will require the approval of a Clearing Permit, in accordance with Part V of the EP Act. Alternatively, clearing may be undertaken without a Clearing Permit if undertaken in accordance with a valid exemption, including any clearing required to implement an approved subdivision or development application granted under the *Planning and Development Act 2005*.

4.2.4 Predicted environmental outcomes

The flora and vegetation values of the site are highly degraded and are not considered to be of local or regional significance as a result of historical and existing disturbances. As such, the clearing of vegetation within the site to support industrial development will not result in any significant impacts on flora and/or vegetation values and does not impact the proposed Structure Plan.

4.3 Environmentally Sensitive Areas

4.3.1 Policy framework and management objectives

Within ESAs, exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* do not apply (such as clearing for the construction of fence-lines, the reduction of fire hazards and the collection of firewood) and a Clearing Permit may be required prior to the clearing of any vegetation. Notwithstanding, exemptions under Schedule 6 of the EP Act still apply in ESAs, including any clearing in accordance with a subdivision or development approval under the *Planning and Development Act 2005*.

4.3.2 Structure Plan considerations for Environmentally Sensitive Areas

The extension of a declared ESA into the south-east portion of the site does not require a specific spatial consideration within the Structure Plan.

4.3.3 Future management requirements for Environmentally Sensitive Areas

The portion of the ESA mapped as occurring within the site is predominately cleared and is characterised by a small number of scattered planted trees over introduced grasses, which do not represent significant environmental values. This ESA is inferred to have been declared to provide protection for environmental values located in Lot 4 Bickley Road, situated south of the site.

It is likely that vegetation within the portion of the site declared an ESA will require clearing as part of future industrial development. If this occurs, the clearing must be taken in accordance with either:

- An approved Clearing Permit under Part V of the EP Act; or
- A valid exemption under Schedule 6 of the EP Act, including in accordance with a subdivision or development approval under the *Planning and Development Act 2005*.

Clearing within the ESA for general management purposes, as set out in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, will not be permitted.

The future industrial development of the site will be undertaken in accordance with subdivision or development approval(s), which are valid exemptions for clearing within an ESA, as detailed above.

4.3.4 Predicted environmental outcomes

Any approval requirement to clear remnant vegetation associated with an ESA will be determined at future planning stages. This is unlikely to raise complexities or constraints to the proposed industrial development of the site.

4.4 Terrestrial fauna

4.4.1 Policy framework and management objectives

The EPA states their objective for terrestrial fauna conservation in the development process is *"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 through improvement in knowledge."*

The CoG do not currently provide any specific local planning policies or guidelines relating to management requirements for terrestrial fauna during the development process.

The vast majority of the site has been cleared of remnant vegetation to support historical and existing land uses, and as such fauna habitat values within the site are generally limited. The primary fauna consideration within the site is the presence of limited black cockatoo habitat, including scattered trees and groups of marri, in addition to individuals of banksia and tuart.

4.4.2 Structure Plan considerations for terrestrial fauna

Vegetation and associated fauna habitat within the site is proposed to be largely cleared to support industrial development and therefore the Structure Plan has not provided for the retention of the degraded flora and vegetation values within the site.

The retention of fauna habitat within industrial developments is generally difficult to facilitate, given the provision of Public Open Space, which provides the best opportunities for the retention of remnant vegetation, is not required. Whilst there is no formal mechanism proposed to facilitate the retention of vegetation and associated fauna habitat within the Structure Plan, it is possible that there may be opportunities for retention throughout the development process and these may be implemented where practical. However, there should be no assumption that such opportunities may arise.

4.4.3 Future terrestrial fauna management requirements

Given black cockatoo species are protected under the EPBC Act, the clearing of associated habitat and any resultant impacts on the species will need to be considered by proponents of development. A number of site specific and targeted investigations have been undertaken to quantify black cockatoo habitat values within the site, with regard to the extent, type, quality and known use of identified habitat. The findings of these investigations will inform any requirements for landholders within the site pursuant to the EPBC Act, which must be considered by a proponent prior to development.

4.4.4 Predicted environmental outcomes

Fauna habitat values within the site are generally limited as a result of historical disturbance, however some limited black cockatoo habitat has been identified as occurring, which will require further consideration by future proponents with regard to requirements pursuant to the EPBC Act. Overall the fauna habitat values of the site will not constrain the implementation of the proposed Structure Plan.

4.5 Groundwater and surface water

4.5.1 Policy framework and management objective

The *State Water Strategy* (Government of Western Australia 2003) and *Better Urban Water Management* (WAPC 2008) endorse the promotion of integrated water cycle management and application of Water Sensitive Urban Design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

The key principles of integrated water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater.
- Integrating water and land use planning.
- Allocating and using water sustainably and equitably.
- Integrating water use with natural water processes.
- Adopting a whole of catchment integration of natural resource use and management.

The EPA's *Environmental Assessment Guideline No. 8 Environmental factors and objectives* (EPA 2013) outlines the following key objectives for the management of groundwater and surface water:

- To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.
- To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

State Planning Policy 2.9 Water Resources (WAPC 2006) outlines the following key policy objectives:

- Protect, conserve and enhance water resources that are identified as having significant economic, social, cultural and/or environmental values.
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and all other biological life with attention to maintaining or improving the quality and quantity of water resources.
- Promote and assist in the management and sustainable use of water resources.

The environmental planning framework for development within the MKSEA provided in LPP 5.8 sets out the following urban water management requirements to support a Structure Plan:

- The preparation of a Local Water Management Strategy, in accordance with Bettwer Urban Water Management Principles.
- Wetland studies and management strategies, including the definitions of buffers.

4.5.2 Structure Plan considerations for groundwater and surface water

An LWMS has been prepared by Emerge Associates (2016) to support the preparation of the Structure Plan, in accordance with the requirements of state and local planning policies. The LWMS provides a framework for the future delivery of a best practice approach to integrated water cycle management utilising WSUD principles, including detailed management approaches for groundwater, stormwater, potable water consumption and flood mitigation.

The underlying principle behind the stormwater management strategy for the site is to maintain the existing hydrology by matching pre-development flows within the existing waterways, treat minor event runoff as close to the source as possible, and convey existing upstream flows through the site. Specifically this involves:

- Lots detain runoff from up to the 10 year average recurrence interval (ARI) and provide treatment specific to land use.
- Conveyance of road reserve runoff by surface flow in open swales.
- Treatment of road reserve runoff via extended detention in conveyance swales.
- Peak flow rates to Yule Brook managed by catchment routing and flood detention up to the 100 year ARI event.
- Groundwater controlled to existing MGL via network of open swales.

In regard to groundwater management, the limited separation distance between existing surface levels and groundwater requires further consideration, however, this does not require a spatial response within the Structure Plan and will be addressed at future planning stages, discussed further below.

Given the site does not contain any wetlands of conservation significance (such as CCWs or potentially REWs), the spatial layout of the Structure Plan does not need to accommodate any wetland buffers or other wetland management measures.

4.5.3 Future groundwater and surface water management requirements

If future industrial development within the site is achieved through subdivision or amalgamation, an *Urban Water Management Plan* (UWMP) will be required for each stage of subdivision within the site, in order to address WAPC’s standard model subdivision condition D2 (WAPC 2012) which states:

Prior to the commencement of subdivision works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water, consistent with any approved Local Water Management Strategy. (Local Government).

Generally, an UWMP will address the following considerations:

- The detailed drainage design
- Imported fill specifications and requirements
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program
- Status of groundwater abstraction license.

If future industrial development within the site is achieved through a development approval, the local government may still impose a condition to require the preparation of an UWMP. Alternatively, a Stormwater Management Plan may be required to be prepared.

To achieve suitable clearance to groundwater across the site, the importation of sand fill is likely to be required as part of the industrial development process. The addition of sand fill will allow for increased retention of stormwater runoff onsite, and minimise detention requirements.

Model subdivision condition D3 (WAPC 2012) requires the submission and approval of engineering drawings and specifications regarding the filling and/or draining of the land, including ensuring that stormwater is contained onsite, or appropriately treated and connected to the local drainage system. Such engineering drawings and specifications will be in accordance with an approved UWMP. The requirement for fill within the site will also address model subdivision condition D4 (WAPC 2012), which may also be applied to relevant development applications as required, and states:

The land being filled, stabilised, drained and/or graded as required to ensure that:

a) Lots can accommodate their intended development

b) Finished ground levels at the boundaries of the lot(s) the subject of this approval match or otherwise coordinate with the existing and/or proposed finished ground levels of the land abutting; and

c) Stormwater is contained on-site, or appropriately treated and connected to the local drainage system. (Local Government).

4.5.4 Predicted environmental outcomes

The LWMS provides the framework for the Structure Plan to manage the quality and quantity of surface water and in a contemporary best-practice approach that utilises WSUD principles in accordance with the WAPC and EPA guidelines and policy frameworks. The future preparation of an UWMP or a Stormwater Management Plan to support future planning stages will detail how the LWMS framework has been implemented within the industrial design of the site.

4.6 Surrounding land uses – sensitive land uses

4.6.1 Policy framework and management objectives

Industrial land uses have the potential to impact upon nearby sensitive land uses through noise, odour, air and dust emissions. The CoG LPP 5.8 outlines the requirement for future industrial land uses within the MKSEA to manage any such emissions to meet EPA environmental objectives, as to avoid and minimise impacts on nearby sensitive land uses and avoid land use conflicts and constraints to industrial development.

The EPA and DER seek to apply to objectives of the *Environmental Protection Act 1986* through an approach which protects the amenity of sensitive land uses from industrial land uses and their associated emissions, based on the following hierarchy:

- Avoidance of impacts.
- Individual industry to take all reasonable and practicable measures to prevent or minimise emissions from their premises by implementing best practice.
- Ensure environmental impacts from industrial emissions are acceptable and meet the relevant regulations and health criteria beyond the boundary of the site, industrial estate or buffer area.

This is generally applied through Parts IV and V of the *Environmental Protection Act 1986*, as detailed below.

<u>Part IV of the EP Act</u>

Part IV of the EP Act is associated with the environmental impact assessment of proposals. The EPA is responsible for assessing the impacts of projects, proposals, town planning schemes and scheme amendments on the environment in the context of EPA policies and guidance. Based on this assessment, the EPA then provides advice to the Minister for the Environment in relation to the proposal.

The EPA has considered the proposal to develop the site for industrial land uses through the referral of MRS amendment 1302/57 by the WAPC. As discussed in **Section 1.4**, the EPA advised the WAPC that the proposed amendment did not require formal assessment under Part IV of the EP Act and provided advice and recommendations to address relevant environmental factors throughout development, specifically in regard to flora and vegetation and inland waters environmental quality. These recommendations outlined the significance of environmental values across the MKSEA, including BF 387, various Conservation Category Wetlands and vegetation representative of the Guildford Complex. None of these values are identified as occurring within the site.

Part V of the EP Act

Part V of the EP Act provides a basis for environmental regulation and compliance, and encourages the promotion of best practice and waste minimisation. It aims to ensure that the operation of certain industrial facilities (identified as 'prescribed premises' under the *Environmental Protection Regulations 1987*) protects the environment, specifically through the use of infrastructure works approvals and operational licences, and is administered through the DER. Prescribed premises are described as industries that have the potential to cause emissions and discharges to air, land or water (i.e. pollution of the environment). They encompass a range of activities and thresholds, with 89 categories currently identified in the *Environmental Protection Regulations 1987*.

This regulatory process is generally undertaken on a case by case basis by individual proponents when specific construction or operations are proposed, as opposed to the broader land use planning process of structure planning.

4.6.2 Structure Plan considerations for sensitive land uses

In preparing the Indicative LSP for the MKSEA, the CoG considered the broader land use planning framework and undertook a range of preliminary investigations in order to determine the suitability of the site for industrial land uses. As part of this, the strategic location of the site was considered with regard to nearby sensitive land use receptors. In light of these considerations, the MKSEA is currently in the process of being rezoned by the WAPC to support industrial land uses. On this basis, the site and greater MKSEA is considered suitable for industrial land uses generally and is not fundamentally constrained by adjacent sensitive land uses.

The provision of industrial land uses in the Structure Plan is in accordance with the existing local and regional planning framework and can suitably avoid any potential impacts from industrial land uses through the implementation of the control measures discussed above.

4.6.3 Future sensitive land use management requirements

The construction and operation of certain industrial facilities within the site may be subject to regulation under Part V of the EP Act if the proposed use meets the respective threshold criteria for the corresponding category of 'prescribed premise'. Such regulation is enforced by the DER and will involve the following:

- The attainment of an approved Works Approval to construct industrial-purposed buildings and structures. This incorporates the avoidance of offsite emissions primarily through building design, ensuring the structure is compliant with all relevant building and environmental standards. In addition, the location of the proposed structure is considered in relation to nearby land uses, which may preclude certain building types (based on the type of anticipated use) being constructed close to sensitive land uses.

- The attainment of an approved Operating Licence in order to operate the prescribed premise as an industrial facility for an approved category of use. The Operating Licence will detail the category of use, in addition to the production capacity of the facility which specifies the maximum output and associated emissions permitted. The DER considers surrounding land uses when granting an Operating Licence, as this can inform the allowable size and/or output capacity of the facility.

This regulatory process will be undertaken by individual proponents of industrial land uses on a case by case basis, once finalised industrial lots are purchased and constructed upon.

In addition, the majority of potential industrial land uses which could be developed within the site are identified as 'discretionary uses' under the CoG TPS No. 6. As such, the acceptability of each proposal will be assessed by local government during the consideration of development applications.

4.6.4 Predicted environmental outcomes

Through the implementation of Part IV of the EP Act through the MRS amendment process, the future application of Part V of the EP Act through works approvals and operating licenses, and the development application and approval process through local government, the industrial land uses of the site can be developed to ensure impacts on sensitive land uses are avoided and minimised on a case by case basis. As such, industrial development of the site is not anticipated to impact upon nearby sensitive land uses.

4.7 Surrounding land uses – regional gas pipelines

4.7.1 Policy framework and management objectives

The WAPC published *Planning Bulletin 87 High Pressure Gas Transmission Pipelines in the Perth Metropolitan Region* (Planning Bulletin 87) (WAPC 2007) to ensure that people and property are not put at an unacceptable level of risk as a result of nearby petroleum pipelines and that pipeline corridors and easements are not constrained by adjacent land uses.

Planning Bulletin 87 sets out a generic setback distance of 45 m between the Parmelia Mainline and industrial land uses, measured from the extent of the easement. These setbacks can be reduced through the implementation of various mitigation measures, including:

- Increased pipeline wall thickness (generally not feasible for an operating pipeline).
- Increased depth of cover (there is a maximum depth of cover to ensure maintenance accessibility).
- Below ground concrete or other hard cover above the pipeline.
- Restriction of access to the easement through bollards, fencing, etc.

4.7.2 Structure Plan considerations for regional gas pipelines

Discussions with the APA Group were initiated to identify any requirements within the Structure Plan with regard to accommodating the Parmelia Mainline. Based on the outcomes of this process, APA Group outlined that the establishment of a public purposes or utility reserve over the easement was not required, however a notional 45 m buffer zone has been added to the Structure Plan to reflect the generic setback distance specified in Planning Bulletin 87.

4.7.3 Future regional gas pipeline management requirements

Based on the outcomes of discussions with APA as part of the structure planning process, the following measures will be implemented as part of future industrial development within the site:

- All development and subdivision within 356 m will be referred to the APA Group for consideration of its potential impact on the operation and maintenance of the Parmelia Gas Pipeline;
- Development within the 45 m buffer area, and up to the pipeline easement, is achievable subject to undertaking the necessary risk assessment procedures and agreement on a risk management plan to the satisfaction of the APA Group.

On this basis, a quantitative risk assessment is not required for future development up to the easement area, however a qualitative risk assessment will be required prior to subdivision or development. This will inform the setback distance from the pipeline easement, which will consider the implementation of risk mitigation strategies such as the installation of a reinforced concrete slab over the pipeline, the importation of fill and the construction of hardstand.

Restrictions may apply within the setback area for the storage of certain chemicals and/or flammable materials, however these would be subject to a specific qualitative risk assessment. There will be no restrictions on buildings and associated infrastructure within the setback area outside of the easement.

4.7.4 Predicted environmental outcomes

The management of the Parmelia Mainline will be addressed at future planning stages, through the completion of qualitative risk assessment(s) to the satisfaction of APA Group. This will involve the determination of any required setback distance from the pipeline easement, in accordance with Planning Bulletin 87.

4.8 Bushfire hazard

4.8.1 Policy framework and management objectives

State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7) (WAPC 2015c) provides the bushfire risk management planning framework for private land in Western Australia. To provide guidance on implementing SPP 3.7, the WAPC and DFES have also prepared the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2015). These documents aim to inform and guide bushfire hazard management across various stages of the planning process to avoid inappropriately located or designed land uses, subdivision and development on land where a bush fire risk is identified, and to ensure that an appropriate level of protection to life and property from bushfires is provided.

SPP 3.7 is aimed toward the management of bushfire risk in land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. SPP 3.7 sets out a requirement for the preparation of a BMP to support development of areas identified as bushfire prone.

SPP 3.7 also includes specific guidance on some forms of industrial development identified as ‘high-risk’, which are defined as ‘*a land use which may lead to the potential ignition, prolonged duration and/or increased intensity of a bushfire*’. Examples of high risk land uses include, but are not limited to: service stations, fuel depots, certain heavy industries and bulk storage of hazardous materials (WAPC and DFES 2015).

A BMP generally addresses the bushfire protection performance criteria outlined within the *Guidelines for Planning in Bushfire Prone Areas* and can result in the imposition of Bushfire Attack Levels (BALs) in accordance with AS 3959.

AS 3959 only applies to buildings identified as Class 1, 2, 3 or 10a under the Building Code of Australia. The proposed development of the site will typically involve the establishment of industrial type buildings (Class 5, 6, 7 or 8 under the Building Code of Australia) with small commercial site offices. On this basis, AS 3959 will not be applicable to the site.

Whilst AS3959 is not expected to apply to industrial development within the site, a BMP is required to demonstrate that development can address the bushfire protection performance criteria and also manage any 'high risk land uses', given the site is identified as bushfire prone.

In addition to state planning policy requirements, the environmental planning framework for development within the MKSEA set out in LPP 5.8 requires fire management planning to be undertaken to support the preparation of a Structure Plan. This should consider the protection and management of natural assets, and the protection of the adjoining built environment. LPP 5.8 also sets out a requirement for a fire management plan to be prepared to support a subdivision or development application.

4.8.2 Structure Plan considerations for bushfire hazard

As outlined in **Section 2.8**, areas within and adjacent to the site are identified as bushfire prone. The post-development scenario as a result of implementing the Structure Plan will result in the removal of most vegetation within the site, and as such reduce the bushfire hazard of the site to 'low'. Areas of vegetation within the Roe Highway road reserve and Woodlupine Brook Reserve are expected to be permanently retained and as such, maintain an 'extreme' bushfire hazard. The post-development bushfire hazards within and immediately surrounding the site are shown in **Figure 13**.

In order to mitigate the bushfire risk within the site, the Structure Plan has been designed to address the bushfire protection criteria set out in Appendix 4 of the *Guidelines for Planning in Bushfire Prone Areas*. This is discussed in detail in the BMP (**Appendix D**) and includes the following considerations:

- **Location**. Future industrial development within the site can be located and designed in such a way that bushfire hazard within 20 m of a future industrial facility will be low.
- **Vehicular access**. The proposed road network integrates with the existing Grove Road to the south (which provides access to Brook Road, Bickley Road and Roe Highway), in addition to Coldwell Road to the north-east (which provides access to Welshpool Road). The Structure Plan also provides for the realignment of Grove Road in order to allow for the future possible connection to the Welshpool Road and Hale Road intersection. Based on the current and proposed road network, two access points to the site will be provided at all times to the public and emergency personnel in the form of public roads. The requirement for the preparation of an Emergency Evacuation Plan is also likely to be imposed for industrial facilities as part of the building licence process, which should consider the bushfire considerations outlined in the BMP.
- **Water**. The site will be supplied with scheme water for potable and non-potable uses, in addition to fire hydrants. This will provide a suitable water source for fire response services in the event of a bushfire emergency within the site.
- **Siting and design of development**. Bushfire hazards will be mitigated through the provision of a minimum 20 m Asset Protection Zone (APZ) adjacent to areas of permanent classified vegetation, which is accommodated within the adjacent freight railway reserve. As such, no spatial

requirement to accommodate an APZ within the site is required. Based on the industrial land use proposed in the Structure Plan, AS 3959 is not applicable and as such no BAL considerations are required.

Further detail on the proposed bushfire risk mitigation strategies is provide in the BMP (**Appendix D**).

4.8.3 Future bushfire hazard management requirements

A BMP has been prepared to support the lodgement of the Structure Plan and to demonstrate how the bushfire protection performance criteria have been achieved through the Structure Plan design, in accordance with SPP 3.7. The BMP will be updated at future planning stages if required.

Environmental regulation under Part V on the EP Act may also incur environmental controls on industrial land uses within the site where ‘prescribed premises’ are proposed for development, as discussed in **Section 4.6**. This may involve provisions for the minimisation of risk through building design and location, in addition to operational restrictions, such as the amount and location of hazardous material storage. These considerations are likely to contribute to reducing the bushfire risk within the site.

4.8.4 Predicted environmental outcomes

By considering bushfire hazard management elements detailed in SPP 3.7 and the *Guidelines for Planning in Bushfire Prone Areas* in the early stage of planning process, the Structure Plan has been able to incorporate bushfire hazard management considerations into the design of the development. This ensures that bushfire risk to life, property and emergency response personnel is reduced.

5 Conclusions and recommendations

5.1 Conclusions

Emerge Associates were engaged by Linc Property to provide environmental consultancy services to support the preparation of a Structure Plan for the site, which has been prepared by TBB on behalf of Linc Property. The Structure Plan will guide industrial development within the site.

The environmental attributes and values identified within the site have been outlined in **Section 2**. The proposed Structure Plan has responded to the environmental attributes and values of the site, as discussed in **Section 4**, through specific provisions for the:

- Accommodation of the Dongara-Pinjarra regional gas pipeline easement along the western boundary of the Structure Plan.
- Preparation of a *Local Water Management Strategy* to address the stormwater management requirements of the proposed development.
- Preparation of a *Bushfire Management Plan* to demonstrate how the proposed development meets the established bushfire protection criteria.

In addition to the above, the structure planning process has accommodated the requirements of the local environmental planning framework, set out in *Local Planning Policy 5.8 Maddington Kenwick Strategic Employment Area Planning Framework*, as detailed in **Table 13**.

Table 13: MKSEA environmental planning framework, adapted from Table 1 of LPP 5.8 (CoG 2014)

REQUIRED INFORMATION TO SUPPORT A STRUCTURE PLAN	HOW THIS REQUIREMENT HAS BEEN ADDRESSED
Preparation of a Local Water Management Strategy in accordance with Better Urban Water Management Principles.	A *Local Water Management Strategy* (Emerge Associates 2016) has been prepared for Precinct 3A.
Wetland studies and management strategies.	The wetland characteristics of the site are detailed in this EAMS, with management strategies specified in **Section 4.5**.
Buffer definition studies for wetlands, threatened ecological communities (TECs) and other conservation assets.	No environmental assets of conservation significance are identified as occurring within the site and as such no buffers are required. This is discussed further in this EAMS.
TEC and other conservation value vegetation management plans.	No vegetation of conservation value is identified as occurring within the site, notwithstanding vegetation management strategies for the site are discussed in **Section 4.2**.
Odour, noise and dust management strategy to address separation distances between proposed industrial development and sensitive land uses, including the intended approach to removal of sensitive land uses within MKSEA to avoid land use conflict and constraints to development.	**Section 4.6** of this EAMS addresses how potential impacts on adjacent sensitive land uses as a result of industrial development within the site will be managed through the development process.
Fire Management Planning for the protection and management of natural assets, and the protection of the adjoining built environment.	Addressed through the preparation of a *Bushfire Management Plan* (Emerge Associates 2016), provided as **Appendix D**.
A Structure Plan that clearly provides for the conservation and protection of important natural assets, and incorporates recommended initiatives from the above studies and plans, including ecological linkages.	**Section 4** of this EAMS discusses how the Structure Plan has responded to the identified environmental values within the site.

This document outlines the proposed environmental management framework to manage environmental values of the site as part of future planning stages. The key future management considerations are discussed in **Section 4** and include:

- Preparation of an *Urban Water Management Plan(s)* or a *Stormwater Management Plan* to support subdivision or development respectively, to demonstrate how groundwater and surface water are appropriately managed in accordance with the framework set out in the LWMS.
- Importation of clean sand fill across the site to achieve suitable clearance between final surface levels and groundwater.
- If it is deemed to be required, consideration of acid sulfate soils risk through the completion of an *Acid Sulfate Soils Self-Assessment Form* as part of subdivision.
- Updating of the *Bushfire Management Plan* prepared to support the Structure Plan as required, to support future subdivision or development.

Overall, the Structure Plan provides for the proposed industrial development of the site in accordance with the established strategic planning framework. The spatial considerations of the Structure Plan and proposed management measures set out in this EAMS, in addition to the established statutory planning framework, ensures that future development within the site suitably accommodates the existing environmental values of the site and will not incur any significant environmental impacts.

5.2 Recommendations

Based on the findings of the EAMS, the following recommendations are made in relation to the finalisation of the Structure Plan and subsequent subdivision and development:

- There are no significant environmental values that would constrain the proposed industrial uses.
- Future subdivision and development should accommodate the Dongara-Pinjarra regional gas pipeline easement, including the undertaking of qualitative risk assessment(s) to identify any required easement setback.
- The implementation of bushfire mitigation strategies in accordance with the *Bushfire Management Plan,* including consideration of any changes to the plan through the subdivision and development process as required.

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FIGURES

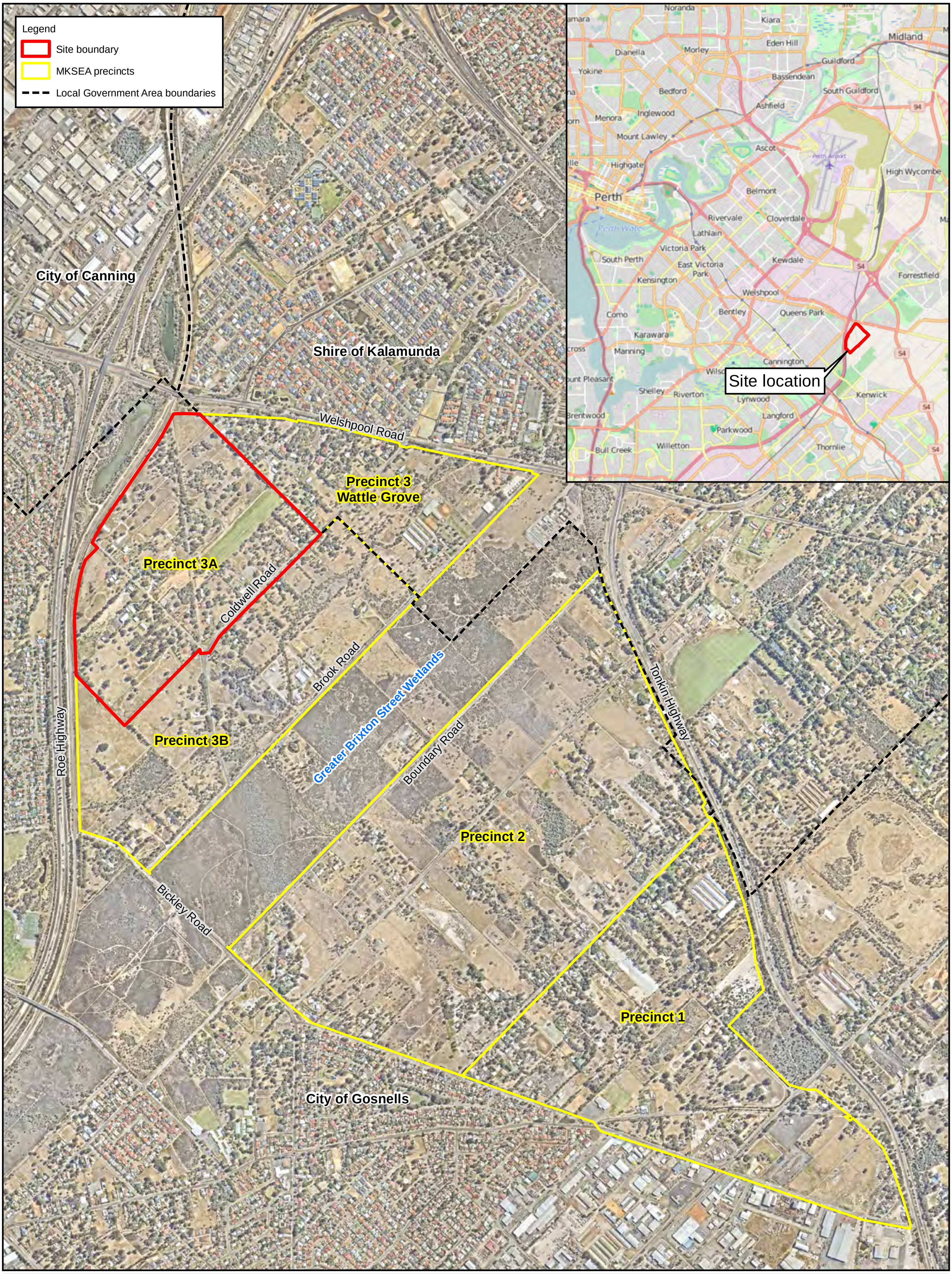

Figure 1:	**Location Plan**		
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Client:	Linc Property Pty Ltd		

Plan Number: EP14-056(05)--F05a

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Approved:	JDH	Date:	23/03/2016
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Figure 2:	**Site Plan**
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F06a

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Approved:	JDH	Date:	23/03/2016
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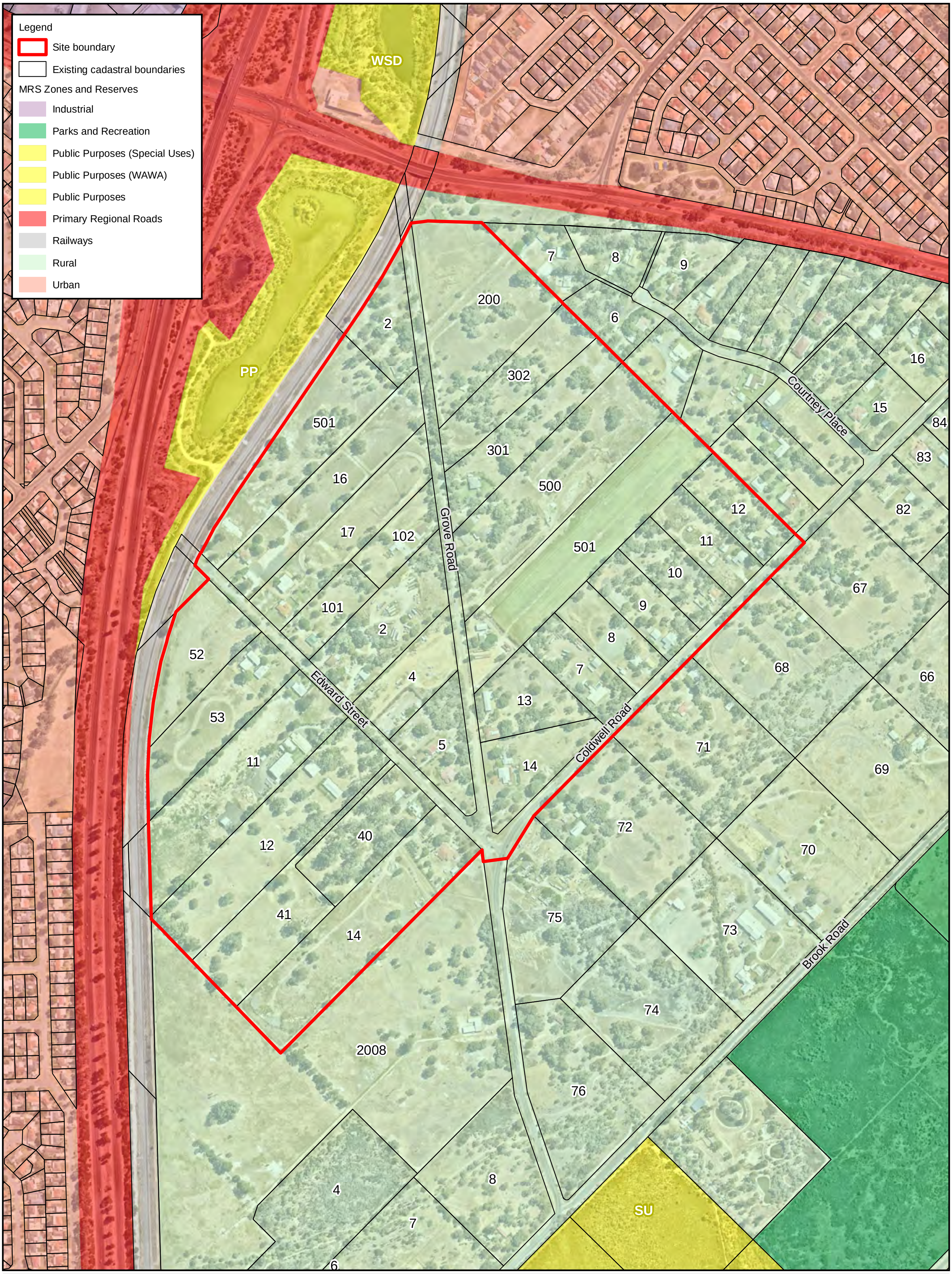

Figure 3:	Existing Metropolitan Region Scheme
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Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F07a

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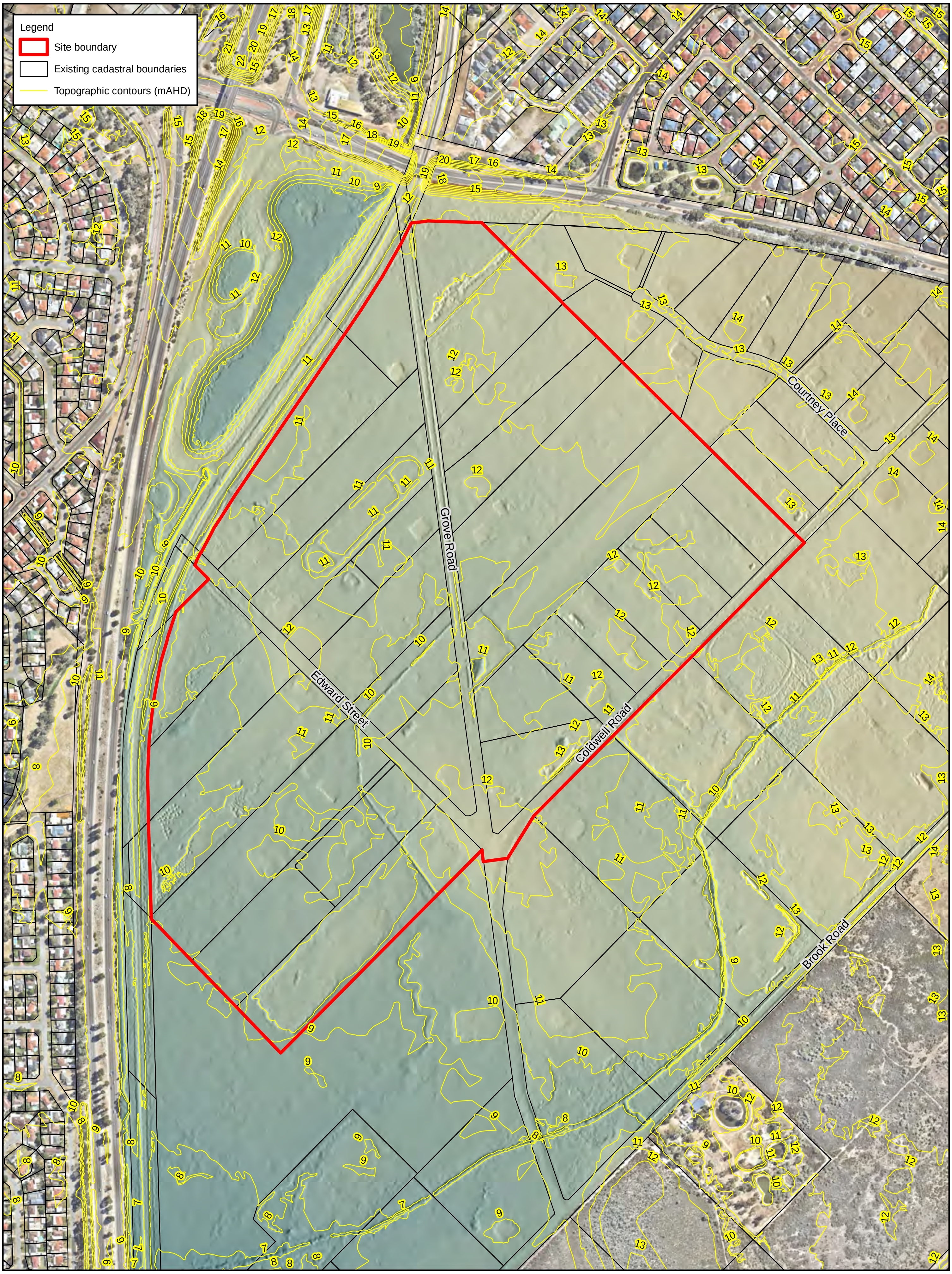

Figure 4: **Site Topography**

Project: Environmental Assessment and Management Strategy
MKSEA Precinct 3A Structure Plan

Client: Linc Property Pty Ltd

Plan Number: EP14-056(05)--F08a	
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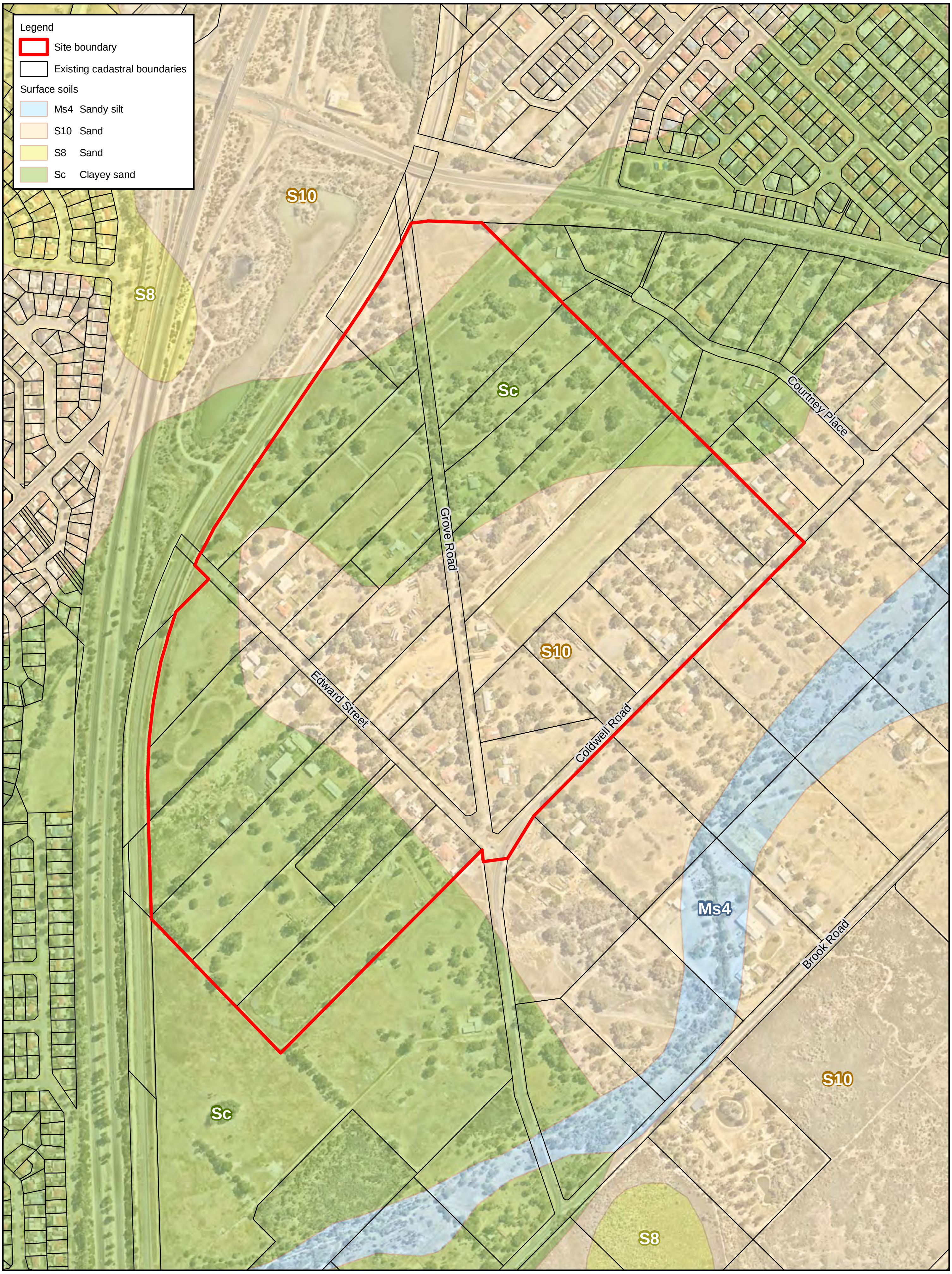

Figure 5:	**Environmental Geology**
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Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F09a

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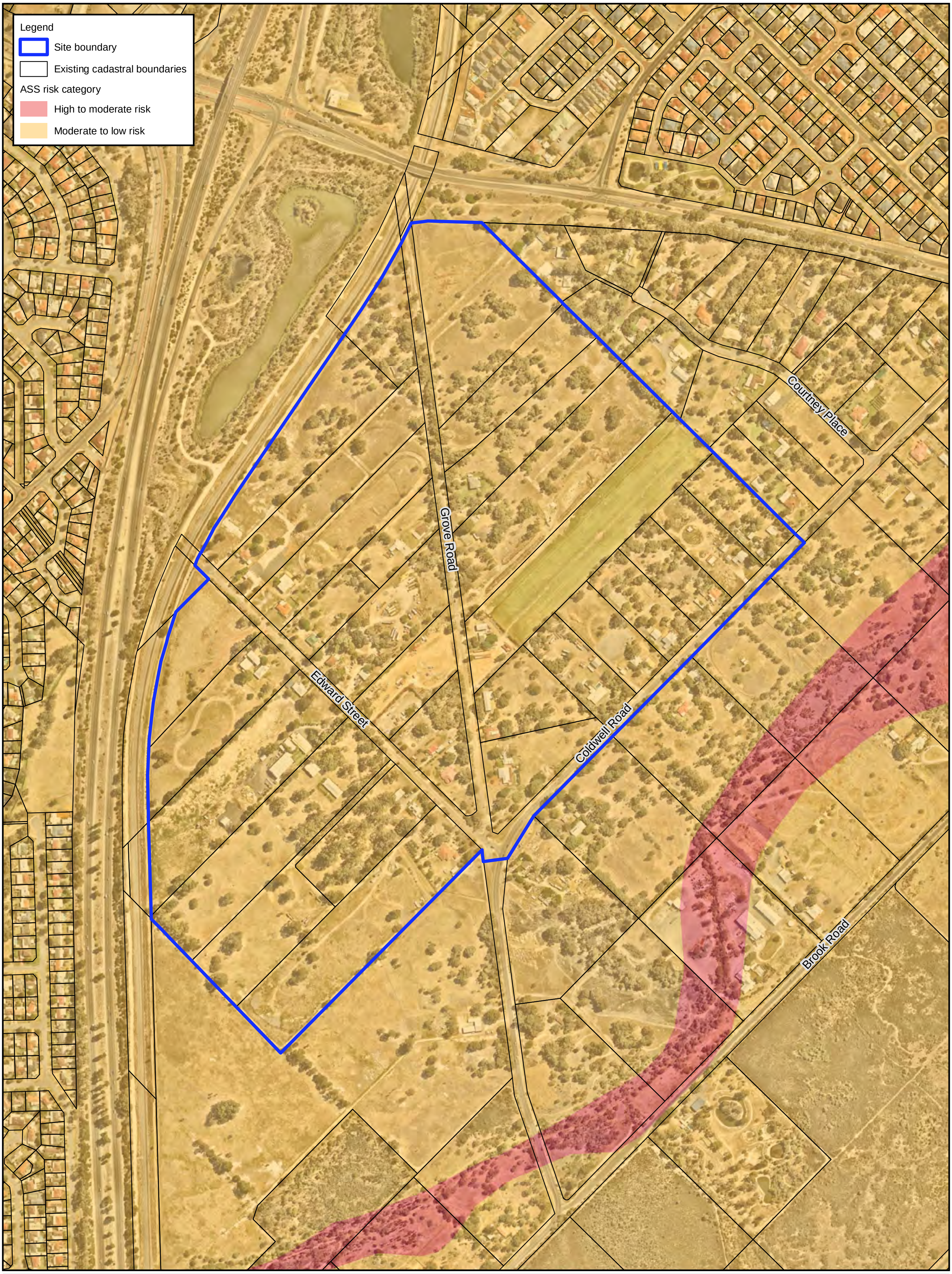

Figure 6:	**Acid Sulfate Soils Risk Mapping**
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F10a

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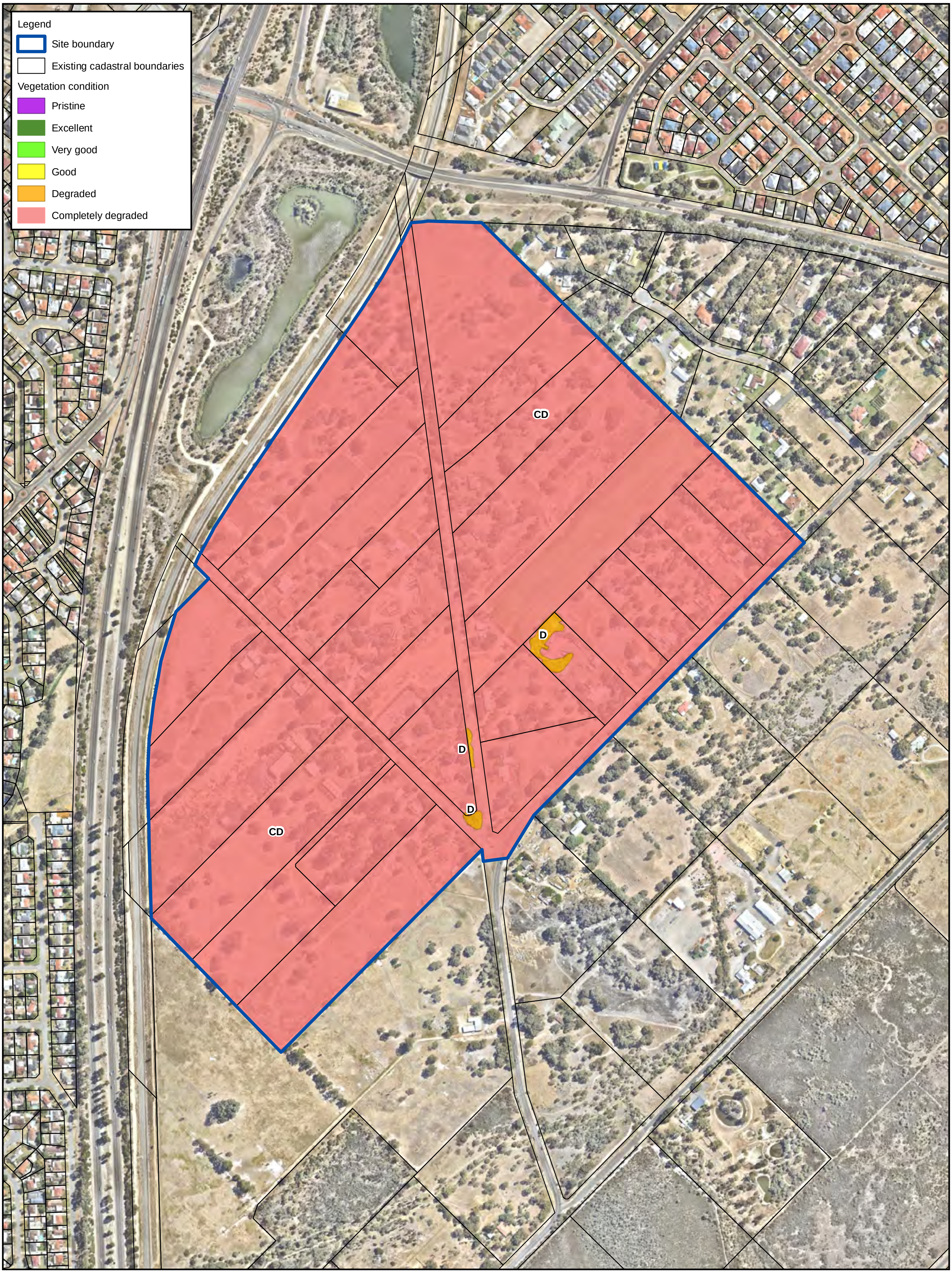

Figure 7:	**Vegetation Condition**	**Plan Number: EP14-056(05)--F19a**		
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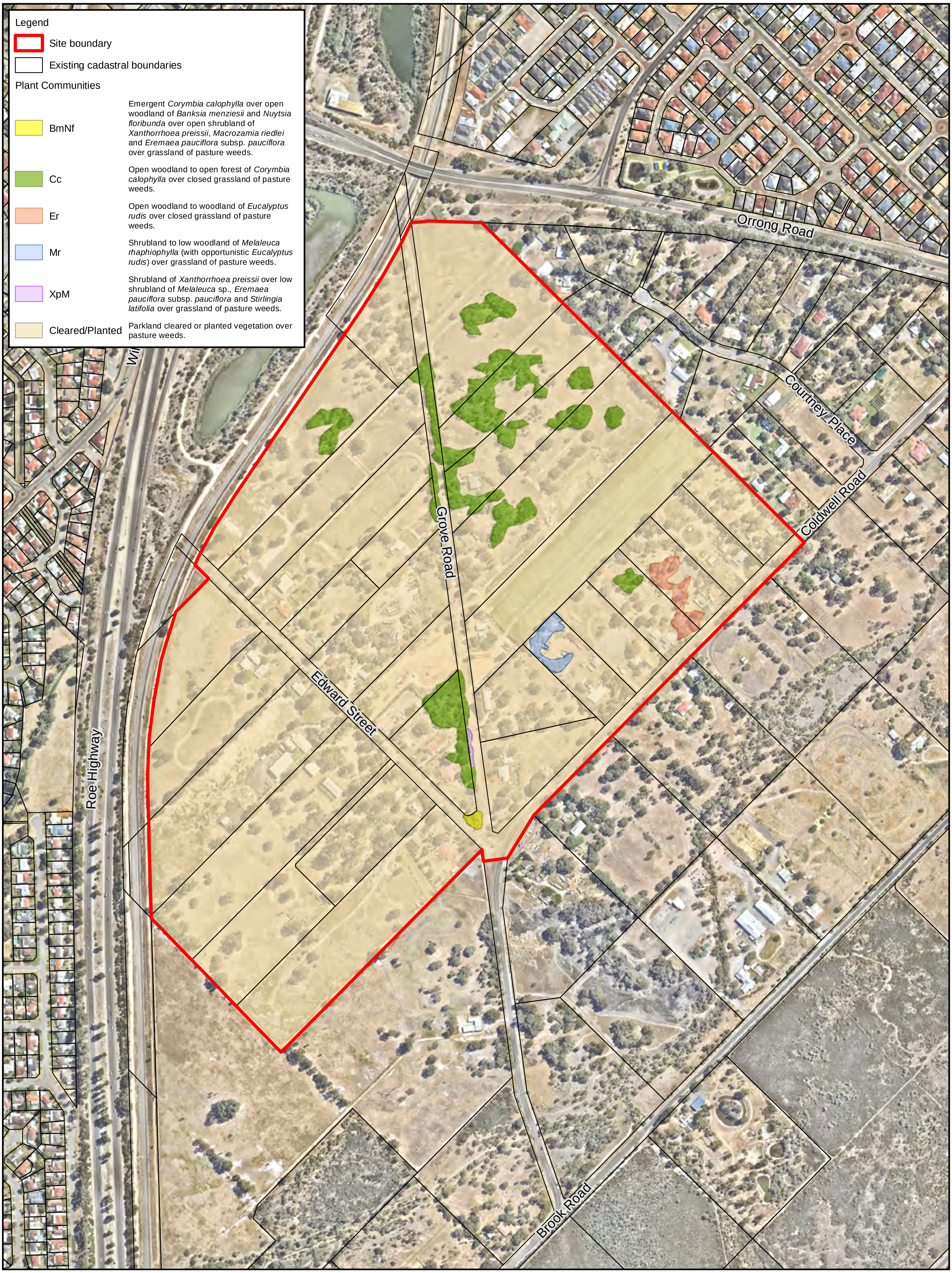

Figure 8:	**Plant Communities**	**Plan Number: EP14-056(05)--F18a**	
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		Approved: JDH	Date: 23/03/2016
Client:	Linc Property Pty Ltd.	Checked: ADB	Scale: 1:7,500@A4

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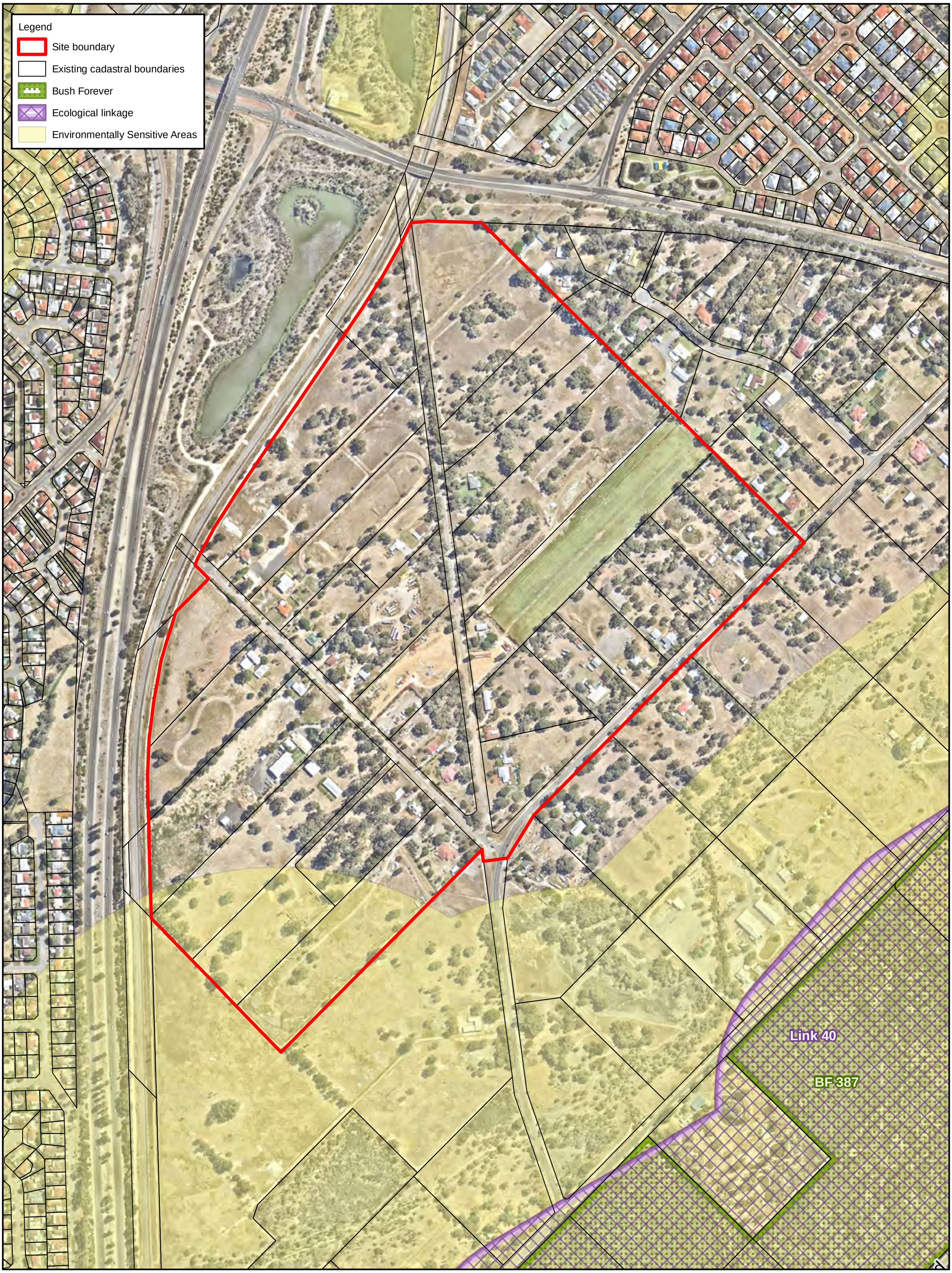

Figure 9:	Bush Forever, Ecological Linkages and Environmentally Sensitive Areas	Plan Number: EP14-056(05)--F24a		
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Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan	Approved: JDH	Date: 23/03/2016	
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Client:	Linc Property Pty Ltd	0 150 300 Metres		

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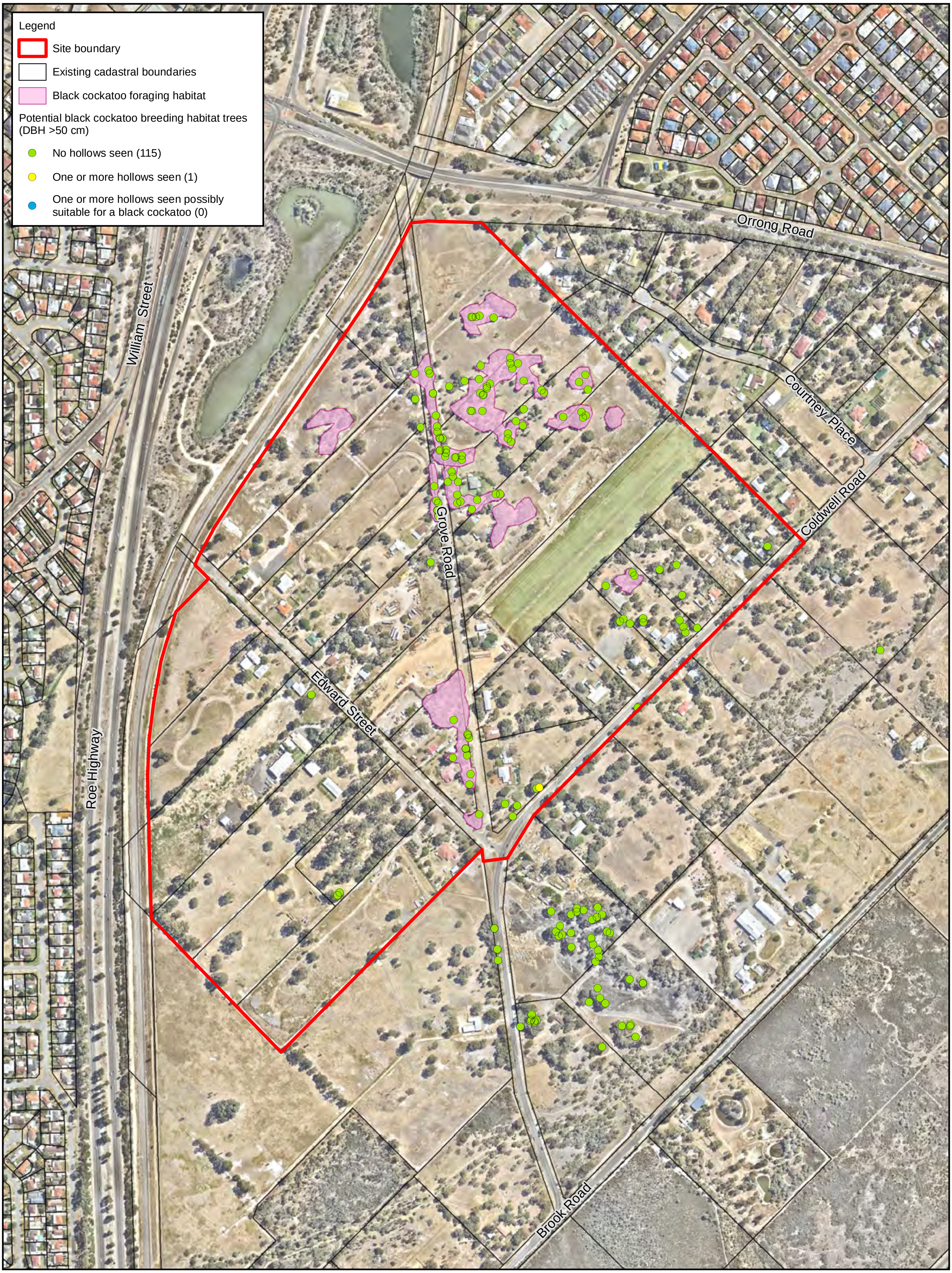

Figure 10: Black Cockatoo Habitat

Project: Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan

Client: Linc Property Pty Ltd.

Plan Number: EP14-056(05)--F20a			
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Approved:	JDH	Date:	23/03/2016
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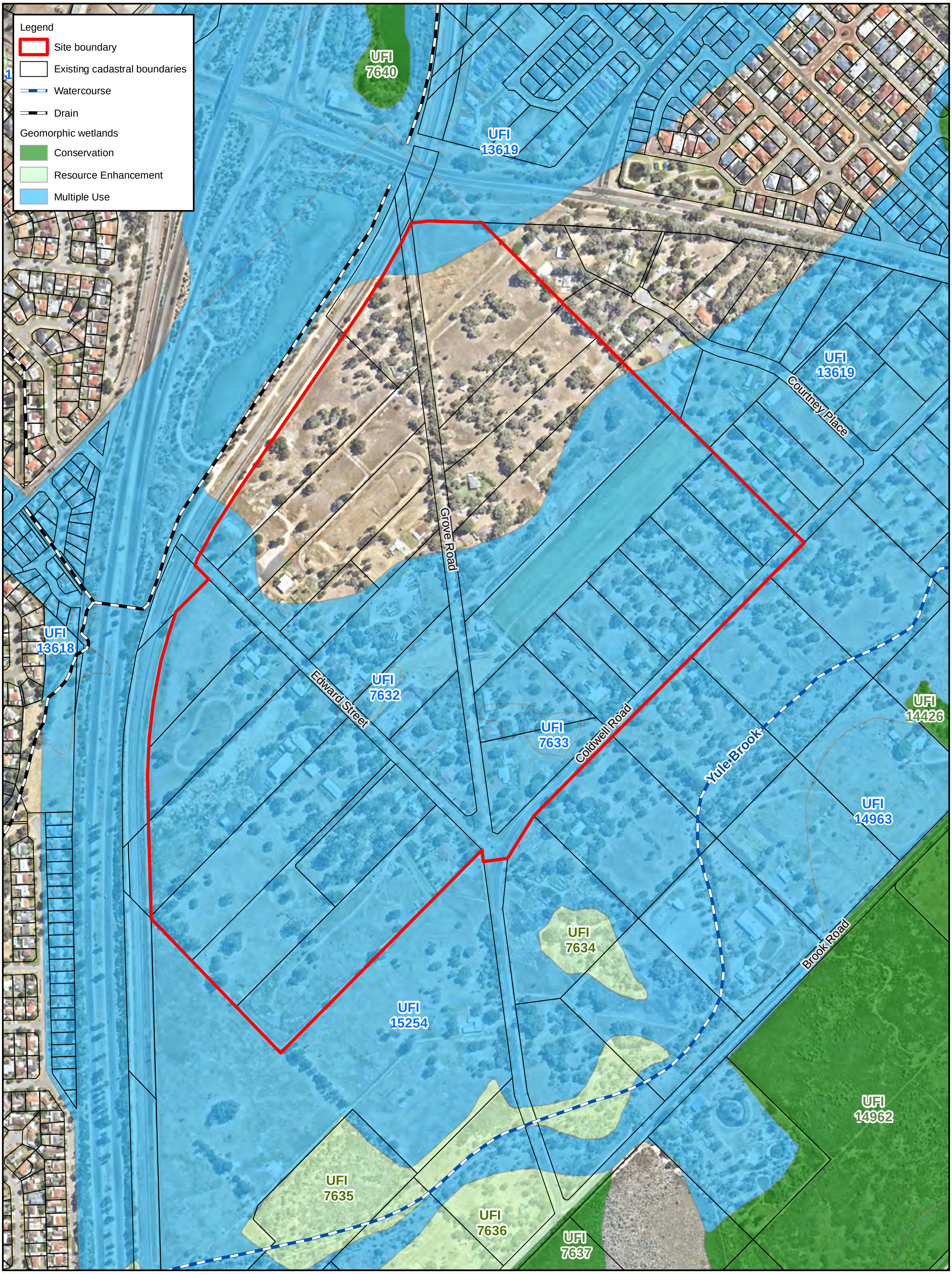

Figure 11:	Surface Water Features and Wetlands
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F11a

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Approved:	JDH	Date:	23/03/2016
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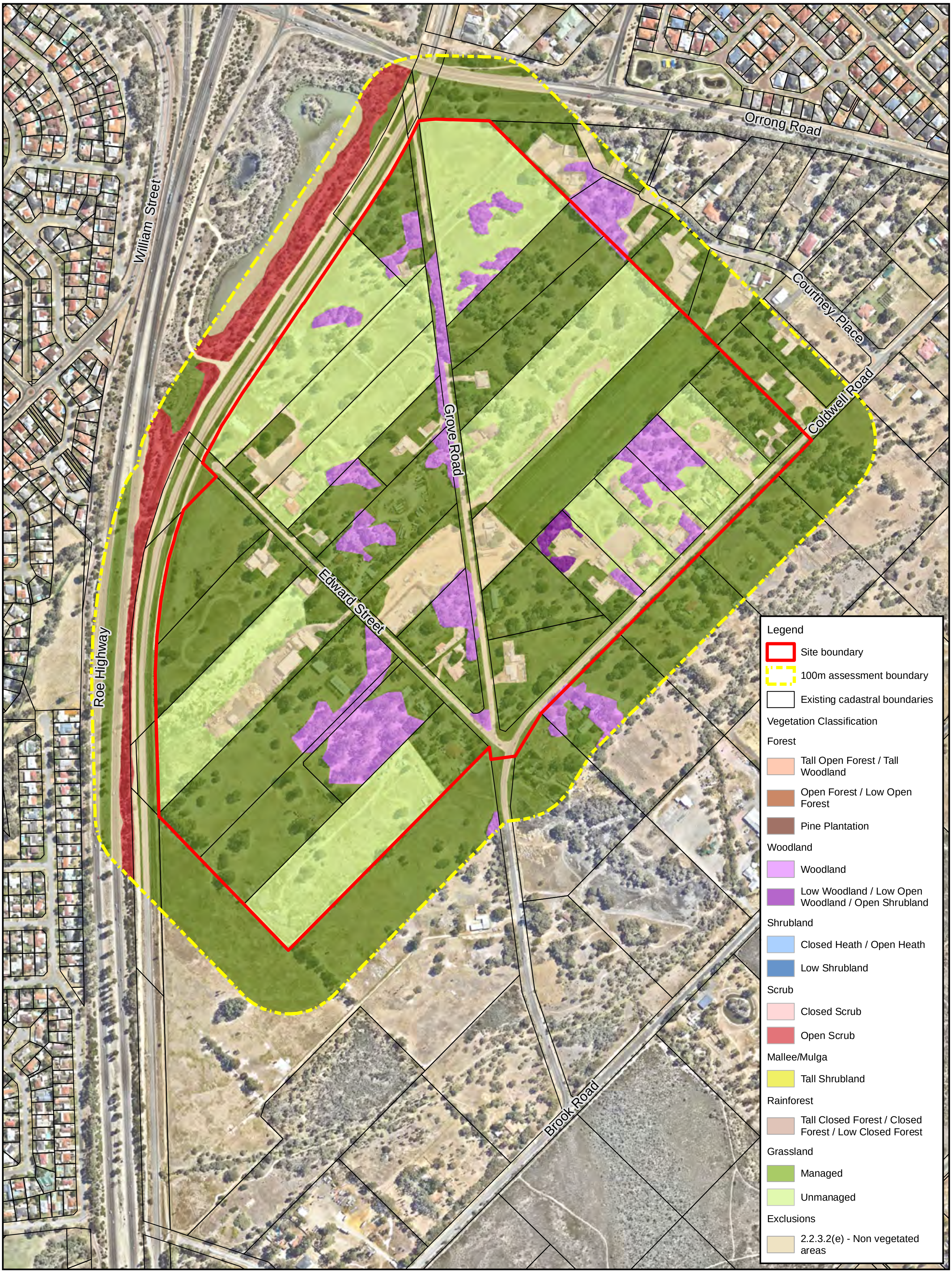

Figure 12:	**Pre-Development AS 3959 Vegetation Classification**
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

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Plan Number: EP14-056(05)--F22a

Drawn:	ADB	Date:	18/03/2016
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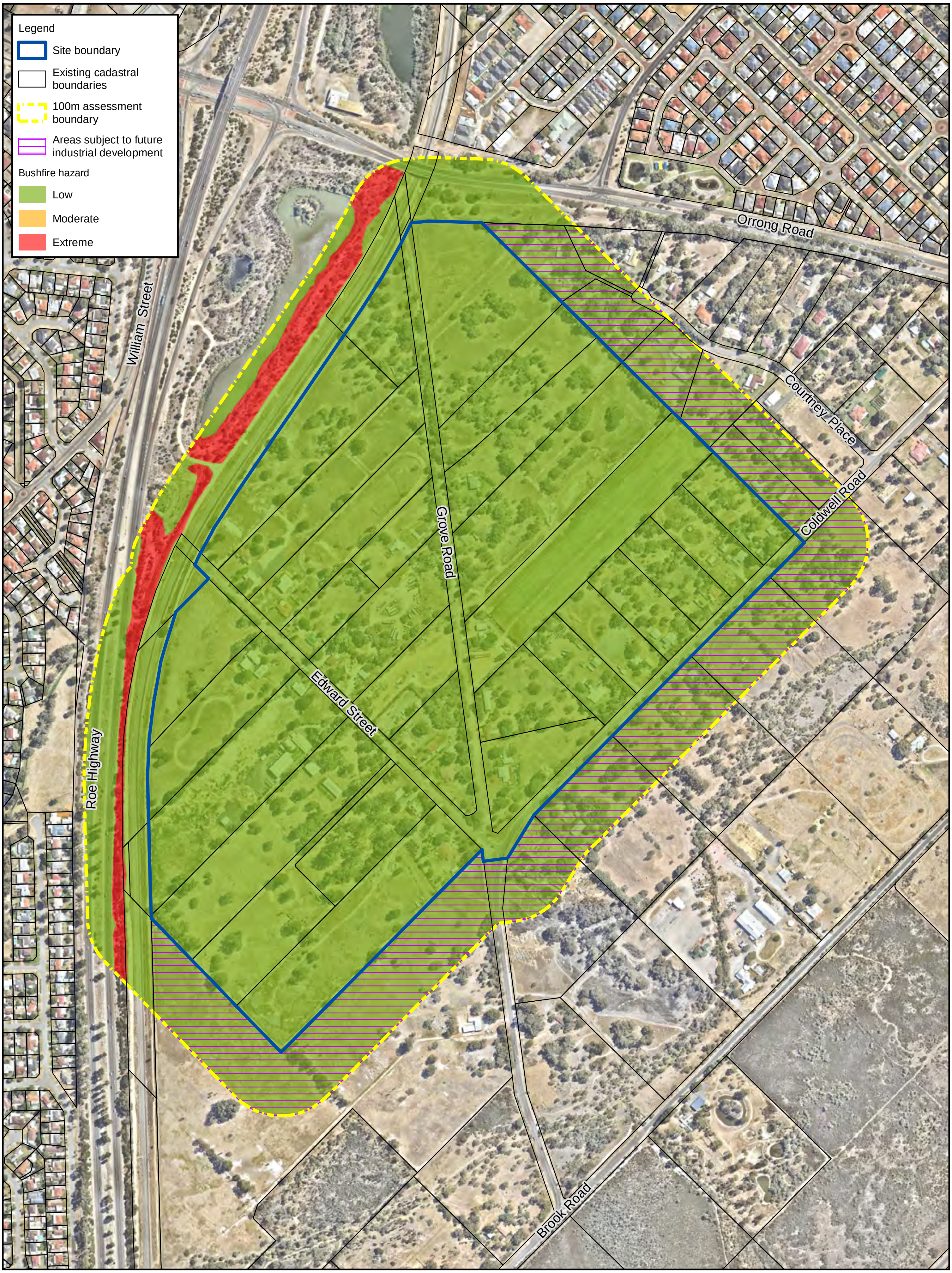

Figure 13:	**Post Development Bushfire Hazard Levels**
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(05)--F23a

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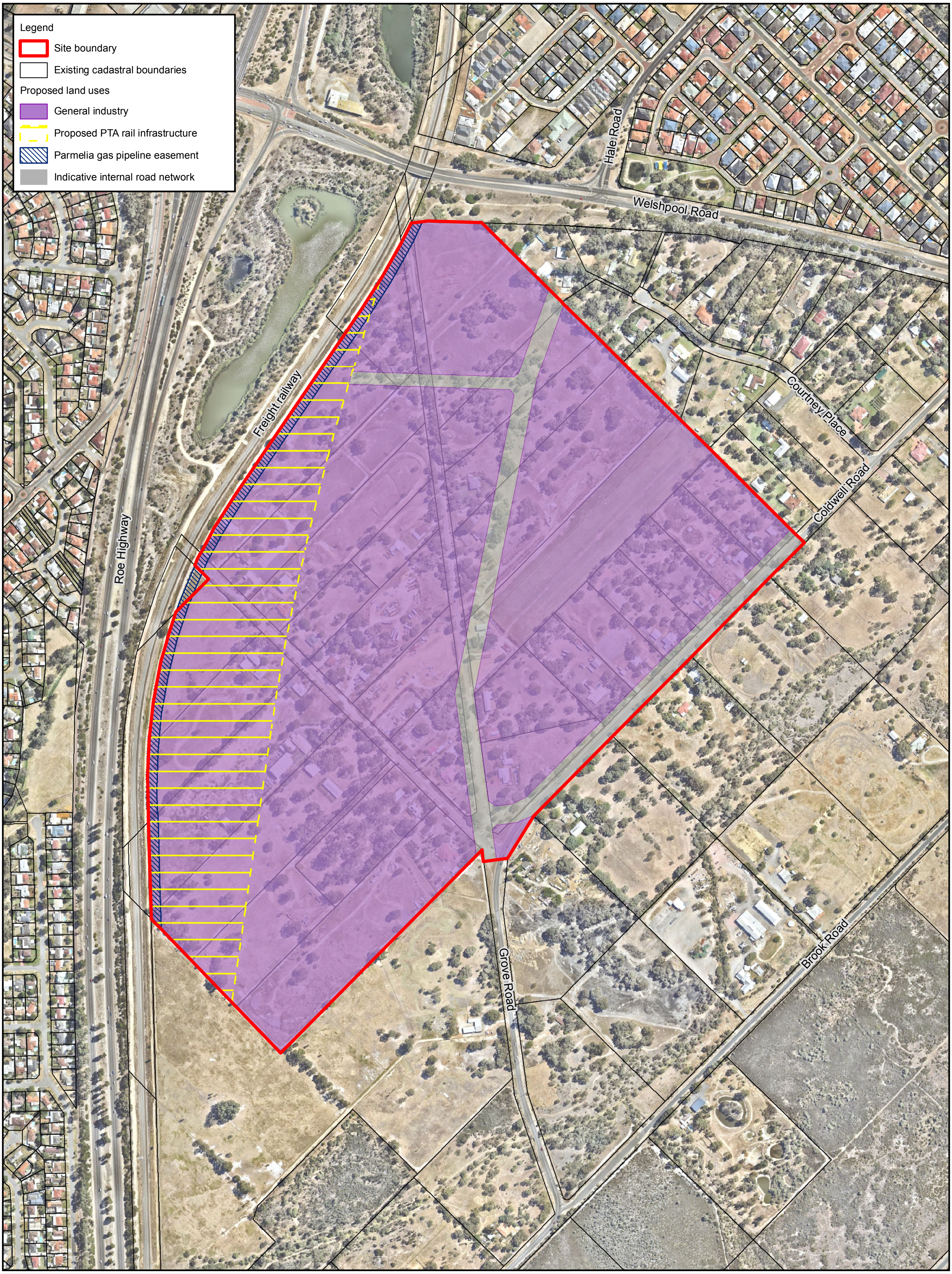

Figure 14:	**Proposed Structure Plan**
Project:	Environmental Assessment and Management Strategy MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(05)--F12d

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Approved:	JDH	Date:	04/05/2016
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APPENDIX A

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FLORA AND VEGETATION ASSESSMENT (EMERGE ASSOCIATES 2016)

FLORA AND VEGETATION ASSESSMENT

MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA PRECINCT 3A

Project Number EP14-056(03)

Prepared for Linc Property Pty Ltd.
April 2016

Document Control

DOC NAME	**FLORA AND VEGETATION ASSESSMENT – MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA PRECINCT 3A**				
DOC NO.	**EP14-056(03)—013**				
REVISION	**DATE**	**AUTHOR**		**REVIEWER**	
1	March 2016	Sarah Paul	SKP	Tom Atkinson	TAA
	Draft prepared for client review				
A	April 2016	Andreas Biddiscombe	ADB	Tom Atkinson	TAA
	Minor updates following review from client.				
B					
C					
D					

Executive Summary

Linc Property Pty Ltd (Linc Property) are currently progressing with structure planning to guide industrial development across Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA). Precinct 3A of the MKSEA, herein referred to as 'the site', is located within the City of Gosnells (CoG) approximately 12 km south-east of the Perth Central Business District, as shown in **Figure 1**.

Emerge Associates (Emerge) conducted a 'level 1' flora and vegetation assessment in accordance with the Environmental Protection Authorities (EPA's) Guidance Statement No. 51 – *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* to inform the proposed industrial development of the site. A botanist from Emerge visited the site on the 7 and 9 December 2015 and the site was traversed on foot, where access was available.

A total of 14 native flora species and 33 introduced or planted species were recorded. None of the native flora species recorded are listed as threatened or priority flora species. The majority of the site was in 'completely degraded' condition comprising cleared/planted vegetation over pasture weeds, with scattered remnant patches of five native plant communities which were marginally more intact and in 'degraded' condition. These plant communities consisted of a partially intact overstorey layer over a weed dominated understorey, with minimal native flora species remaining. The areas comprising intact native plant communities are described as:

- **BmNf** – Emergent *Corymbia calophylla* over open woodland of *Banksia menziesii* and *Nuytsia floribunda* over open shrubland of *Xanthorrhoea preissii, Macrozamia riedlei* and *Eremaea pauciflora* subsp. *pauciflora* over grassland of pasture weeds.
- **XpM** – Shrubland of *Xanthorrhoea preissii* over low shrubland of *Melaleuca* sp., *Eremaea pauciflora* subsp. *pauciflora* and *Stirlingia latifolia* over grassland of pasture weeds.
- **Mr** – Shrubland to low woodland of *Melaleuca rhaphiophylla* (with scattered *Eucalyptus rudis*) over grassland of pasture weeds.
- **Cc** – Open woodland to open forest of *Corymbia calophylla* over closed grassland of pasture weeds.
- **Er** – Open woodland to woodland of *Eucalyptus rudis* over closed grassland of pasture weeds.

Plant communities **Er** and **Mr** are likely to represent 'floristic community type' (FCT) 11 – 'Wet forest and woodlands' or 'FCT 13 - Deeper wetlands on heavy soils', of which neither are listed as 'threatened ecological communities' (TECs) or 'priority ecological communities' (PECs). Areas of these communities were in degraded or completely degraded condition. Plant communities **Cc**, **BmNf** and **XpM** may have originally represented TECs or PECs. However, these plant communities are now in degraded or completely degraded condition with few native species present and an FCT could not be accurately assigned based on their current condition.

The results of this assessment indicate that the proposed industrial development of the site are unlikely to result in the loss of any significant flora or vegetation values given the degree of historical clearing that has occurred. Therefore, the flora and vegetation values are not likely to need further consideration throughout the proposed planning and development process.

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1 Introduction

1.1 Project background

Linc Property Pty Ltd (Linc Property) are currently progressing with structure planning to guide industrial development across Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA). Precinct 3A of the MKSEA, herein referred to as 'the site', is located within the City of Gosnells (CoG) approximately 12 km south-east of the Perth Central Business District, as shown in **Figure 1**.

The site is currently zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and CoG Town Planning Scheme (TPS) No. 6 respectively. An amendment to the MRS (no. 1302/57) is currently being progressed to rezone the site to 'Industrial'.

1.2 Purpose and scope of assessment

Emerge Associates (Emerge) conducted a 'level 1' flora and vegetation assessment across the entire site in support of the structure planning process. However, access was not available for all lots, as shown on **Figure 1**. For those lots that could not be directly accessed, the flora and vegetation values were obtained by observations made from road reserves or adjacent lots and therefore have not been surveyed in detail as part of this assessment.

As part of this scope of works, the following tasks have been undertaken.

- A desktop review of relevant information pertaining to the site and surrounds was completed.
- A level 1 flora and vegetation survey was conducted in accordance with Environmental Protection Authority's (EPA) *Guidance Statement No. 51 - Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (EPA 2004).
- A list of flora species recorded as part of the field survey was compiled.
- Plant communities and vegetation condition across the site were defined and mapped.
- The desktop assessment, field methods and results were compiled into a report.

2 Background

2.1 Climate

The climate of the site and wider Perth metropolitan region is described as Mediterranean, with hot, dry summers and moderately wet, mild winters. The majority of rainfall within the region occurs between May and October each year, and on average is between 600 to 1000 millimetres annually. However, in the last 40 years there has been a marked decrease in rainfall, with a noticeable shift to a drier climate across the south-west of Western Australia (CSIRO 2009).

The closest weather station which records rainfall and temperature data is located at Meteorology (BoM) station number 9106 approximately 3 km south of the site within the CoG. Based on weather data collected from 1961 to 2015, the site experiences an average annual rainfall of 825 mm and a mean annual maximum and minimum temperature of 25.6˚C and 13.4˚C respectively (BoM 2015).

2.2 Geomorphology and soils

The site occurs on the Swan Coastal Plain, which is the geomorphic unit that characterises the Perth region and surrounds. The Swan Coastal Plain is approximately 500 km long and 20 to 30 km wide and broadly consists of two sedimentary belts of different origin. On the eastern side of the Swan Coastal Plain, the Pinjarra Plain has formed from the deposition of alluvial material washed down from the Darling Scarp. The remaining portion of the Swan Coastal Plain is comprised of three dune systems referred to as Quindalup, Spearwood and Bassendean associations that run roughly parallel to the Indian Ocean coastline (Seddon 2004). These dune systems represent a succession of coastal deposition that has occurred since the late Quaternary period (approximately 2 million years ago) (Kendrick *et al.* 1991) and, as a result, the three associations contain soils at different stages of leaching and formation. The site specifically occurs at the junction of the Pinjarra Plain and the Bassendean association, which is the oldest and most leached of the Swan Coastal Plain dune sequence.

The majority of the site is situated within the Guildford soil-landform formation, which is described as a flat plain with medium textured deposits and yellow duplex soils. The northern-most portion of the site is mapped as the Southern River soil-landform formation, which is described as a sandplain with low dunes and many intervening swamps (Churchward and McArthur 1980).

The site is generally flat and low-lying, with elevation ranging from approximately 7 m Australian height datum (AHD) in the south-west to 13 m AHD in the north-east. Much of the site is comprised of seasonally waterlogged flats (palusplains), as discussed further within **Section 2.9**.

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986), indicates the site contains the following two soil types:

- Clayey sand (Sc): silty in part, pale grey-brown, medium to coarse, poorly sorted, sub-angular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin
- Sand (S_{10}): white to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin, over other units.

2.3 Regional vegetation

The site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by Beard (1990). This region is characterised by *Banksia* low woodlands on leached sands, woodlands of *Eucalyptus gomphocephala* (tuart), *Eucalyptus marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils and *Melaleuca* spp. swamps.

At a finer scale, vegetation complex mapping undertaken by Heddle *et al.* (1980) for the Swan Coastal Plain, indicates that the site primarily occurs within the Guildford complex (Pinjarra Plain). Some of the northern most lots are mapped as comprising the Southern River complex, which is transitional between the Bassendean dunes and the Pinjarra Plain. Vegetation in the Guildford complex is characterised by a mixture of open forest to tall open forest of marri, *Eucalyptus wandoo* (wandoo), jarrah and woodland of wandoo (with rare occurrences of *Eucalyptus lane-poolei*). Minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla*. Vegetation of the Southern River complex includes open woodland of marri, jarrah and *Banksia* spp. with fringing woodland of *Eucalyptus rudis - Melaleuca rhaphiophylla* along creek beds (Heddle *et al.* 1980).

Prior to European settlement and the extensive land clearing that followed, the Guildford complex covered 92,281 ha of the Swan Coastal Plain. In 2013, 5,413 ha of this complex was estimated to remain on the Swan Coastal Plain which is 5.9% of its original extent (LBP 2013). The Southern River complex once covered 57,172 ha of the Swan Coastal Plain. In 2013, 11,255 ha of this complex was estimated to remain on the Swan Coastal Plain which is 19.7% of its original extent (LBP 2013).

Many studies have indicated that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent (Miles 2001). However this is a purely biodiversity orientated objective, and on the Swan Coastal Plain portion of the Perth Metropolitan area, which is considered a ‘constrained area’, the EPA has applied a biodiversity protection objective of retaining 10% of each vegetation complex (EPA 2006). As described above, the extent of the Guildford complex remaining is below this target.

2.4 Significant flora species

Some flora species are considered to be rare or under threat and therefore to warrant special protection, either under State and/or Commonwealth legislation. Similarly, certain introduced species that are particularly aggressive and invasive are ascribed ‘declared pest’ status, indicating that they warrant special management to limit further spread.

At a Commonwealth level, flora species can be considered ‘threatened’ pursuant to Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the EPBC Act, threatened species are listed as ‘critically endangered’ (CE), ’endangered’ (E) or ‘vulnerable’ (V). Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment.

At a state level, plant species are classed ‘threatened’ (‘declared rare’) (T) or ‘priority’ (P) conservation status where populations are restricted geographically or threatened by local processes. DPaW recognise these threats and subsequently considers population protection and species conservation. DPaW enforces the *Wildlife Conservation Act 1950* (WC Act) to conserve threatened flora and protect populations. Threatened flora are gazetted under Subsection 2 of Section 23F of the WC Act and it is an offence to "take" or damage rare flora without Ministerial approval. Section 23F of the WC Act defines "to take" as "… to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora to cause or permit the same to be done by any means". Priority flora species are potentially rare or threatened and are classified in order of threat, but are not afforded statutory protection. The definition and categories of threatened and priority flora are listed in **Table 1**.

Table 1: Definition of threatened and priority flora species (Smith 2010)

CONSERVATION CODE	CATEGORY
T	**Threatened Flora – Extant Taxa** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
X	**Threatened Flora – Presumed Extinct Taxa** Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
P1	**Priority One – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat e.g. road verges, urban areas, farmland, active mineral leases etc., or the plants are under threat, e.g. from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	**Priority Two – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3	**Priority Three – Poorly Known Taxa** Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but needs further survey.
P4	**Priority Four – Rare Taxa** Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

A search was conducted of DPaW's databases of threatened and priority flora species within a 5 km radius of the site and EPBC Act list of 'matters of national environmental significance' (MNES) that occur within the wider area. These searches indicated that 28 threatened flora species and 48 priority flora species have been recorded within the wider local area. These species are listed in **Table 2**, along with an inference of the likelihood of occurrence for each species based on habitat preferences and known species characteristics. Based on the coordinates of each occurrence, a number of occurrences are located close to the south of the site, in intact remnant vegetation close to Yule Brook. None of the occurrences are located within the site.

Table 2: Significant flora species known to occur within the general area.

SPECIES	LEVEL OF SIGNIFICANCE		LIFE STRATEGY	SUBSTRATE	FLOWERING PERIOD	LIKELIHOOD OF OCCURRENCE
	STATE	EPBC ACT				
Acacia anomala	T	V	P	Lateritic soils. Slopes.	Aug-Sep	Unlikely
Andersonia gracilis	T	E	P	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Sep-Nov	Possible
Austrostipa bronwenae	T	-	P	Muddy sand or loam, often over clay. Seasonal wetlands.	Sep	Possible
Banksia mimica	T	E	P	White or grey sand over laterite, sandy loam.	Dec or Jan-Feb	Possible
Caladenia huegelii	T	E	Pg	Grey or brown sand, clay loam.	Sep-Oct	Possible
Calectasia cyanea	T	CE	P	White, grey or yellow sand, gravel.	Jun-Oct	Unlikely
Calytrix breviseta subsp. *breviseta*	T	E	P	Sandy clay. Swampy flats.	Oct-Nov	Possible
Chamelaucium sp. Gingin (N.G.Marchant 6)	T	E	P	Dry sand, sometimes with gravel. Undulating plains, slopes or hill rises.	Sep-Dec	Unlikely
Conospermum undulatum	T	E	P	Grey or yellow-orange clayey sand.	May-Oct	Possible
Darwinia apiculata	T	E	P	Lateritic soils.	Oct	Unlikely
Darwinia foetida	T	CE	P	Moist to dry flats. Dry grey sands. Some occurrences in winter wet wetlands.	Sep-Nov	Possible
Diuris micrantha	T	V	Pg	Brown loamy clay. Winter-wet swamps, in shallow water.	Sep-Oct	Possible
Diuris purdiei	T	E	Pg	Grey-black sand, moist. Winter-wet swamps.	Sep-Oct	Possible
Drakaea elastica	T	E	Pg	White or grey sand. Low-lying situations adjoining winter-wet swamps.	Oct-Nov	Possible
Drakaea micrantha	T	V	Pg	White-grey sand.	Sep-Oct	Possible
Eleocharis keigheryi	T	V	P	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	Aug-Nov	Possible

SPECIES	LEVEL OF SIGNIFICANCE		LIFE STRATEGY	SUBSTRATE	FLOWERING PERIOD	LIKELIHOOD OF OCCURRENCE
	STATE	EPBC ACT				
Eremophila glabra subsp. *chlorella*	T	-	P	Sandy clay. Winter-wet depressions.	Jul-Nov	Possible
Eucalyptus x *balanites*	T	E	P	Sandy soils with lateritic gravel.	Oct to Dec or Jan to Feb.	Unlikely
Grevillea curviloba subsp. *incurva*	T	E	P	Sand, sandy loam. Winter-wet heath.	Aug-Sep	Possible
Grevillea thelemanniana subsp. *thelemanniana*	T	-	P	Sand or clay soils. Winter wet depressions.	May-Nov	Possible
Lepidosperma rostratum	T	E	P	Peaty sand, clay.	Jun-Jul (Sep) and Nov	Possible
Macarthuria keigheryi	T	E	P	White or grey sand.	Sep-Dec or Feb-Mar	Possible
Ptilotus pyramidatus	T	CE	P	Sandy clay. Floodplain.	Oct	Possible
Synaphea stenoloba	T	E	P	Sandy or sandy clay soils. Winter-wet flats, granite.	Aug-Oct	Possible
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	E	P	Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses.	Oct	Unlikely
Tetraria australiensis	T	V	P	Sandy loam/clay. Some occurrences over laterite. Flats or gentle slopes.	Nov-Dec	Possible
Thelymitra dedmaniarum	T	E	Pg	Granite.	Nov-Dec (Jan)	Unlikely
Thelymitra stellata	T	E	Pg	Sand, gravel, lateritic loam.	Oct-Nov	Unlikely
Taraxacum cygnorum	X	V	A	Brown loamy sand. Limestone outcrops.	Oct-Dec	Unlikely – not seen in WA in over a century
Acacia horridula	P3	-	P	Gravelly soils over granite, sand. Rocky hillsides.	May-Aug	Unlikely
Acacia mutabilis subsp. *incurva*	P2	-	P	Sandy loam, clayey loam. Undulating plains.	Aug-Sep	Possible
Acacia oncinophylla subsp. *patulifolia*	P4	-	P	Granitic soils, occasionally on laterite.	Aug-Nov or Nov-Dec	Unlikely

SPECIES	LEVEL OF SIGNIFICANCE		LIFE STRATEGY	SUBSTRATE	FLOWERING PERIOD	LIKELIHOOD OF OCCURRENCE
	STATE	EPBC ACT				
Aponogeton hexatepalus	P4	-	P	Mud. Freshwater: ponds, rivers, claypans.	Jul-Oct	Possible
Babingtonia urbana	P3	-	P	Sand, peat, clay and loam, swampy. Seasonal wetlands.	Jan-Mar	Known
Banksia pteridifolia subsp. *vernalis*	P3	-	P	White/grey sand over laterite.	Sep-Oct	Unlikely
Boronia tenuis	P4	-	P	Laterite, stony soils, granite.	Aug-Nov	Unlikely
Byblis gigantea	P3	-	P	Sandy-peat swamps. Seasonally wet areas.	Sep-Dec or Jan	Possible
Calandrinia sp. Piawaning (A.C. Beauglehole 12257)	P1	-	A	Brown/grey silty sandy loam over granite. Near pools, small rise within large saline valley flats, disturbed shrubland.	Oct	Unlikely
Carex tereticaulis	P3	-	P	Black peaty sand.	Sep-Oct	Unlikely
Centrolepis caespitosa	P4	-	A	White sand, clay. Salt flats, wet areas.	Oct-Dec	Possible
Chamaescilla gibsonii	P3	-	Pg	Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	Sep	Possible
Comesperma griffinii	P2	-	A/P	Yellow or grey sand. Plains.	Oct	Unlikely
Comesperma rhadinocarpum	P2	-	P	Sandy or clay soils. Sometimes over laterite. Sometimes in winter wet flats.	Oct-Nov	Possible
Conostylis pauciflora subsp. *euryrhipis*	P4	-	P	White, grey or yellow sand. Consolidated dunes.	Aug-Oct	Unlikely
Dampiera sericantha	P3	-	P	Sand, sometimes with gravel. Plains.	May or Aug-Dec	Possible
Drosera occidentalis subsp. occidentalis	P4	-	P	Sandy & clayey soils. Swamps & wet depressions.	Nov-Dec	Possible
Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)	P3	-	A	Sandy or clay flats or depressions. Sometimes inundated.	Sep-Nov	Possible

SPECIES	LEVEL OF SIGNIFICANCE		LIFE STRATEGY	SUBSTRATE	FLOWERING PERIOD	LIKELIHOOD OF OCCURRENCE
	STATE	EPBC ACT				
Eryngium sp. Subdecumbens (G.J. Keighery 5390)	P3	-	A/P	Clay soils. Winter wet.	Sep-Nov	Possible
Grevillea bipinnatifida subsp. pagna	P1	-	P	Grey sandy clay and loam, ironstone. Seasonal wetlands, swamps, roadsides.	Aug or Oct-Nov	Possible
Haemodorum loratum	P3	-	P	Grey or yellow sand, gravel.	Nov	Unlikely
Haloragis scoparia	P1	-	P	Clay over limestone (one occurrence). Winter wet.	Unknown	Possible
Hibbertia montana	P4	-	P	Loam over granite, lateritic soils, gravel. Granite rocks, lateritic ridges & boulders, hills.	Jul-Oct	Unlikely
Hydrocotyle lemnoides	P4	-	Aa	Swamps. Inundated.	Aug-Oct	Unlikely
Isopogon drummondii	P3	-	P	White, grey or yellow sand, often over laterite.	Feb-Jun	Possible
Lasiopetalum bracteatum	P4	-	P	Sandy clay, clay, lateritic gravel. Along drainage lines, creeks, gullies, granite outcrops.	Aug-Nov	Possible
Lasiopetalum glutinosum subsp. *glutinosum*	P3	-	P	Sandplains, rocky slopes, sand, clay and gravelly ironstones/granitic soils.	Sep-Dec	Unlikely
Lepyrodia curvescens	P2	-	P	Sand, laterite. Seasonally inundated swampland.	Sep-Nov	Possible
Meionectes tenuifolia	P3	-	Aa	Clay and sand. Seasonal wetlands.	Oct-Dec	Unlikely
Melaleuca viminalis	P2	-	P	Damp sandy, loamy or clay soils. Flats, creeklines.	Aug-Dec	Possible
Myriophyllum echinatum	P3	-	A	Clay. Winter-wet flats.	Nov	Possible
Ornduffia submersa	P4	-	Aa	Damp sand, loam and clay. Seasonal wetlands.	Sep-Nov	Possible
Platysace ramosissima	P3	-	P	Sandy soils. Occasionally over clay or limestone. Within or sandy rises adjacent to wetlands.	Oct-Nov	Possible

SPECIES	LEVEL OF SIGNIFICANCE		LIFE STRATEGY	SUBSTRATE	FLOWERING PERIOD	LIKELIHOOD OF OCCURRENCE
	STATE	EPBC ACT				
Schoenus benthamii	P3	-	P	White, grey sand, sandy clay. Winter-wet flats, swamps.	Oct-Nov	Possible
Schoenus capillifolius	P3	-	A	Brown mud. Claypans. Semi aquatic.	Oct-Nov	Possible
Schoenus loliaceus	P2	-	A	Sandy soils. Winter-wet depressions.	Aug-Nov	Possible
Schoenus natans	P4	-	Aa	Winter-wet depressions.	Oct	Possible
Schoenus pennisetis	P3	-	A	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.	Aug-Sep	Possible
Schoenus sp. Beaufort (G.J. Keighery 6291)	P1	-	A	Mud. Winter-wet claypans.	Sep-Oct	Possible
Schoenus sp. Waroona (G.J. Keighery 12235)	P3	-	A	Clay or sandy clay. Winter-wet flats.	Oct-Nov	Possible
Stylidium longitubum	P4	-	A	Sandy clay, clay. Seasonal wetlands.	Oct-Dec	Possible
Stylidium periscelianthum	P3	-	Pg	Loamy clay, moist soils pockets. Wet flats, low granitic hills.	Sep-Oct	Unlikely
Tetratheca sp. Granite (S. Patrick SP1224)	P3	-	P	Clay, moist loam, clayey sand. Granite boulders.	Sep-Nov (Dec)	Unlikely
Thelymitra magnifica	P1	-	Pg	Dry-moist brown clay, loam or gravel. Stony ridges.	Oct	Possible
Thelymitra variegata	P2	-	Pg	Sandy clay, sand, laterite.	Jun-Sep	Possible
Thomasia brachystachys	P1	-	P	Littered, organic brown soil. High, open or dense forests.	Unknown	Unlikely
Thysanotus anceps	P3	-	P	White or grey sand, lateritic gravel, laterite.	Oct-Dec	Unlikely
Verticordia lindleyi subsp. *lindleyi*	P4		P	Sand, sandy clay. Winter-wet depressions.	May or Nov-Dec or Jan	Possible

Note: P = perennial, PG = perennial geophyte, A = annual, Aa = aquatic annual, T= threatened, E = endangered, V = vulnerable, CE = critically endangered.

Declared pests are listed pursuant to the State's *Biosecurity and Agriculture Management Act 2007* (BAM Act). Under the BAM Act, all declared pests are placed in one of three categories, namely C1 (exclusion), C2 (eradication) or C3 (management). These categories are described further in **Table 3**.

Table 3: Categories of declared pest species under the BAM Act (DAFWA 2013).

CATEGORY	DESCRIPTION
C1 (Exclusion)	Not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 (Eradication)	Present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 (Management)	Established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Pursuant to Part 2.3.23 of the BAM Act, a person must not; "*a) keep, breed or cultivate the declared pest; b) keep, breed or cultivate an animal, plant or other thing that is infected or infested with the declared pest; c) release into the environment the declared pest, or an animal, plant or other thing that is infected or infested with the declared pest; or d) intentionally infect or infest, or expose to infection or infestation, a plant, animal or other thing with a declared pest*".

The presence of declared pest species occurring within the site will be identified during the field survey and reported in **Section 4.2**.

2.5 Threatened and priority ecological communities

Generally an ecological community can be described as a naturally occurring group of native plants, animals and other organisms that are interacting in a unique habitat. An ecological community's structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability (DotE 2016). 'Threatened ecological communities' (TECs) are recognised as specific ecological communities that are rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under section 181 of the EPBC Act. TECs nominated for listing under the EPBC Act are considered by the Threatened Species Scientific Committee and a final decision is made by the Minister of the Environment. Once listed under the EPBC Act, communities are categorised as either 'critically endangered', 'endangered' or 'vulnerable'. Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment.

Within Western Australia, TECs are determined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (WATECSAC) and endorsed by the Minister for the Environment. The WATECSAC is an independent group comprised of representatives from organisations including tertiary institutions, the WA Museum and DPaW. Communities are assigned to one of the categories outlined in **Table 4** relating to their status of threat. While they are not afforded direct statutory protection at a state level (unlike threatened flora under the WC Act) their significance is acknowledged through other state environmental approval processes such as the Environmental Impact Assessment pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the Part V of the EP Act and associated clearing regulations.

A community may also be recognised as a 'priority ecological community' (PEC). This is an ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined, and can be placed on the list of PECs in either category 1, 2 or 3 (these are described in **Table 5**). Ecological communities that are adequately known and are rare but not threatened, or meet criteria for 'near threatened', or have been recently removed from the threatened list, are placed in Priority 4, and require regular monitoring. Conservation dependent ecological communities are placed in Priority 5 (DEC 2009a).

Table 4: Categories of threatened ecological communities (English and Blyth 1997)

CONSERVATION CATEGORY	DESCRIPTION
PD	Presumably totally destroyed An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	Critically endangered An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	Endangered An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	Vulnerable An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Table 5: Categories of priority ecological communities (DEC 2009a)

PRIORITY CATEGORIES	DESCRIPTION
Priority 1	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (i) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (ii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

PRIORITY CATEGORIES	DESCRIPTION
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened or that have been recently removed from the threatened list. These communities require regular monitoring.
Priority 5	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

A search was conducted of the following datasets:

- the EPBC Act list of MNES (DotE 2015)
- the 'weed and native flora data for the Swan Coastal Plain' dataset (Keighery *et al.* 2012) available through NatureMap (DPaW 2015)
- DPaW's TEC and PEC database (ref 01-0216EC).

These datasets indicated the presence of 13 TECs and three PECs recorded within a 5 km radius of the site. These are listed in **Table 6**. Five of the listed TECs are also listed pursuant to the EPBC Act. The federally listed critically endangered TEC 'Clay Pans of the Swan Coastal Plain' includes SCP07-SCP10a as listed in **Table 6**.

Table 6: TECs known to occur within the wider local area.

COMMUNITY CODE	COMMUNITY NAME	TEC/PEC	LEVEL OF SIGNIFICANCE	
			STATE	EPBC ACT
SCP3a	*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain	TEC	CE	E
SCP3c	*Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	TEC	CE	E
SCP20c	Shrublands and woodlands of the eastern side of the Swan Coastal Plain	TEC	CE	E
Muchea Limestone	Shrublands and woodlands on Muchea Limestone	TEC	E	E
SCP10a	Shrublands on dry clay flats	TEC	E	CE (Clay pans of the Swan Coastal Plain)
SCP07	Herb rich saline shrublands in clay pans	TEC	V	CE (Clay pans of the Swan Coastal Plain)
SCP08	Herb rich shrublands in clay pans	TEC	V	CE (Clay pans of the Swan Coastal Plain)
SCP09	Dense shrublands on clay flats	TEC	V	CE (Clay pans of the Swan Coastal Plain)
SCP2	Southern wet shrublands, Swan Coastal Plain	TEC	E	-
SCP20a	Eastern shrublands and woodlands	TEC	E	-

COMMUNITY CODE	COMMUNITY NAME	TEC/PEC	LEVEL OF SIGNIFICANCE	
			STATE	EPBC ACT
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	TEC	E	-
SCP3b	*Corymbia calophylla – Eucalyptus marginata* woodlands on sandy slay soils of the southern Swan Coastal Plain	TEC	V	-
Coastal Saltmarsh	Subtropical and Temperate Coastal Saltmarsh	TEC	-	V
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	PEC	P3	-
SCP23a	Central *Banksia attenuata – B. menziesii* woodlands	PEC	P3	-
Central Granite Shrublands	Central Northern Darling Scarp Granite Shrubland Community	PEC	P4	-

2.6 Bush Forever

The Government of Western Australia's *Bush Forever Policy* is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10% of each vegetation complex for protection (Government of WA 2000). Bush Forever sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

No Bush Forever sites occur within the site. *Bush Forever Site 387: Greater Brixton Street Wetlands* (BF 387) abuts the south eastern side of Brook Road, approximately 500 m from the site, as shown in **Figure 2**.

2.7 Regional and local significance

Apart from being listed as either threatened or priority flora, plant species may be significant for a number of other reasons. EPA *Guidance Statement No. 51* (2004) states that significant flora may include taxa that:

- have a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species
- have relic status
- have anomalous features that indicate a potential new discovery
- are representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- have the presence of restricted subspecies, varieties or naturally occurring hybrid
- have local endemism/a restricted distribution
- are poorly reserved.

Similarly, plant communities may be significant for reasons other than a listing as a TEC or PEC. EPA (2004) indicates that these reasons include:

- scarcity
- the presence of unusual species
- a novel combinations of species
- a role as a refuge
- a role as a key habitat for threatened species
- a role as a key habitat for large populations representing a significant proportion of the local to regional total population of a species
- being representative of the range of a unit (particularly, a good local and/or regional example
- of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range
- a restricted distribution.

Such species or communities will be identified through the field survey and reported on in **Section 4** of this document.

2.8 Ecological linkages

Ecological linkages allow the movement of fauna, flora and genetic material between areas of fragmented remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances (i.e. fire) and assists in maintaining the genetic diversity of plant communities and populations. Ecological linkages are often continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

Ecological linkages have been identified by the state government in Bush Forever (2000b), Perth's Greenways (1998) and the System 6 study. These identified linkages reflect the on-ground linkages throughout the Perth Metropolitan area and are published by the Perth Biodiversity Project (PBP).

No ecological linkages are identified as occurring within the site. Approximately 500 m from the site, the GBSW area is identified as an ecological linkage, the extent of which is shown in **Figure 2**.

2.9 Wetlands

In Western Australia wetlands have been defined as: "*areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh and saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries* (Wetlands Advisory Committee 1977). This definition has been adopted by Semeniuk (1987) and by the V & C Semeniuk Group for the purposes of mapping and classification.

Wetlands can further be recognised by the presence of vegetation associated with waterlogging or the presence of hydric soils such as peat, peaty sand or carbonate mud (Hill *et al.* 1996). When determining the boundary of a wetland, it should encompass all features diagnostic of 'wet' lands, therefore within a single wetland, there may be parts or zones that are permanently inundated, seasonally inundated or seasonally waterlogged by water table rise, and all of these zones or parts of wetlands would be viewed as being wetland (Hill *et al.* 1996).

2.9.1 Consanguineous suites

The term 'consanguineous suite' as defined by Semeniuk (1988) has been used to describe the relatedness between wetlands with respect to their proximity, size, shape, type, salinity, hydrology and geological origin. The concept was further developed and the wetlands of the Swan Coastal Plain delineated into consanguineous suites by Hill *et al.* (1996).

Hill *et al.* (1996) indicates that the geomorphic wetlands within the site comprise the Mungala consanguineous suite. The Mungala suite occurs at the junction of the Bassendean Dunes and Pinjarra Plain (Hill *et al.* 1996). The wetlands within the site comprise lakes, sumplands, floodplains and creeks. Statistics of the distribution of consanguineous suites across the Swan Coastal Plain indicate that Mungala wetlands comprised 25,978 ha as of 2008, of which 10.2% is classified as CCW (DPaW 2013).

2.9.2 Geomorphic wetland types and management categories

The geomorphic wetland classification system of Semeniuk (1987) is a recognised classification system for the Darling System (which includes the Swan Coastal Plain) and is based on the landform shape and water permanence (hydro-period) of the wetland.

DPaW maintains the *Geomorphic Wetland Swan Coastal Plain* dataset, which also categorises individual wetlands into specific management categories as described in **Table 7**. The significance of each wetland is based on hydrological, biological and human use features, which are the key components for the determination of management categories. This dynamic dataset is continually updated with site-specific wetland surveys providing new and relevant information. The guidelines for proposing changes to the wetland boundaries and management categories state that relevant information should be obtained in the optimal season for vegetation condition and water levels, which is usually spring (DEC 2009b).

Each classified wetland listed in the *Geomorphic Wetland Swan Coastal Plain* dataset is given a 'unique feature identifier' (UFI). However in the case of larger wetlands that have undergone a degree of disturbance, a separate management category may be assigned to parts of the wetland in order to reflect the current values.

Table 7: Geomorphic wetlands of the Swan Coastal Plain management categories (Hill et al. 1996).

MANAGEMENT CATEGORY	DESCRIPTION OF WETLAND	MANAGEMENT OBJECTIVES
Conservation (CCW)	Support high levels of attributes	Preserve wetland attributes and functions through reservation in national parks, crown reserves and state owned land. Protection provided under environmental protection policies.
Resource Enhancement (REW)	Partly modified but still supporting substantial functions and attributes	Restore wetland through maintenance and enhancement of wetland functions and attributes. Protection via crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple Use (MUW)	Few wetland attributes but still provide important hydrological functions	Use, development and management considered in the context of water, town and environmental planning through land care.

A review of the *Geomorphic Wetlands Swan Coastal Plain* dataset identified portions of three geomorphic wetlands occur within the site, as shown on **Figure 3** and detailed in **Table 8**. These wetlands are comprised of a large palusplain (seasonally waterlogged flat) with a small dampland (seasonally waterlogged basin) and sumpland (seasonally inundated basin) also present.

Table 8: Geomorphic wetlands identified within the site (DPaW 2014)

UNIQUE FEATURE IDENTIFIER (UFI)	WETLAND TYPE	MANAGEMENT CATEGORY
15254	Palusplain	Multiple Use
7632	Dampland	Multiple Use
7633	Sumpland	Multiple Use

2.10 Environmentally sensitive areas

The south-western portion of the site intersects the extent of a declared Environmentally Sensitive Area (ESA), as shown in **Figure 2**. The portion of the ESA mapped as occurring within the site is predominately cleared and is characterised by a small number of scattered planted trees over introduced grasses, which do not represent significant environmental values. This ESA is inferred to be associated with remnant vegetation and wetland values located within Lot 4 Bickley Road to the south of the site.

ESAs are identified to protect native vegetation values of areas surrounding significant threatened or scheduled flora, vegetation communities, wetlands or ecosystems and are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. No such values occur within the site and specifically in the area mapped within the extent of the declared ESA.

2.11 Previous surveys

Cardno BSD undertook an assessment of the site in 2004. This assessment found that the site was cleared, with no intact plant communities remaining. No threatened or priority flora species were identified as occurring within Precinct 3A or 3B.

Subsequently a flora, vegetation and wetland assessment was undertaken by Tauss and Weston (2010) which covered the site as well as a large area to the south east (comprising Precincts 1, 2 and 3B). A number of threatened and priority flora species were identified as occurring within Precinct 3B to the south of the site, but none were located within the site.

Similarly, whilst a number of the vegetation units described within Precinct 3B were considered to represent conservation significant vegetation, no such vegetation was identified as occurring within the site.

3 Methods

3.1 Field survey

A botanist from Emerge visited the site on the 7 and 9 December 2015 and the site was traversed on foot, where access was available. Detailed sampling of the vegetation was undertaken at two locations within lots 7 and 101 using non-permanent relevés and condition/notable features recorded at another 12 ‘photo points’ (PPs). Only a limited number of relevés were required due to the degraded nature of the vegetation and limited native flora species remaining across the majority of the site. All lots were assessed for the flora and vegetation values. However, the lots in which access was not permitted were assessed from the road reserves or via adjacent lots. Thus detailed sampling was not undertaken for these lots, as discussed further in **Section 3.3**.

The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan Region, but which is also appropriate for other urbanised and rural areas. The categories are listed and defined in **Table 9** (Keighery 1994).

Table 9: Vegetation condition scale (Keighery 1994).

VEGETATION CONDITION	DEFINITION
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as ‘parkland cleared’ with the flora comprising weed or crop species with isolated native trees or shrubs.

All plant specimens collected during the field survey were dried, pressed and then named in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys.

3.2 Mapping and data analysis

Plant communities were defined by structural field descriptions. Hierarchical analysis was not undertaken for this particular site due to the degraded nature of the vegetation and the high number of introduced weed species that would have likely disrupted a normal classification. Therefore, plant communities were described using dominant native species, composition and cover according to that of the National Vegetation Information System (Thackway and Cresswell 1995).

The identified plant communities were then mapped on aerial photography (1:7,500) from the relevé data points and interpretation of aerial photography.

Once all the plant communities were described and mapped, each community was compared to the regional 'floristic community type' (FCT) studies and dataset by Gibson *et al.* (1994). Due to the degraded nature of the vegetation and the dominance of weed species within the site, this comparison was made without a statistical classification. FCTs were inferred for each plant community based on the native species present, soil, landform and regional vegetation characteristics.

3.3 Survey limitations

It is important to note the specific constraints imposed on surveys. Constraints are often difficult to predict, as is the extent to which they influence survey outcomes.

The flora and vegetation assessment was undertaken by a qualified botanist with five years of botanical survey experience on the Swan Coastal Plain. Technical review was undertaken by senior environmental consultant with 14 years' experience in environmental science.

Comprehensive flora and vegetation assessments can require multiple surveys, at different times of year, and over a period of a number of years, to enable observation of all species present. This is primarily because of the variability in the 'life strategy' of many plant species in the south-west of Western Australia. In particular some species, especially herbaceous species, spend part of their life-cycle as either underground storage organs (such as corms or rhizomes) or as seed. This is an adaptation to unfavourable environmental conditions such as excessive heat or drought. These species, also known as 'geophytes' or 'annuals', will re-sprout or germinate during favourable conditions such as after rainfall. Most species re-emerge during winter and are most visible during their flowering period, which is spring for a majority of the plant species in the south-west of Western Australia.

This survey was conducted in December and thus outside of the main flowering season for the region. Hence some flora species may occur that were not detectable at the time of survey. Due to the high degree of historical disturbance, it is considered unlikely such species were present across most of the site. However, the potential that species went undetected cannot be ruled out.

Additionally, access to the entirety of the site was not possible during the survey. For those lots that could not be accessed flora and vegetation values were assessed from adjacent lots or road reserves. As these lots were largely cleared, they are not expected to contain flora and vegetation values that were not documented. However, the presence of such values cannot be ruled out.

4 Results

4.1 Flora

A total of 14 native flora species and 33 introduced or planted species were recorded during the survey occurring within the site representing 17 families. The dominant families containing native taxa were Myrtaceae (seven native taxa and ten introduced or planted taxa), Fabaceae (two native taxa and 4 introduced taxa) and Proteaceae (two native taxa). The species list is provided in **Appendix A** and raw survey data and site photographs are provided in **Appendix B**.

4.2 Declared pests

Declared plant status denotes weed species that are highly invasive and aggressive. No species listed as a 'declared pest' pursuant to the BAM Act were recorded within the site.

4.3 Threatened, priority flora and species of significance

No threatened or priority flora species were recorded during the survey. It is considered unlikely that any such species occur within the site due to the high degree of historical disturbance and the dominance of weed species.

4.4 Plant communities

Vegetation within the site comprised seven partially intact plant communities and cleared/planted areas, as described below:

- **BmNf** – Emergent *Corymbia calophylla* over open woodland of *Banksia menziesii* and *Nuytsia floribunda* over open shrubland of *Xanthorrhoea preissii, Macrozamia riedlei* and *Eremaea pauciflora* subsp. *pauciflora* over grassland of pasture weeds (**Plate 1**). Plant community **BmNf** was noted in the road reserve at the junction of Edward St and Grove Rd.
- **XpM** – Shrubland of *Xanthorrhoea preissii* over low shrubland of *Melaleuca* sp., *Eremaea pauciflora* subsp. *pauciflora* and *Stirlingia latifolia* over grassland of pasture weeds (**Plate 2**). A small area of plant community **XpM** was located along the Edward St road reserve.
- **Mr** – Shrubland to low woodland of *Melaleuca rhaphiophylla* (with opportunistic *Eucalyptus rudis*) over grassland of pasture weeds (**Plate 3**). Plant community **Mr** was found to occur in Lot 7.
- **Cc** – Open woodland to open forest of *Corymbia calophylla* over closed grassland of pasture weeds (**Plate 4**). Plant community **Cc** was found to occur in a number of lots over the site.
- **Er** – Open woodland to woodland of *Eucalyptus rudis* over closed grassland of pasture weeds (**Plate 5**). Plant community **Er** was located within lot 10 (not accessed).
- **Cleared/Planted** – Parkland cleared or planted vegetation over pasture weeds (**Plate 6**).

The extent of each plant community was determined by the observations made during the field survey and aerial photography and is shown on **Figure 4**. Representative areas of these communities are also shown in **Plate 1** – **Plate 6** below.

*Plate 1: Disturbed area of plant community **BmNf** in degraded condition at the intersection of Edward St and Grove Rd (located at 389240 E; 6421046 S).*

*Plate 2: Plant community **XpM** in degraded condition (R3 located at 403308 E; 6457957 S).*

*Plate 3: Plant community **Mr** in degraded condition in Lot 7 (PP13 located at 403607 E; 6457873 S).*

*Plate 4: Plant community **Cc** in completely degraded condition in Lot 9 (PP14 located at 403736 E; 6457836 S).*

*Plate 5: Plant community **Er** in completely degraded condition in Lot 82 (PP18; 404172 E; 6458027 S).*

Plate 6: Cleared/planted vegetation in completely degraded vegetation (403666 E; 6457686 S).

4.5 Conservation significance of vegetation

The FCTs inferred to occur within the site are listed in **Table 10**. The majority of the site contained few native species which limited the ability to assign FCTs with a high degree of certainty.

Plant communities **Cc**, **BmNf** and **XpM** may have once represented TECs or PECs based on the dominant species remaining within these plant communities. However, the plant communities were in degraded or completely degraded condition with few native species present. Thus these plant communities would not represent any TECs or PECs in their current condition.

Table 10: Floristic community types inferred to occur within the site.

PLANT COMMUNITY	MOST LIKELY FCT	TEC/PEC	CONSERVATION STATUS	
			STATE	FEDERAL
*Er	FCT 11 – Wet forests and woodlands	-	-	-
*Mr	FCT 11 – Wet forests and woodlands	-	-	-
*Cc	FCT 3c - *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	TEC	Critically Endangered	Endangered
*BmNf	FCT 20a – Banksia attenuata woodlands over species rich dense shrublands or FCT 23a – Central *Banksia attenuata – B. menziesii* woodlands	TEC	Endangered	-
*XpM		PEC	Priority 3	-

*Note: * denotes communities with minimal native species remaining and could not be considered to represent any FCT in their current condition.*

4.6 Vegetation condition

The majority of the site was in 'completely degraded' condition, consisting of cleared paddocks or semirural and residential land uses. Small patches of remnant native trees were also considered to be in completely degraded condition on the basis that these contained an overstorey of native species associated with closed grasslands of pasture weeds. These include disturbed plant communities **Cc** and **Er**. Plant communities **BmNf**, **XpM** and **Mr** exist in small isolated patches across the site and were in degraded condition, containing small numbers of species and a high frequency of weed species compared what would have been present in original assemblages. Vegetation condition over the site is shown on **Figure 5**.

5 Discussion

Generally the site contains disturbed vegetation dominated by introduced weed species. A total of 24 native flora species were identified within the site, compared to 43 introduced or planted species. A greater diversity of native species would be expected in native vegetation in this area and so the results indicate a significant reduction in native species has occurred due to historic clearing and rural land uses. This is apparent when compared to the adjacent Bush Forever site which contains highly diverse plant communities and flora species.

No threatened or priority flora species were recorded within the lots that were directly surveyed. The flora and vegetation survey was conducted in December, which is after the main flowering period for most flora species in the region. As a result, some geophytic or annual species are likely to have been detectable at the time of the survey. As detailed in **Table 2**, the wider local area is known to support a highly diverse list of threatened and priority flora species (28 threatened and 48 priority flora species), characterising the high variability of wetland and dryland plant present. Tauss and Weston (2010) reported the occurrence of *Eremophila glabra* var. *chlorella* (T), *Grevillea thelemanniana* subsp. *thelemanniana* (T), *Schoenus pennisetis* (P1) and *Baeckea* sp. Perth Region (now named *Babingtonia urbana*) (P3) occurring within Precinct 3B to the south of the site. DPaW's threatened and priority flora database (2016) also recorded locations of *Lepidosperma rostratum* (T) and *Byblis gigantea* (P3) occurring within Precinct 3B. Based on the high degree of historical disturbance and highly degraded state of most of the site's vegetation, it is considered unlikely that any of these threatened or priority species could remain within the site itself.

Five partially intact remnant plant communities and cleared/planted vegetation were identified as occurring within the site. The site was entirely in completely degraded condition, with small patches in degraded condition, due to extensive historical clearing and grazing. The scattered native species present appear to be broadly representative of the Southern River and Guildford vegetation complexes as mapped by Heddle *et al.* (1980). A number of plant communities within the site may have once represented TECs or PECs including **Cc**, **BmNf** and **XpM**. As areas of these communities were in degraded or completely degraded condition, with minimal native species remaining, it was not possible to assign them to a FCT and they are not considered to potentially represent TECs or PECs.

6 Conclusions and recommendations

The majority of the site contained cleared or planted areas dominated by weed species and was in completely degraded condition. Five disturbed native plant communities occur in small patches throughout the site. It is considered unlikely that any threatened or priority flora species occur within the site, despite the fact this assessment was undertaken in December outside of the main flowering period for this region.

Plant communities **Cc**, **BmNf** and **XpM** may have once represented TECs or PECs but they are now highly disturbed and contain minimal native species making FCT assignment impossible.

The results of this assessment indicate that the proposed industrial development of the site is unlikely to result in the loss of any significant flora or vegetation values given the degree of historical clearing that has occurred. Therefore, the flora and vegetation values are not likely to need further consideration throughout the proposed planning and development process.

7 References

7.1 General

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FIGURES

Figure 1:	**Site Location**
Project:	Flora and Vegetation Assessment MKSEA Precinct 3A
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(03)--F55

Drawn:	ADB	Date:	23/03/2016
Approved:	TA	Date:	24/03/2016
Checked:	SKP	Scale:	1:15,000@A4

0 200 400 600 Metres

emerge ASSOCIATES
Integrated Science & Design

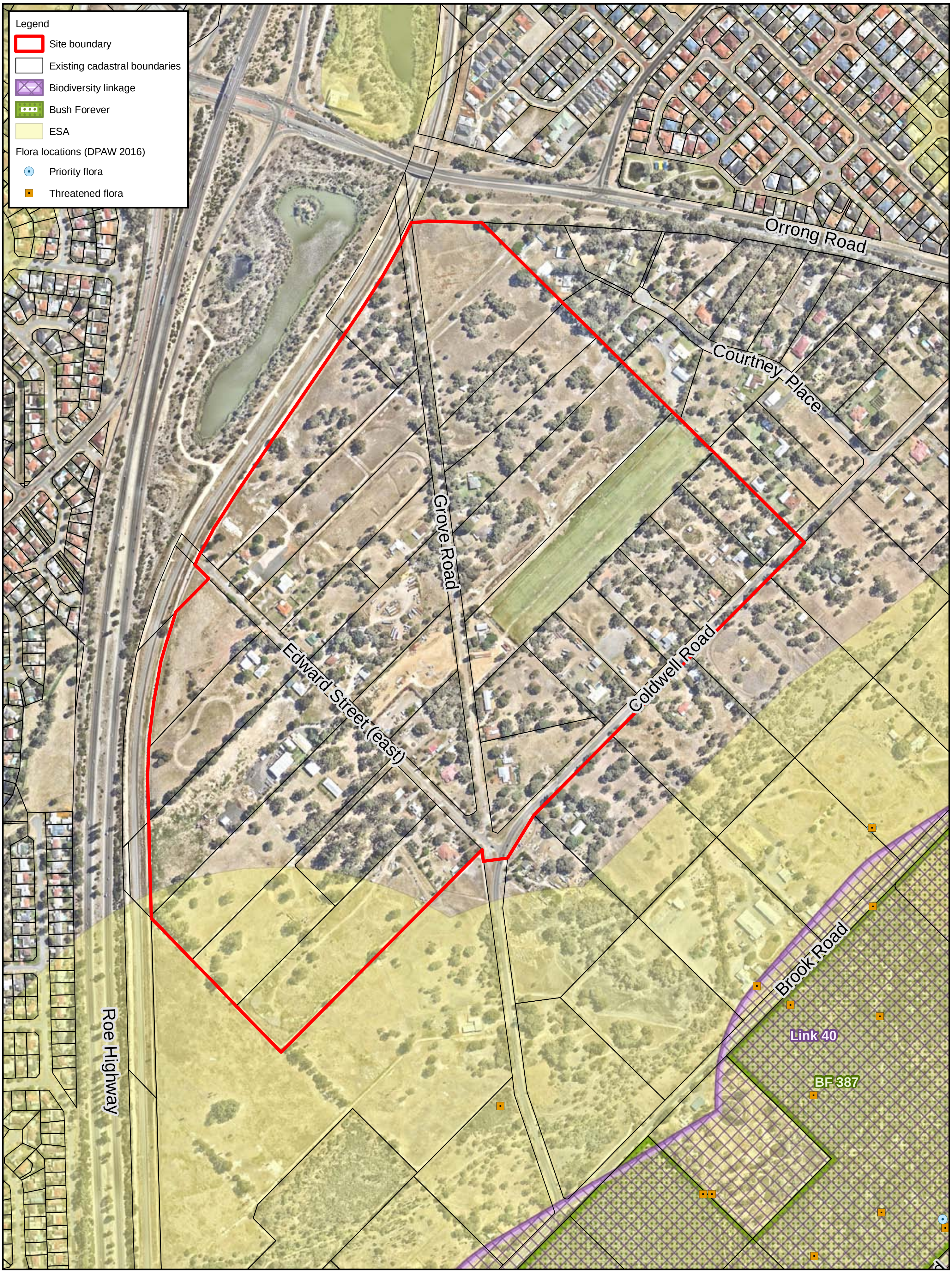

Figure 2:	**Environmental Features**
Project:	Flora and Vegetation Assessment MKSEA Precinct 3A
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(03)--F56

Drawn:	ADB	Date:	23/03/2016
Approved:	TA	Date:	24/03/2016
Checked:	SKP	Scale:	1:7,500@A4

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emerge ASSOCIATES
Integrated Science & Design

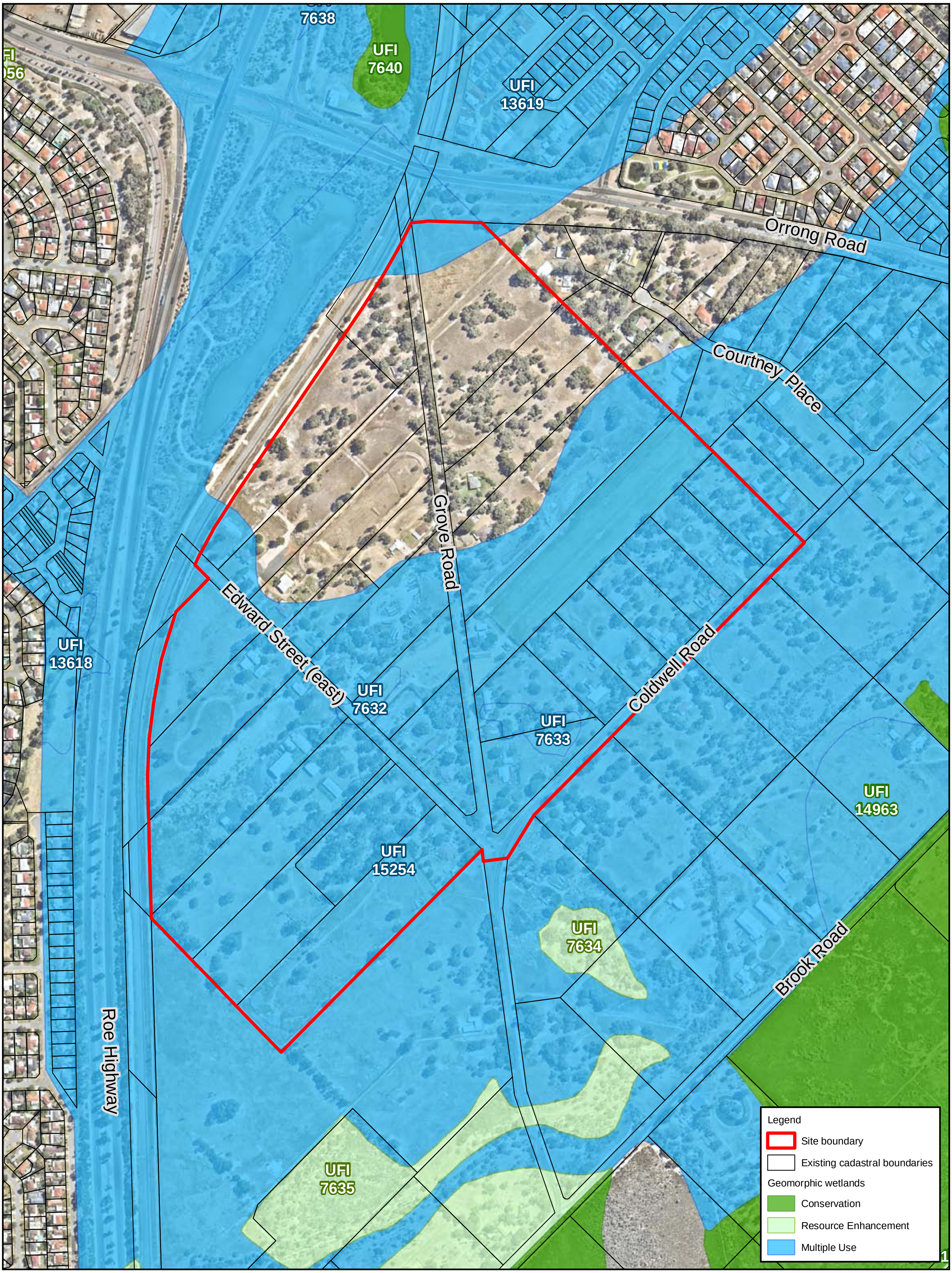

Figure 3:	**Geomorphic Wetlands**		
Project:	Flora and Vegetation Assessment MKSEA Precinct 3A		
Client:	Linc Property Pty Ltd.		

Plan Number: EP14-056(03)--F57

Drawn:	ADB	Date:	23/03/2016
Approved:	TA	Date:	24/03/2016
Checked:	SKP	Scale:	1:7,500@A4

0 150 300 Metres

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Figure 4: **Plant Communities**

Project: Flora and Vegetation Assessment MKSEA Precinct 3A

Client: Linc Property Pty Ltd.

N

Plan Number: EP14-056(03)--F58			
Drawn:	ADB	Date:	23/03/2016
Approved:	TA	Date:	24/03/2016
Checked:	SKP	Scale:	1:7,500@A4

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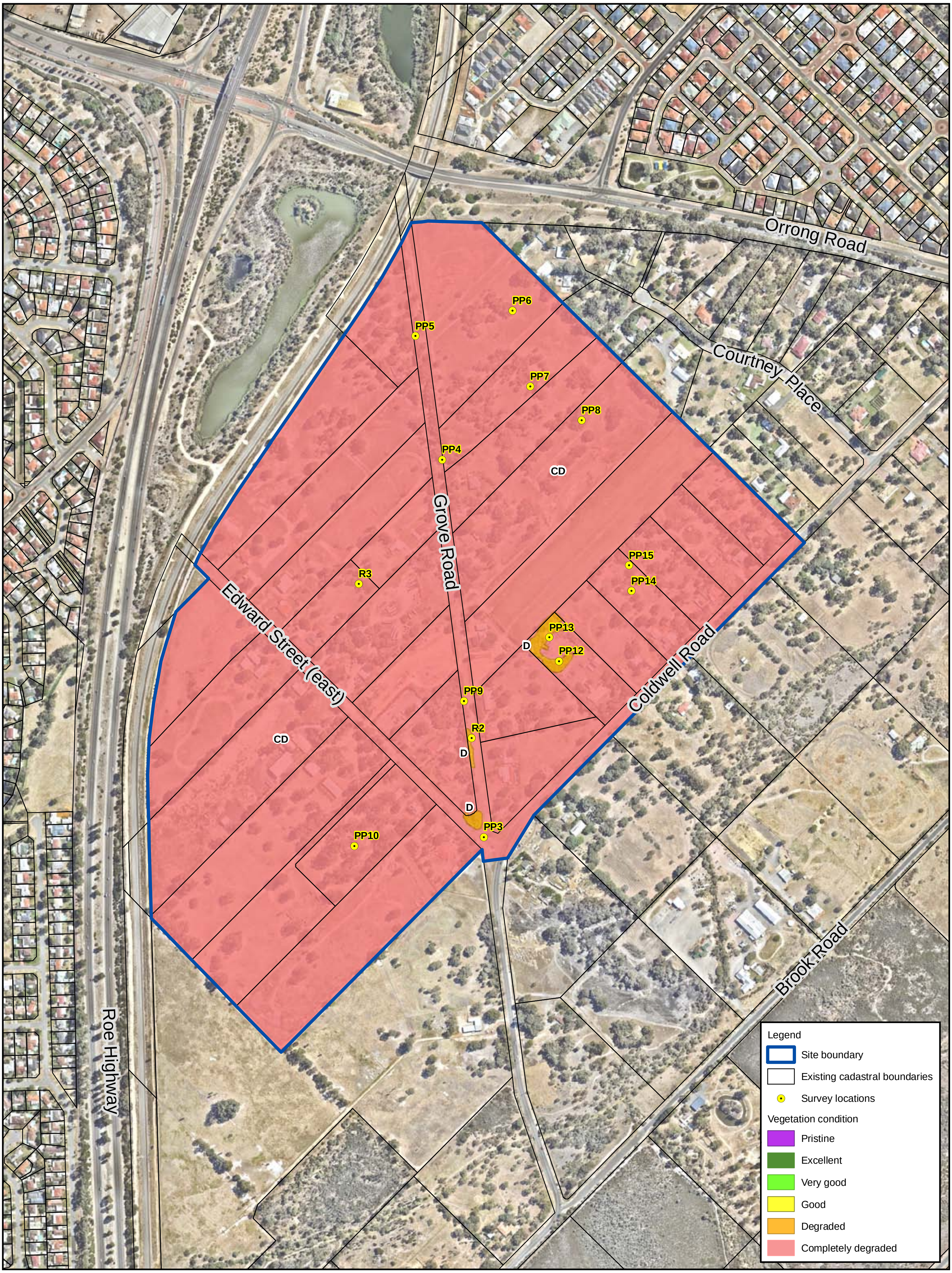

Figure 5:	**Vegetation Condition**
Project:	Flora and Vegetation Assessment MKSEA Precinct 3A
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(03)--F59

Drawn:	ADB	Date:	23/03/2016
Approved:	TA	Date:	24/03/2016
Checked:	SKP	Scale:	1:7,500@A4

0 150 300 Metres

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APPENDIX A

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SPECIES LIST

Species List – Maddington Kenwick Strategic Employment Area Precinct 3A
Note: * denote introduced species.

Family		Species
Anacardiaceae		
	*	*Schinus molle*
	*	*Schinus terebinthifolius*
Apocynaceae		
	*	*Nerium oleander*
Araucariaceae		
	*	*Araucaria heterophylla*
Asteraceae		
	*	*Symphyotrichum subulatum*
Bignoniaceae		
	*	*Jacaranda mimosifolia*
Cyperaceae		
		Tetraria capillaris
Euphorbiaceae		
	*	*Euphorbia terracina*
Fabaceae		
		Jacksonia sternbergiana
	*	*Lotus subbiflorus*
Loranthaceae		
		Nuytsia floribunda
Meliaceae		
	*	*Melia azedarach*
Myrtaceae		
	*	*Agonis flexuosa*
	*	*Callistemon sp.*
		Corymbia calophylla
	*	*Corymbia citreodora*
	*	*Corymbia ficifolia*
		Eremaea pauciflora var. pauciflora
	*	*Eucalyptus camaldulensis*
	*	*Eucalyptus lehmannii*
		Eucalyptus rudis
		Eucalyptus todtiana
	*	*Eucalyptus sp.*
	*	*Leptospermum laevigatum*
	*	*Melaleuca nesophila*
		Melaleuca rhaphiophylla

Species List – Maddington Kenwick Strategic Employment Area Precinct 3A
Note: * denote introduced species.

Family		Species
		Melaleuca seriata
		Melaleuca viminea subsp. viminea
	*	*Melaleuca viridiflora*
Pinaceae		
	*	*Pinus pinaster*
Poaceae		
	*	*Arundo donax*
	*	*Avena barbata*
	*	*Bromus* sp.
	*	*Cynodon dactylon*
	*	*Ehrharta calycina*
	*	*Eragrostis curvula*
	*	*hyparrhenia hirta*
	*	*Lagurus ovatus*
	*	*Lolium sp.*
	*	*Paspalum distichum*
	*	*Pennisetum clandestinum*
	*	*Phalaris paradoxa*
Proteaceae		
		Banksia menziesii
		Stirlingia latifolia
Typhaceae		
	*	*Typha orientalis*
Xanthorrhoeaceae		
		Xanthorrhoea preissii
Zamiaceae		
		Macrozamia riedlei

APPENDIX B

RAW DATA AND SITE PHOTOGRAPHS

Site Details			
Locality	MKSEA prec 3	Photo No.	
Date	09.12.15	Photo direction	
Author	SKP	Geographic datum and zone	GDA94 50
Sampling unit	releve	Easting	403485
Sample number	2	Northing	6457715
Geographic and Habitat Data			
Aspect		Hydrology	
Slope		Adjacent Vegetation	
Topographic position	flat	Vegetation Condition	D-CD
Altitude		Time since fire	
Bare ground %		Disturbance	weeds, clearing (roadside)
Soil type/texture	sand	Rock type	lateritic gravel
Soil colour	pale yellow	Rock %	2
Microclimate		Litter type and %	

Vegetation Description

Open woodland of marri over open shrubland Xanthorrhoea preissii over low open shrubland of Melaleuca sp. and Eremaea pauciflora over grassland pasture grasses

Strata	Height	Total % Cover	Observations
Emergent tree			360 breeding tree- hollows not big enough
Canopy			for BCs
Sub-canopy			
Lower tree			
Upper shrub			
Lower shrub			
Upper herb			
Middle herb			
Lower herb			

Coll. No.	Species	Layer	Life Form	Height	Habit	% Cover
	Corymbia calophylla					20
	Xanthorrhoea preissii					5
SP08	Melaleuca seriata					5
	Stirlingia latifolia					3
	Eremaea pauciflora var. pauciflora					4
	Jacksonia sternbergiana					3
	Ehrharta calycina					20
	Eragrostis curvula					20
	Nuytsia floribunda					opp.
	Banksia menziesii					opp.
	Xanthorrhoea preissii					opp.
	Macrozamia riedlei					opp.

Coll. No.	Species	Layer	Life Form	Height	Habit	% Cover

Site Details			
Locality	MKSEA prec 3	Photo No.	
Date	09.12.15	Photo direction	
Author	SKP	Geographic datum and zone	GDA94 50
Sampling unit	releve	Easting	403308
Sample number	3	Northing	6457957

Geographic and Habitat Data			
Aspect	-	Hydrology	
Slope	3	Adjacent Vegetation	
Topographic position	small manmade dep	Vegetation Condition	CD (planted)
Altitude		Time since fire	
Bare ground %	0	Disturbance	weeds, clearing
Soil type/texture	sand/clay	Rock type	
Soil colour	brown	Rock %	
Microclimate		Litter type and %	

Vegetation Description

Planted open woodland of Eucalyptus rudis and E. lehmanniana Over open shrubland of Melaleuca rhaphiophylla over closed grassland of pasture grasses

Strata	Height	Total % Cover	Observations
Emergent tree			
Canopy			
Sub-canopy			
Lower tree			
Upper shrub			
Lower shrub			
Upper herb			
Middle herb			
Lower herb			

Coll. No.	Species	Layer	Life Form	Height	Habit	% Cover
	Eucalyptus rudis					opp.
	Melaleuca rhaphiophylla					opp.
	Eucalyptus lehmannii					opp.
	Lotus subbiflorus					opp.
	Cynodon dactylon					opp.
	Eragrostis curvula					opp.
	Melaleuca viminea subsp. viminea					opp.
	Melaleuca viridiflora					opp.
	Eucalyptus camaldulensis					opp.
	Pinus pinaster					opp.
	Agonis flexuosa					opp.
	Schinus terbinthefolia					opp.
	Schinus molle					opp.
	Euphorbia terracina					opp.
	Leptospermum laevigatum					opp.
	Typha orientalis					opp.
	Corymbia ficifolia					opp.
	Jacaranda mimosifolia					opp.

Coll. No.	Species	Layer	Life Form	Height	Habit	% Cover
	Eucalyptus todtiana					opp.
	Eucalyptus sp.					opp.
	Nerium oleander					opp.
	Callistemon sp.					opp.
	Viminaria juncea					opp.
	Melaleuca nesophylla					opp.
	Arundo donax					opp.
	Lagurus ovatus					opp.
	Lolium sp.					opp.
	Paspalum distichum					opp.
	Phalaris paradoxa					opp.
	Hyparrhebia hirta					opp.
	Bromus sp.					opp.
	Araucaria heterophylla					opp.
	Corymbia citreodora					opp.
	Pennisetum clandestinum					opp.
	Symphyotrichum subulatum					opp.

Photographs

Plate 1: Photo point 3 facing southwest (403504 E; 6457560 S)

Plate 2: Photo point 4 facing west (403439 E; 6458152 S)

Plate 3: Photo point 6 facing south (403549 E; 6458386 S).

Plate 4: Photo point 8 facing east (403653 E; 6458214 S).

Plate 5: Photo point 9 facing north west (403473 E; 6457773 S).

Plate 6: Photo point 10 (403301 E; 6457546 S).

Plate 7: Photo point 11 facing east (403971 E; 6457703 S).

Plate 8: Photo point 12 facing west (403622 E; 6457836 S).

Plate 9: Photo point 13 facing north (403607 E; 6457873 S).

Plate 10: Photo point 14 facing west (403736 E; 6457946 S).

Plate 11: Photo point 15 facing east (403732 E; 6457986 S).

APPENDIX B

emerge ASSOCIATES
Integrated Science & Design

FAUNA ASSESSMENT (HAREWOOD 2016)

Fauna Assessment

Maddington Kenwick Strategic Employment Area Precinct 3

City of Gosnells

APRIL 2016

Version 4

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Acronyms/Abbreviations:

ALA: Atlas of Living Australia – Website - www.ala.org.au/

BA: Birdlife Australia (Formerly RAOU, Birds Australia).

BC Bill: Biodiversity Conservation Bill (2015). WA Government.

°C: Degrees Celsius.

CALM: Department of Conservation and Land Management (now DPaW), WA Government.

CAMBA: China Australia Migratory Bird Agreement 1998.

CBD: Central Business District.

DEC: Department of Environment and Conservation (now DPaW), WA Government.

DEH: Department of Environment and Heritage (now DotE), Australian Government.

DEP: Department of Environment Protection (now DER), WA Government.

DER: Department of Environment Regulation (formerly DEC, DoE), WA Government.

DEWHA: Department of the Environment, Water, Heritage and the Arts (now DotE), Australian Government

DMP: Department of Mines and Petroleum (formerly DoIR), WA Government.

DoE: Department of Environment (now DER/DPaW), WA Government.

DotE: Department of the Environment (formerly SEWPaC, DWEHA, DEH), Australian Government.

DoIR: Department of Industry and Resources (now DMP), WA Government.

DPaW: Department of Parks and Wildlife (formerly DEC, CALM, DoE), WA Government.

EP Act: *Environmental Protection Act 1986*, WA Government.

EPA: Environmental Protection Authority, WA Government.

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999,* Australian Government.

ha: Hectare (10,000 square metres).

IBRA: Interim Biogeographic Regionalisation for Australia.

IUCN: International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.

JAMBA: Japan Australia Migratory Bird Agreement 1981.

km: Kilometre.

m: Metre.

mm: Millimetre.

P: Priority - DPaW fauna conservation ranking.

POS: Public Open Space.

RAOU: Royal Australia Ornithologist Union.

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement 2007.

S: Schedule - Western Australian *Wildlife Conservation Act (1950)* Threatened Fauna Category.

SEWPaC: Department of Sustainability, Environment, Water, Population and Communities (now DotE, formerly DEH, DEWHA), Australian Government

SSC: Species Survival Commission, International.

WA: Western Australia.

WAM: Western Australian Museum, WA Government.

WC Act: *Wildlife Conservation Act 1950*, WA Government.

SUMMARY

This report details the results of a fauna assessment of various freehold allotments within Precinct 3 (3A and 3B) of the Maddington Kenwick Strategic Employment Area (MKSEA) located in the City of Gosnells (subject site). The subject site covers approximately 153 ha most of which is cleared or parkland cleared though some areas of remnant native vegetation remain (Figures 1& 2).

It is understood that outline development plans are being prepared to support future development across Precinct 3. A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental values across the area.

The scope of works was to conduct a level 1 fauna survey as defined by the Environmental Protection Authority (EPA 2004). Because some listed threatened species (i.e. several species of black cockatoo) are known to occur in the general area, the scope of the survey work was expanded to include targeted assessment of the site's significance to these particular species. The assessment has included a literature review ("desktop study") and single daytime reconnaissance survey.

Overall fauna habitat values at the subject site have been severely compromised by the removal of most of the original native vegetation and the degradation of remnant patches. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in disturbed/highly disturbed habitats. As a consequence the fauna diversity of the subject site is well below levels present prior to historical disturbances having occurred.

The individual remnant native trees and groves of trees, while limited in extent support the primary fauna habitat value within the site although these areas vary in quality, with most areas being totally degraded and lacking significant native groundcover/shrubs and microhabitats such as hollow logs.

Yule Brook is also highly degraded but has value as an ecological linkage which provides a corridor for wildlife movement (albeit tenuous at some points) across the subject site.

Opportunistic fauna observations are listed in Appendix B. A total of 30 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the subject site during the single day time survey. Excluding domestic livestock, six introduced species were also confirmed as being present. Most of the fauna species recorded are common, widespread bird species.

Evidence of two listed threatened black cockatoo species was observed (forest red-tailed black cockatoo - foraging evidence (chewed marri fruits) and Carnaby's black-cockatoo – foraging evidence (chewed marri fruits and banksia cones)). Evidence of

the southern brown bandicoot, a Department of Parks and Wildlife Priority 4 species was recorded (dead individual along Yule Brook, and diggings in dense grasses within a paddock area). A single rainbow bee-eater (a listed migratory species) was also observed foraging in a cleared paddock area during the survey period.

The black cockatoo breeding habitat tree assessment (including previous results collected by 360 Environmental 2012) identified 174 trees within the subject site with a DBH of >50cm. Only four (4) of the 174 trees were observed to contain hollows of some type and none appeared to possibly have large enough hollows for black cockatoos to use for nesting. No actual evidence of any hollows being used by black cockatoos for nesting (currently or previously) was seen.

Additional details on each habitat tree observed can be found in Appendix D.

Foraging evidence left on marri fruits by forest red-tailed black-cockatoos and Carnaby's black-cockatoo black cockatoos were found at several locations across the subject site. Evidence of Carnaby's black-cockatoo foraging on pine cones was also found however this was limited to one or two cones at one location where two pine trees exist. 360 Environmental (2012) also identified evidence of black cockatoos foraging on marri and *Banksia* spp.

Overall the extent of potential foraging habitat within the subject site is mainly comprised of areas of vegetation mapped as containing marri (see Figure 3). Other potential foraging species (e.g. *banksia* spp., pine) are represented by only a few individual specimens and/or occupy such small areas that they cannot be regarded as contributing to the total foraging resource to any significant degree. Other species such as flooded gum and tuart are only utilised rarely and to a small degree relative to marri and therefore also do not represent quality foraging habitat.

It is very difficult to estimate the area of foraging habitat present within the subject site due to the patchy nature of the vegetation, with much being made up by just individual or small groups of trees. The areas mapped as marri within Figure 3 covers an area of about 4.0 ha though it should be noted that the density of marri trees varies greatly within these areas so this value is an overestimation of the total resource. The scattered trees within parkland cleared areas and along road verges also contribute to the overall resource however this is hard to quantify with any accuracy.

No existing roosting trees (trees used at night by black cockatoos to rest) were positively identified during the survey.

With respect to native vertebrate fauna, 10 mammals (includes eight bat species), 87 bird, 15 reptile, eight frog and two fish species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the study area at times, a conclusion largely based on the presence of apparently suitable habitat.

Of the 122 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under State and/or Commonwealth legislation (these being the three species of black cockatoo and the peregrine falcon). In addition, three migratory species (great egret, cattle egret and the rainbow bee-eater) and the Priority 4 southern brown bandicoot may or are known to occur, though habitat for some of these species is marginal in quality and therefore the site cannot be considered of significance to them.

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent. However, the vegetation along Yule Brook has been identified as being of primary importance to fauna in the area and its retention and ongoing management should be considered during development planning.

Based on available information it is considered at this stage very unlikely that impacts on black cockatoos (or any other *EPBC Act* listed threatened or migratory species) which may occur as a result of development at any scale within the subject site will result in a “significant impact” as defined by the Commonwealth DotE (DotE 2013).

1. INTRODUCTION

This report details the results of a fauna assessment of various freehold allotments within Precinct 3 (3A and 3B) of the Maddington Kenwick Strategic Employment Area (MKSEA) located in the City of Gosnells (subject site). The subject site is situated about 12 kilometres south east of the Perth central business district in south west Western Australia and is centred at approximately 32.013261°S and 115.978398°E (Figure 1).

The subject site covers approximately 153 ha most of which is cleared or parkland cleared though some areas of remnant native vegetation remain (Figure 2).

2. DEVELOPMENT PROPOSAL

It is understood that outline development plans are being prepared to support future development across Precinct 3. A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental values across the area. The findings of this fauna survey and other investigations will be used to inform and support the development, with the primary aim of minimising potential environmental impacts as much as reasonable and practicable.

It is also anticipated that the information presented will be used by regulatory authorities to assess the potential impact of the proposal on fauna and fauna habitats as part of finalising the outline development plan and for future subdivision development approval processes.

3. SCOPE OF WORKS

The scope of works was to conduct a level 1 fauna survey as defined by the EPA (EPA 2004). Because some listed threatened species (i.e. several species of black cockatoo) are known to occur in the general area, the scope of the survey work was expanded to include a targeted assessment of the site's significance to these species.

The fauna assessment has therefore included:

1. Level 1 Fauna Survey (to EPA standard);
2. Black Cockatoo Habitat Assessment ("habitat trees" = DBH $\geq$50cm, existing and potential nest hollows, foraging and roosting habitat); and

3. Report summarising methods, results and discussion on likely constraints on development within the subject site.

This survey report has been prepared for use in the EPA's EIA process (if required) and is considered suitable for this purpose.

The scope of work has been restricted to a general fauna survey (Level 1 assessment) and a targeted black cockatoo habitat survey (Level 2 assessment). It is anticipated that this level of survey will provide sufficient information to allow decisions on potential impacts and management to be made.

It is considered unlikely that additional detailed Level 2 surveys within the subject site would provide information that would alter any decision making processes required to allow an informed assessment of the impact of the proposal to be made.

Note: For the purposes of this report the term black cockatoo is in reference to Baudin's black-cockatoo *Calyptorhynchus baudinii*, Carnaby's black-cockatoo *Calyptorhynchus latirostris* and the forest red-tailed black-cockatoo *Calyptorhynchus banksii naso*.

4. METHODS

4.1 POTENTIAL FAUNA INVENTORY – LITERATURE REVIEW

4.1.1 Database Searches

Searches of the following databases were undertaken to aid in the compilation of a list of vertebrate fauna potentially occurring within the subject site:

- DPaW's NatureMap Database Search (combined data from DPaW, ALA, WAM, BA and consultants reports) (DPaW 2015b); and
- Protected matters search tool (Department of the Environment – DotE 2015).

It should be noted that lists produced during the abovementioned database searches contain observations/inferred distributions from a broader area than the subject site and therefore may include species that would only ever occur as vagrants due to a lack of suitable habitat or the presence of only marginal habitat within the subject site itself. The databases also often included or are based on very old records and in some cases the species in question have become locally or regionally extinct.

Information from these sources should therefore be taken as indicative only and local knowledge and information also needs to be taken into consideration when determining what actual species may be present within the specific area being investigated.

4.1.2 Previous Fauna Surveys in the Area

Fauna surveys, assessments and reviews have been undertaken in nearby areas in the past, though not all are publically available and could not be referenced. The most significant of those available have been used as the primary reference material for compiling the potential fauna assemblage for the general area.

Those reports referred to included, but were not limited to:

- 360 Environmental (2012). Black Cockatoo Survey – Maddington Kenwick Strategic Employment Area. Unpublished report for the City of Gosnells.
- ATA (1994). A Report of a Fauna Survey of Perth Airport. Report 93/78. Unpublished report for the Federal Airports Corporation.
- ATA Environmental (2006). Vertebrate Fauna Assessment Brookdale Redevelopment Area. Unpublished report for the Armadale Redevelopment Authority.
- Dell, J. (pers.comm) (1994). Results of Western Australia Museum Surveys, December 1986 to April 1990.
- ENV Australia (2005). Southern River Precinct 3 - Environmental Review. Unpublished report for the City of Gosnells.
- Harewood, G. (2009). Fauna Assessment (Level 1) – Mills Park - Beckenham. Unpublished report for Cardno (WA) Pty Ltd.
- Harewood, G. (2014). Fauna Assessment - Hazelmere Precinct 9A. Unpublished report for Emerge Associates.
- Harvey, M. S., Dell, J. How, R. A., & Waldock, J. M. (1987). Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth. Report to the Australian Heritage Commission. NEP Grant N95/49. 56 pp.
- How, R.A (1995). Objection Assessment of Fauna Values for Perth Airport. Unpublished report for the Australian Heritage Commission.
- How, R.A, Harvey, M.S., Dell J., & Waldock, J.M. (1996). Ground Fauna of Urban Bushland Remnants in Perth. Report to the Australian Heritage Commission. NEP Grant N93/04. 103 pp.
- Turpin, J. and Bamford, M. (2009). Keane Road Strategic Link Armadale, Fauna Assessment. Unpublished report for EnviroWorks Consulting.

As with the databases searches some reports refer to species that would not occur in the subject site due to a lack of suitable habitat (extent and/or quality) and this fact was taken into consideration when compiling the potential fauna species list. It should also be noted that the NatureMap database is likely to include some records from previous fauna surveys in the area including some of those listed above.

4.1.3 Existing Publications

The following represent the main publications used to identify and refine the potential fauna species list for the subject site:

- Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.
- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Victoria.
- Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2007). Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands.
- Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2010). Field Guide to Reptiles and Frogs of the Perth Region. UWA Press, Nedlands.
- Churchill, S. (2008). Australian Bats. Second Edition, Allen & Unwin.
- Cogger, H.G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.
- Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.
- Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth Western Australia.
- Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.
- Morgan, D.L., Beatty, S.J., Klunzinger, M.W, Allen, M.G. and Burnham, Q.E (2011). Field Guide to the Freshwater Fishes, Crayfishes and Mussels of South Western Australia. Published by SERCUL.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1983). Lizards of Western Australia II: Dragons and Monitors. WA Museum, Perth.

- Storr, G.M., Smith, L.A. and Johnstone R.E. (1990). Lizards of Western Australia III: Geckos and Pygopods. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1999). Lizards of Western Australia I: Skinks. Revised Edition, WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition, WA Museum, Perth.
- Tyler M.J. & Doughty P. (2009). Field Guide to Frogs of Western Australia, Fourth Edition, WA Museum, Perth.
- Van Dyck, S., Gynther, I. & Baker, A. Eds (2013). Field Companion to The Mammals of Australia. Queensland Museum.
- Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Reed, New Holland, Sydney.

4.1.4 Fauna of Conservation Significance

The conservation significance of fauna species has been assessed using data from the following sources:

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Administered by the Australian Government Department of the Environment (DotE);
- *Wildlife Conservation Act 1950 (WC Act).* Administered by the Western Australian Department of Parks and Wildlife (DPaW) (Govt. of WA 2015);
- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List - the acronym derived from its former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and the
- DPaW Priority Fauna list. A non-statutory list maintained by the DPaW for management purposes (DPaW 2015a).

The *EPBC Act* also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA);
- China Australia Migratory Bird Agreement 1998 (CAMBA);

- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and

- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

(Note - Species listed under JAMBA are also protected under Schedule 5 of the *WC Act*.)

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as matters of national environmental significance (NES) under the *EPBC Act*.

The conservation status of all vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the subject site has been assessed using the most recent lists published in accordance with the above mentioned instruments and is indicated as such in the fauna listings of this report. A full listing of conservation codes are provided in Appendix A.

A number of other species not listed in official lists can also be considered of local or regional conservation significance. These include species that have a restricted range, those that occur in breeding colonies and those at the limit of their range.

While not classified as rare, threatened or vulnerable under any State or Commonwealth legislation, a number of birds have been listed as species of significance on the Swan Coastal portion of the Perth Metropolitan Region (Bush Forever - Government of Western Australia 1998 and 2000). The bird species are often referred to as Bush Forever Decreaser Species. The three categories used for birds within the Bush Forever documents are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain (code Bh);

- Wide ranging Species with reduced population's on the Swan Coastal Plain. (code Bp); and

- Extinct in the Perth region (code Be).

The presence of Bush Forever species should be taken into some consideration when determining the fauna values of an area. Bush Forever decreaser species are indicated as such within the species list held in Appendix B.

4.1.5 Invertebrate Fauna of Conservation Significance

It can be difficult to identify significant invertebrate species (e.g. short range endemics (SREs) as there are uncertainties in determining the range-restrictions of many species due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. Where invertebrates are collected during surveys, a high percentage are likely to be unknown, or for known species there can be limited knowledge or information on their distribution (Harvey 2002).

For this project, the assessment for conservation significant invertebrates has been limited to those listed by the DPaW and *EPBC Act* database searches (which rely on distribution records and known habitat preferences). No assessment of the potential for SREs to be present has been made.

4.1.6 Likelihood of Occurrence – Vertebrate Fauna of Conservation Significance

Vertebrate fauna of conservation significance identified during the desktop survey as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the survey area itself. The rankings and criteria used were:

- Unlikely to Occur: The subject site is outside of the currently documented distribution for the species in question or the species is generally accepted as being locally/regionally extinct (supported by a lack of recent records), or no suitable habitat (type, quality and extent) was identified as being present during the field assessment. Individuals of some species may occur occasionally as vagrants/transients especially if suitable habitat is located nearby but the subject site itself would not support a population or part population of the species.
    - Locally Extinct: Populations no longer occur within a small part of the species natural range, in this case within 10 or 20km of the subject site. Populations do however persist outside of this area.
    - Regionally Extinct: Populations no longer occur in a large part of the species natural range, in this case within the Perth section of the Swan Coastal Plain. Populations do however persist outside of this area.
- Possibly Occurs: The subject site is within the known distribution of the species in question and habitat of at least marginal quality was identified as being present during the field assessment, supported in some cases by recent records being documented in literature from within or near the survey area. In some cases, while a species may be classified as possibly being present at times, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.
- Known to Occur: The species in question was positively identified as being present (for sedentary species) or as using the subject site as habitat for some other purpose (for non-sedentary/mobile species) during the field

survey. This information may have been obtained by direct observation of individuals or by way of secondary evidence (e.g. foraging debris, tracks, scats). In some cases, while a species may be classified as known to occur, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

4.1.7 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report is generally taken from the DPaW's WA Fauna Census Database which is assumed to follow Aplin and Smith (2001) for amphibians and reptiles and Johnstone (2001) for birds. Jackson and Groves (2015) has been used for mammals.

Common names are taken from the Western Australia Museum (WAM) recognised primary common name listings when specified, though where common names are not provided they have been acquired from other publications. Sources include Cogger (2014), Wilson and Swan (2013), Van Dyck & Strahan (2013), Christidis and Boles (2008), Bush *et al.* (2010), Bush *et al.* (2007), Tyler *et al*. (2000), and Glauret (1961). Not all common names are generally accepted.

4.2 SITE SURVEYS

A daytime reconnaissance survey of the subject site was carried out by Greg Harewood (B.Sc. Zoology) on the 9 December, 2015.

4.2.1 Fauna Habitat Assessment

The vegetation communities identified during the botanical survey of the site carried out by Emerge Associates (Emerge Associates 2015) have been used as the basis for a classification of areas into broad fauna habitat types. This information has been supplemented with observations made during the fauna assessment.

The main aim of the habitat assessment was to determine if it was likely that any species of conservation significance would be utilising the areas that may be impacted on as a consequence of development at the subject site. The habitat information obtained was also used to aid in finalising the overall potential fauna list.

As part of the literature review, available information on the habitat requirements of the species of conservation significance listed as possibly occurring in the area was researched. During the field survey the habitats within the subject site were assessed and specific elements identified, if present, to determine the likelihood of listed threatened species utilising the area and its significance to them.

4.2.2 Opportunistic Fauna Observations

Opportunistic observations of fauna species were made during the field survey. Methods involved traversing a series of transects across the subject site during the day while searching microhabitats such as logs, rocks, leaf litter and observations of bird species with binoculars. Secondary evidence of a species presence such as tracks, scats, skeletal remains, foraging evidence or calls were also noted if observed/heard.

4.2.3 Black Cockatoo Habitat Assessment

It should be noted that a back cockatoo habitat assessment has previously been undertaken over parts of the subject site in 2012 by 360 Environmental (360 Environmental 2012). The aim of this more recent survey was to survey lots that were previously inaccessible (where possible) and to field check some of the previous results (e.g. potential nest hollows and foraging habitat) to determine their current status. The results of this most recent assessment and 360 Environmental's information have then been combined into a single dataset.

The following methods were employed to comply with the defined scope of works and are based on guidelines published by the Commonwealth Department of the Environment (DotE) (SEWPaC 2012) which states that surveys for Carnaby's, Baudin's and forest red-tailed black cockatoo habitat should:

- be done by a suitably qualified person with experience in vegetation or cockatoo surveys, depending on the type of survey being undertaken;
- maximise the chance of detecting the species' habitat and/or signs of use;
- determine the context of the site within the broader landscape—for example, the amount and quality of habitat nearby and in the local region (for example, within 10 km);
- account for uncertainty and error (false presence and absences); and
- include collation of existing data on known locations of breeding and feeding birds and night roost locations.

Habitat used by black cockatoos have been placed into three categories by the DotE (SEWPaC 2012) these being:

- Breeding Habitat;
- Foraging Habitat; and
- Night Roosting Habitat.

So as to comply with the requested scope of works and in line with the published guidelines the following was carried out.

4.2.3.1 Black Cockatoo Breeding Habitat

The black cockatoo breeding habitat assessment involved the identification of all suitable breeding trees species (native, endemic species only) within the subject site not previously assessed by 360 Environmental (360 Environmental 2012) due to property access constraints, that had a Diameter at Breast Height (DBH) of over 50cm. The DBH of each tree was estimated using a pre-made 50 cm “caliper”.

The location of each tree identified as being over the threshold DBH was recorded with a GPS and details on tree species, number and size of hollows (if any) noted. Trees observed to contain hollows (of any size/type) were marked with “H” using spray paint for easy future reference.

Target tree species included marri, jarrah and flooded gum or any other endemic *Corymbia/Eucalyptus* species of a suitable size that was present. Peppermints, *Banksia* spp., sheoak and *Melaleuca* spp. tree species (for example) were not assessed as they typically do not develop hollows that are used by black cockatoos.

For the purposes of this study a tree containing a potential cockatoo nest hollow was defined as:

Generally any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for occupation by black cockatoo for the purpose of nesting/breeding. Hollows that had an entrance greater than about 12cm in diameter and would allow the entry of a black cockatoo into a suitably orientated and sized branch/trunk, was recorded as a “potential nest hollow”.

Identified hollows were examined using binoculars for evidence of actual use by black cockatoos (e.g. chewing around hollow entrance, scarring and scratch marks on trunks and branches).

A tree identified as containing a hollow potentially suitable for black cockatoos was identified by 360 Environmental during their survey of sections of the subject site in 2012 (360 Environmental 2012). This tree, (located in Lot 5 Grove Road at 403457mE 6457743mN) was re-examined to determine its current status.

A review of available literature was carried out to determine the location/extent of any known/likely black cockatoo breeding habitat areas in the vicinity of the subject site.

4.2.3.2 Black Cockatoo Foraging Habitat

The location and nature of black cockatoo foraging evidence (e.g. chewed fruits around base of trees) observed during the field survey was recorded. The nature and extent of potential foraging habitat present was also documented irrespective of the presence of any actual foraging evidence.

A review of available literature was also carried out to determine the location/extent of any known/likely black cockatoo foraging habitat areas in the vicinity of the subject site.

4.2.3.3 Black Cockatoo Roosting Habitat

Direct and indirect evidence of black cockatoos roosting within trees was with the subject site was noted if observed (e.g. branch clippings, droppings or moulted feathers).

A review of available literature was also carried out to determine the location/extent of any known/likely black cockatoo roosting habitat areas in the vicinity of the subject site.

5. SURVEY CONSTRAINTS

No seasonal sampling has been carried out as part of this fauna assessment. The conclusions presented are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the subject site at the time of the field assessments. It should also be recognised that site conditions can change with time.

Some fauna species are reported as potentially occurring within the subject site based on there being suitable habitat (quality and extent) within the subject site or immediately adjacent. With respect to opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- seasonal inactivity during the field survey;
- species present within micro habitats not surveyed;
- cryptic species able to avoid detection; and
- transient wide-ranging species not present during the survey period.

Lack of observational data on some species should therefore not necessarily be taken as an indication that a species is absent from the subject site.

The habitat requirements and ecology of many of the species known to occur in the wider area are often not well understood or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitat or microhabitat within the subject site. As a consequence of this limitation the potential fauna list produced is most likely an overestimation of those species that actually utilise the subject site for some purpose. Some species may be present in the general area but may only use the subject site itself on rare occasions or as vagrants/transients.

In recognition of survey limitations, a precautionary approach has been adopted for this assessment. Any fauna species that would possibly occur within the subject site (or immediately adjacent), as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the Author, has been assumed to potentially occur in the subject site.

During the black cockatoo habitat survey a search for trees containing hollows was completed. It should be noted that identifying hollows suitable for fauna species from ground level has limitations. Generally the full characteristics of any hollow seen are not fully evident (e.g. internal dimensions). It is also difficult to locate all hollows within all trees as some are not observable from ground level.

The location of observations was recorded using a handheld GPS. The accuracy of the GPS cannot be guaranteed above a level of about 5 to 10 metres, though it should be noted that in some circumstance the accuracy can increase or decrease beyond this range.

Access to a small number of lots was restricted and therefore observations where limited to a certain extent in these areas. Nonetheless, most if not all habitat trees (i.e. DBH >50cm) are now recorded in the updated dataset, as despite no direct measurement, all large trees were clearly visible from outside lot boundaries and along roadsides.

6. RESULTS

6.1 POTENTIAL FAUNA INVENTORY – LITERATURE REVIEW

A list of fauna species considered most likely to occur in the subject site has been compiled from information obtained during the desktop study and is presented in Appendix B. This listing was refined after information gathered during the site reconnaissance survey was assessed. The results of some previous fauna surveys carried out in the general area are summarised in this species listing as are the DPaW NatureMap database search results. The raw database search results from NatureMap (DPaW 2015b) and the Protected Matters Search Tool (DotE 2015) are contained within Appendix C.

The list of potential fauna takes into consideration that firstly the species in question is not known to be locally extinct and secondly that suitable habitat for each species, as identified during the habitat assessment, is present within the subject site. Compiling an accurate fauna list has limitations (see Section 5 above) and therefore, as discussed the listing is likely to be an overestimation of the fauna species actually present within the subject site at any one time.

6.2 SITE SURVEYS

6.2.1 Fauna Habitat Assessment

The subject site is situated on the eastern margin of the Swan Coastal Plain at the foot of the Darling Scarp in an area that has largely been cleared of vegetation, primarily for livestock grazing. Remnant native vegetation onsite is now represented mainly by areas of marri and/or flooded gum woodland over grasslands with few areas of native understorey. The balance of the site is either totally cleared or parkland cleared with scattered trees, mostly planted non-endemic euclaytus species with a small number of endemics (e.g. tuart).

Topography of the subject site is almost flat with a gradual rise from about 8 mAHD in the south west to about 13 mAHD in the north east. Soils within the subject site range from thin, light grey Bassendean Sands to clayey grey/brown alluvial sand of the Guildford Formation.

With the exception of Yule Brook which dissects the site in its southern half, the subject site contains no other wetland habitats of significance.

Descriptions and examples images of the main fauna habitats/dominant vegetation present within the subject site are provided in Table 1. The location and extent of the identified habitat elements is shown in Figure 3 (courtesy Emerge 2015).

Table 1: Main Fauna Habitats within the Subject Site

Code	Fauna Habitat Description	Example Image
ErMr	Open woodland to woodland of *Eucalyptus rudi*s over low sparse woodland to open woodland of *Melaleuca rhaphiophylla* over open shrubland *Melaleuca* spp. Over closed grassland *Pennisetum* sp. and pasture weeds.	

Code	Fauna Habitat Description	Example Image
BmNf	Emergent *Corymbia calophylla* over open woodland of *Banksia menziesii* and *Nuytsia floribunda* over open shrubland of *Xanthorrhoea preissii*, *Macrozamia riedlei* and *Eremaea pauciflora* over grassland of pasture weeds.	
CpVjM	Tall shrubland of *Viminaria juncea* and *Callitris pyramidalis* over shrubland of *Melaleuca* spp. And *Acacia* spp. Over open grassland to grassland of pasture weeds.	
XpM	Shrubland of *Xanthorrhoea preissii* over low shrubland of *Melaleuca* sp., *Eremaea pauciflora* and *Stirlingia latifolia* over grassland of pasture weeds.	
Mr	Shrubland to low woodland of *Melaleuca rhaphiophylla* (with occasional emergent *Eucalyptus rudis*) over grassland of pasture weeds.	

Code	Fauna Habitat Description	Example Image
Cc	Open woodland to open forest of *Corymbia calophylla* over closed grassland of pasture weeds.	
Er	Open woodland to woodland of *Eucalyptus rudis* over closed grassland of pasture weeds.	
Cleared/ Planted	Parkland cleared or planted vegetation over pasture weeds.	
Yule Brook	Yule Brook.	

Overall fauna habitat values at the subject site have been severely compromised by the removal of most of the original native vegetation and the degradation of remnant patches. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in disturbed/highly disturbed habitats. As a consequence the fauna diversity of the subject site is well below levels present prior to historical disturbances having occurred.

The individual remnant native trees and groves of trees, while limited in extent support the primary fauna habitat value although these areas vary in quality, with most areas being totally degraded and lacking significant native groundcover/shrubs and microhabitats such as hollow logs.

Yule Brook is also highly degraded but has some value as an ecological linkage which provides a corridor for wildlife movement (albeit tenuous at some points) across the subject site.

6.2.2 Opportunistic Fauna Observations

Opportunistic fauna observations are listed in Appendix B. A total of 30 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the subject site during the single day time survey. Excluding domestic livestock, six introduced species were also confirmed as being present. Most of the fauna species recorded are common, widespread bird species.

Evidence of two listed threatened black cockatoo species was observed (forest red-tailed black cockatoo - foraging evidence (chewed marri fruits) and Carnaby's black-cockatoo – foraging evidence (chewed marri fruits and banksia cones)). Evidence of the southern brown bandicoot, a DPaW Priority 4 species was recorded (dead individual along Yule Brook, and diggings in dense grasses within a paddock area). A single rainbow bee-eater (a listed migratory species) was also observed foraging in a cleared paddock area during the survey period.

6.2.3 Black Cockatoo Habitat Assessment

Trees considered potentially suitable for black cockatoos to use as nesting habitat (using DotE criteria - SEWPaC 2012, but ultimately subject to a suitable hollow being present or developing and a range of other factors) which were found within the subject site (including those identified by 360 Environmental 2012) comprised the following species:

- Marri – *Corymbia calophylla;*
- Flooded Gum - *Eucalyptus rudis;* and
- Tuart – *Eucalyptus gomphocephala* (planted specimens only).

It should be noted that the propensity to develop hollows suitable for black cockatoo varies greatly between tree species. For example relative to marri or tuart, flooded gum trees rarely develop hollows that are then used by black cockatoos for breeding.

A summary of the potential black cockatoo habitat trees observed within the subject site is provided in Table 2 below and their location shown in Figure 4.

Table 2: Summary of Potential Black Cockatoo Habitat Trees (DBH >50cm) within the Subject Site

Total Number of Habitat Trees	Number of Trees with No Hollows Observed	Number of Trees with Hollows Considered Unsuitable for Nesting Black Cockatoos	Number of Trees with Hollows Considered Possibly Suitable for Nesting Black Cockatoos	Tree Species		
				Marri	Flooded Gum	Tuart (Planted)
174	170	4	0	140	19	15

The combined results identified 174 trees within the subject site with a DBH of $\geq$50cm. Only four (4) of the 174 trees were observed to contain hollows of some type and none appeared to possibly have large enough hollows for black cockatoos to use for nesting. No actual evidence of any hollows being used by black cockatoos for nesting (currently or previously) was seen.

Additional details on each habitat tree observed can be found in Appendix D.

The tree (ID 360 – 5 in Appendix D) previously identified as containing a hollow potentially suitable for black cockatoos by 360 Environmental (2012) was re-examined. This tree does however not appear suitable for a black cockatoo to utilise due to the hollow entrances present being too small (i.e. less that ~10cm). No evidence was seen to suggest that it has or was being used by black cockatoos for nesting purposes. The hollows present appeared to only be of a size suitable for medium sized parrots (galahs, corellas, 28s) but nothing bigger. Bees were also observed occupying one small hollow within this tree which further lessens its suitability for breeding birds.

A review of available data showed no previous breeding records within the subject site (DoP 2011b). The closest breeding records shown in the DoP document are located over 14 km south east of the subject site in state forest areas near Roleystone.

6.2.3.1 Black Cockatoo Foraging Habitat

Foraging evidence left on marri fruits by forest red-tailed black-cockatoos and Carnaby's black-cockatoo black cockatoos were found at several locations across the subject site. Evidence of Carnaby's black-cockatoo foraging on pine cones was also found however this was limited to one or two cones at one location where two pine trees exist.

360 Environmental (2012) also identified evidence of black cockatoos foraging on marri and *Banksia* spp.

Overall the extent of potential foraging habitat within the subject site is mainly comprised of areas of vegetation mapped as containing marri (see Figure 3). Other potential foraging species (e.g. *banksia* spp., pine) are represented by only a few individual specimens and/or occupy such small areas that they cannot be regarded as contributing to the total foraging resource to any significant degree. Other species such as flooded gum and tuart are only utilised rarely and to a small degree relative to marri and therefore also do not represent quality foraging habitat.

It is very difficult to estimate the area of foraging habitat present within the subject site due to the patchy nature of the vegetation, with much being made up by just individual or small groups of trees. The areas mapped as marri within Figure 3 covers an area of about 4.0 ha though it should be noted that the density of marri trees varies greatly within these areas so this value is an overestimation of the total resource. The scattered trees within parkland cleared areas and along road verges also contribute to the overall resource. However this is hard to quantify with any accuracy.

360 Environmental (2012) estimated there to be about 19.5 ha of foraging habitat within Precinct 3 (see their Appendix D). However this appears to include all areas of vegetation not just marri which is the only quality foraging habitat present. Some areas of planted non-endemic trees also appear to have been included in this total.

As pointed out by 360 Environmental (2012) the subject site lies in close proximity to extensive areas (>50,000 ha in total) of potential black cockatoo foraging habitat in various national/regional parks and state forest areas (see Table 2 - 360 Environmental 2012).

6.2.3.2 Black Cockatoo Roosting Habitat

No existing roosting trees (trees used at night by black cockatoos to rest) were positively identified during the survey. 360 Environmental (2012) identified three forest red-tailed black cockatoo roost sites within the subject site during their assessment in 2012. No direct evidence of these sites actually being used for overnight roosting was however obtained by 360 Environmental. Their conclusion was based the presence of “significant” accumulations of bird droppings attributed to the forest red-tailed black cockatoo due to the "large amount of forest red-tailed black cockatoo feeding evidence surrounding each of these roost sites" (360 Environmental 2012). It is therefore possible that these sites were not actually being used for overnight roosting but just represented temporary focal points of high intensity foraging by forest red-tailed black cockatoos over one or more days.

A review of other available data shows one previously documented black cockatoo roosting location about 4km east of the subject site (DoP 2011b), though its current status is unknown.

6.3 FAUNA INVENTORY – SUMMARY

6.3.1 Vertebrate Fauna

Table 3 summarises the number of vertebrate fauna species potentially occurring within or utilising at times the subject site, based on results from the desktop study and observations made during the field assessment. A complete list of vertebrate fauna possibly inhabiting or frequenting the subject site is located in Appendix B.

Table 3: Summary of Potential Vertebrate Fauna Species (as listed in Appendix B)

Group	Total number of potential species	Potential number of specially protected species	Potential number of migratory species	Potential number of priority species	Number of species recorded during field survey
Fish	3^{1}	0	0	0	0
Amphibians	8	0	0	0	0
Reptiles	15	0	0	0	0
Birds	93^{6}	4	3	0	33^{4}
Non-Volant Mammals	8^{6}	0	0	1	3^{2}
Volant Mammals (Bats)	8	0	0	0	0
Total	**135^{13}**	**4**	**3**	**1**	**36^{6}**

Superscript = number of introduced species included in total.

Not all species listed as potentially occurring within the subject site in existing databases and publications (i.e. *EPBC Act* Threatened Fauna and Migratory species lists, DPaW's NatureMap database, various reports and publications) are shown in the expected listing in Appendix B. Some species have been excluded from this list based largely on the lack of suitable habitat within the subject site and in the general area or known local extinction, even if suitable habitat is present.

Despite the omission of some species it should be noted that the list provided is still very likely an over estimation of the fauna species utilising the subject site (either on a regular or infrequent basis) as a result of the precautionary approach adopted for the assessment. At any one time only a subset of the listed potential species are likely to be present within the bounds of the subject site.

As most of the subject site is cleared the majority represents unsuitable habitat for many of the potential species listed. Most, if present, would be confined to the small areas of remnant native bushland and even in these areas only a subset of the species listed are likely to be present at any one time.

6.3.2 Vertebrate Fauna of Conservation Significance

A review of the *EPBC Act* threatened fauna list, DPaW's Threatened Fauna Database and Priority List, unpublished reports and scientific publications identified a number of specially protected, priority or migratory vertebrate fauna species as potentially occurring in the general vicinity of the subject site. Of these species, most that have no potential whatsoever to utilise the subject site for any purpose have been omitted from the potential list (Appendix B), principally due to lack of suitable habitat (including extent and/or quality) or known local extinction.

In summary, four vertebrate fauna species of conservation significance were positively identified as utilising the subject site for some purpose during the survey period, these being:

- *Calyptorhynchus latirostris* Carnaby`s Black-Cockatoo – S2 (*WC Act*), Endangered (*EPBC Act*)
  Some foraging evidence attributed to this species found during field survey (chewed marri fruits and pine cones). Most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

- *Calyptorhynchus banksii naso* Forest Red-tailed Black-Cockatoo – S3 (*WC Act*), Vulnerable (*EPBC Act*)
  Some foraging evidence attributed to this species found during field survey (chewed marri fruits). Most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

- *Merops ornatus* Rainbow Bee-eater – S5 (*WC Act*), Migratory (*EPBC Act*)
  A single individual was observed foraging in paddock areas during the field survey. This species is a common seasonal visitor to south west. It possibly breeds in some sections of the subject site where ground conditions permit (e.g. sandy areas) though population levels would not be significant as it usually breeds in pairs, rarely in small colonies (Johnstone and Storr 1998).

- *Isoodon obesulus fusciventer* Southern Brown Bandicoot – P4 (DPaW Priority Species)
  Evidence of the southern brown bandicoot (a dead individual and some diggings) was observed at some locations in the subject site where ground vegetation was relatively dense (i.e. Yule Brook and some paddocks with dense grasses). Most of the subject site is however unsuitable for this species to persist.

Based on the habitats present and current documented distributions it is considered possible that four additional species of conservation significance may use the subject site for some purpose at times, though, as no evidence of any using the subject site at the time of the field survey was found, the status of some in the area remains uncertain.

These species are:

- *Ardea alba* Great Egret – S5 (*WC Act*), Migratory (*EPBC Act*)
  This species may occasionally utilise Yule Brook and flooded/waterlogged paddocks in the subject site but these appear to represent marginal habitat at best. It would not breed onsite.

- *Ardea ibis* Cattle Egret – S5 (*WC Act*), Migratory (*EPBC Act*)
  Very marginal habitat. It may occur very occasionally in paddock areas with livestock. It would not breed onsite.

- *Calyptorhynchus baudinii* Baudin`s Black-Cockatoo – S3 *(WC Act),* Vulnerable (*EPBC Act*)
  No evidence of this species utilising the site observed though most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

- *Falco peregrinus* Peregrine Falcon – S7 (*WC Act*)
  This species potentially utilises some sections of the subject site as part of a much larger home range. No evidence of nesting was observed and the probability of this species breeding within the subject site can be considered to be very low.

Habitat for some of these species on-site, while considered possibly suitable, may be marginal in extent/quality and species listed may only visit the area for short periods, or as rare/uncommon vagrants/transients.

As previously indicated a number of other species of conservation significance, while possibly present in the wider area (e.g. forested areas of the nearby Darling Range), are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas), lack of suitable habitat and/or the presence of feral predators. Details on conservation significant species and reasons for the omission of some from the potential listing are provided in Appendix E and Table 4.

Twenty six bird species that potentially frequent or occur in the subject site are noted as Bush Forever Decreaser Species in the Perth Metropolitan Region (seven were sighted/identified as having used the within the subject site during the survey). Decreaser species are a significant issue in biodiversity conservation in the Perth section of the Swan Coastal Plain as there have been marked reductions in range and population levels of many sedentary bird species as a consequence of disturbance and land clearing (Dell & Hyder-Griffiths 2002).

6.3.3 Invertebrate Fauna of Conservation Significance

Five invertebrate species of conservation significance appeared in the DPaW or *EPBC Act* database searches (DPaW 2015b, DotE 2015), these being an unnamed cricket (*Kawaniphila pachomai*), two unnamed bees (*Leioproctus bilobatus* & *Leioproctus douglasiellus*), the short-tongued bee (*Neopasiphae simplicior*) and Carter's freshwater mussel (*Westralunio carteri*).

None of these species are considered likely to persist within the subject site due to a total absence of suitable habitat, local extinction and/or because the area is outside of their currently documented range. Additional information on each species can be found in Appendix E.

7. FAUNA VALUES

7.1 CONSERVATION SIGNIFICANCE OF THE SUBJECT SITE

The conservation significance of the subject site has been determined by applying site specific criteria such as:

- Fauna species and/or habitat present within the subject site that is poorly represented in the general vicinity;
- Fauna habitat within the subject site supporting species of conservation or other significance; and

- Fauna habitat within the subject site in better condition than other similar locations in the general vicinity.

The majority of the subject site is cleared and as a consequence the diversity of fauna species has been significantly reduced from its original natural levels. Habitat degradation as a result of partial clearing, altered fire regimes and the presence of introduced predators is also likely to have had a significant effect on species diversity in the remnants that remain. Because of these factors most of the site has very little conservation significance to fauna in general. This is to a certain extent supported by the fact that none of the vegetation remaining on site was selected for inclusion in bush forever while some nearby remnants were (Government of Western Australia 2000a).

The site does have some value principally as foraging habitat for black cockatoos but the extent of this vegetation, relative to that present in nearby reserved/national park areas, is relatively small. Yule Brook and the associated surrounding vegetation, does however provide habitat for native fauna species (e.g. southern brown bandicoot) in a largely cleared landscape and the retention and ongoing management of this areas should be considered during development planning.

7.2 VALUE OF THE SUBJECT SITE AS AN ECOLOGICAL LINKAGE/WILDLIFE CORRIDOR

Wildlife or ecological corridors are considered to provide avenues for the movement of individuals and populations of both flora and fauna. An ecological corridor is defined as ‘habitat that permits the movement of organisms between ecological isolates’ and linkage with adjacent bushland areas is therefore a natural attribute of high priority in the assessment of any sites significance. These corridors can be important for the survival of species as they provide access to feeding and breeding locations as well as access to other populations and therefore to a wider gene pool (Newmark 1993).

Within Bush Forever Volume 1 (Figure 6 - Government of Western Australia 2000a) conceptual “greenway” corridors are shown. The subject site is shown as forming part of recognised greenway corridor, the conceptual linkage following the path of the Yule Brook ultimately linking with the Canning River to the west of the subject site. The balance of the subject site, away for Yule Brook, has limited value in supporting the conceptual linkage given that it is almost totally cleared and only contains small fragments of degraded/highly degraded native vegetation.

It is important to maintain and improve Greenway corridors and other links between areas of ecological significance. This is necessary to maintain the diversity and vigour of ecological systems and to integrate areas of retained vegetation within the broader urban and industrial landscape.

Where possible, greenways should be incorporated into future planning proposals as part of the development of best practice planning and design solutions (Government of Western Australia 2000a).

8. POTENTIAL IMPACTS AND DEVELOPMENT CONSIDERATIONS

8.1 POTENTIAL IMPACTS OF DEVELOPMENT

In general the most significant impacts to fauna of any development include:

- Loss of vegetation/fauna habitat that may be used for foraging, breeding, roosting, or dispersal (includes loss of hollow bearing trees);
- Fragmentation of vegetation/fauna habitat which may restrict the movement of some fauna species;
- Modifications to surface hydrology, siltation of creek lines;
- Changes to fire regimes;
- Pollution (e.g. oil spills);
- Noise/light/dust;
- Spread of plant pathogens (e.g. dieback) and weeds;
- Potential increase in the number of predatory introduced species (e.g. cats);
- Death or injury of fauna during clearing and construction; and
- An increase in fauna road kills subsequent to development.

The exact extent of development within the subject site is not known at this stage. However, assuming that the area is developed for industrial purposes in accordance the City of Gosnell's LSP it is expected that the majority of the remnant vegetation would be removed, with the exception of that bordering Yule Brook. Based on this assumption possible impacts on specific species of conservation significance previously recorded in the general area is provided in the table below. Additional information on those species listed is provided in Appendix E.

Table 4: Likelihood of Occurrence and Possible Impacts – Fauna Species of Conservation Significance (continues on following pages).

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Maximum Possible Impacts
Unnamed Cricket	*Kawaniphila pachomai*	P1	No	Unlikely	No impact.
Unnamed Bee	*Leioproctus bilobatus*	P2	No	Unlikely	No impact.
Short-tongued Bee	*Neopasiphae simplicior*	S2, CR	No	Unlikely	No impact.
Unnamed Bee	*Leioproctus douglasiellus*	S2, VU	No	Unlikely	No impact.
Carter's Freshwater Mussel	*Westralunio carteri*	S3, VU	No	Unlikely	No impact.
Perth Lined Lerista	*Lerista lineata*	P3	No	Unlikely	No impact.
Darling Range Heath Ctenotus	*Ctenotus delli*	P4	No	Unlikely	No impact.
Coastal Plains Skink	*Ctenotus ora*	P3	No	Unlikely	No impact.
Black-striped Snake	*Neelaps calonotos*	P3	No	Unlikely	No impact.
Southern Death Adder	*Acanthophis antarcticus*	P3	No	Unlikely	No impact.
Malleefowl	*Leipoa ocellata*	S3, VU	No	Unlikely - species locally extinct.	No Impact.
Australasian Bittern	*Botaurus poiciloptilus*	S2, EN	No	Unlikely	No impact.
Little Bittern	*Ixobrychus minutus*	P4	No	Unlikely	No impact.
Great Egret	*Ardea alba*	S5, Mig	Yes/ Marginal	Possible but only rarely.	Loss/modification of very small areas of very marginal habitat. Significant impact not likely.
Cattle Egret	*Ardea ibis*	S5, Mig	Yes/ Marginal	Possible but only rarely.	Loss/modification of very small areas of very marginal habitat. Significant impact not likely.
Glossy Ibis	*Plegadis falcinellus*	S5, Mig	No	Unlikely	No impact.
Painted Snipe	*Rostratula benghalensis*	S2, Mig, EN	No	Unlikely	No impact.
Migratory Shorebirds/Wetland Species	Various	S5, Mig, Various	No	Unlikely	No impact.
Blue-billed Duck	*Oxyura australis*	P4	No	Unlikely	No impact.
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Mig	No	Unlikely	No impact.
Osprey	*Pandion haliaetus*	S5, Mig	No	Unlikely	No impact.

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Maximum Possible Impacts
Peregrine Falcon	*Falco peregrinus*	S7	Yes	Possible but only rarely.	Loss/modification of very small areas of degraded habitat. Significant impact not likely.
Masked Owl	*Tyto novaehollandae novaehollandae*	P3	No/Marginal	Unlikely	No impact.
Fork-tailed Swift	*Apus pacificus*	S5, Mig	Yes	Unlikely, Flyover only on very rare occasions.	No impact.
Rainbow Bee-eater	*Merops ornatus*	S5, Mig	Yes	Known to occur.	Loss/modification of small areas of natural habitat. Significant impact not likely.
Grey Wagtail	*Motacilla cinerea*	S5, Mig	No	Unlikely	No impact.
Carnaby`s Black Cockatoo	*Calyptorhynchus latirostris*	S2, EN	Yes	Known to Occur	Loss/modification of small areas of habitat. Significant impact not likely.
Baudin`s Black Cockatoo	*Calyptorhynchus baudinii*	S3, VU	Yes	Possible	Loss/modification of small areas of habitat. Significant impact not likely.
Forest Red-tailed Black Cockatoo	*Calyptorhynchus banksii naso*	S3, VU	Yes	Known to Occur.	Loss/modification of small areas of habitat. Significant impact not likely.
Chuditch	*Dasyurus geoffroii*	S3, VU	No	Unlikely.	No impact.
Southern Brush-tailed Phascogale	*Phascogale tapoatafa ssp*	S3	No	Unlikely.	No impact.
Southern Brown Bandicoot	*Isoodon obesulus fusciventer*	P5	Yes	Known to Occur.	Loss/modification of small areas of habitat. Significant impact not likely.
Numbat	*Myrmecobius fasciatus*	S3, VU	No	Unlikely - species locally extinct.	No Impact.
Western Ringtail Possum	*Pseudocheirus occidentalis*	S2, VU	No	Unlikely - species locally extinct.	No Impact.
Woylie	*Bettongia penicillata ogibyi*	S1, EN	No	Unlikely - species locally extinct.	No Impact.
Western Brush Wallaby	*Macropus irma*	P4	No	Unlikely	No impact.
Water Rat	*Hydromys chrysogaster*	P4	No	Unlikely	No impact.

8.2 CONSIDERATIONS FOR PLANNING AND DEVELOPMENT

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent. There are substantial areas of similar habitat in nearby areas including some nature reserves/regional parks and most if, not all species likely to utilise the subject site will persist in these locations despite any future development.

Yule Brook and the associated surrounding vegetation forms part of recognised greenway corridor and also provides habitat for native fauna species (e.g. southern brown bandicoot) in a largely cleared landscape and the retention and ongoing management of this area should however be considered during development planning.

The assessment does indicate that any considerations required during ongoing development planning would be limited to the presence of habitat used or potentially used by some threatened fauna species in particular those listed under the *EPBC Act*, namely the three species of black cockatoo. The proposed development area is however made up of numerous individual lots with different landowners potentially undertaking “actions” as separate entities, and therefore possible “impacts” in each lot are likely to be assessed individually by the proponents.

With this in mind it is considered less likely that impacts on black cockatoos that may occur as a result of development at any scale within each individual landholding would be considered a “significant impact” as defined by the Commonwealth DotE (DotE 2013).

While the retention of areas of vegetation potentially utilised by black cockatoos should be considered during the planning process, based on the assessment above it is not likely to represent a constraint to development in any one lot.

This conclusion is primarily based on the fact that most of the individual lots are totally cleared or almost totally cleared of natural vegetation and therefore don’t contain significant areas of potential cockatoo habitat. Where some habitat is present it is limited in extent and patchy in distribution. Also, given the presence of significant areas of better quality habitat to the east (Darling Range forests) black cockatoos are considered far more likely to frequent these areas than to be specifically attracted to vegetation within the subject site itself.

The study area is also not located in a documented cockatoo breeding area, and while some trees present are classified as “potential breeding habitat” using DotE criteria (SEWPaC 2012) the probability of any one tree actually developing hollows that would then be used by black cockatoos for breeding can be considered to be extremely low. The area is also unlikely to be considered of specific importance for the recovery of black cockatoos in the long term. For example the population growth of the Carnaby’s black-cockatoo is primarily limited by factors associated with breeding, and consequently priority areas for the recovery of the species are currently focused on known breeding sites (Cale 2003).

9. CONCLUSION

The fauna assessment within the subject site was undertaken for the purposes of categorising the fauna assemblages and identifying fauna habitats present. A targeted assessment of black cockatoo habitat within the area was also carried out.

With respect to native vertebrate fauna, 10 mammals (includes eight bat species), 87 bird, 15 reptile, eight frog and two fish species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the study area at times, a conclusion largely based on the presence of apparently suitable habitat.

Of the 122 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under State and/or Commonwealth legislation, these being the three species of black cockatoo and the peregrine falcon. In addition, three migratory species (great egret, cattle egret and the rainbow bee-eater) and the Priority 4 southern brown bandicoot may or are known to occur, though habitat for some of these species is marginal in quality and therefore the site cannot be considered of significance to them.

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent. However, the vegetation along Yule Brook has been identified as being of primary importance to fauna in the area and its retention and ongoing management should be considered during development planning.

Based on available information it is considered at this stage very unlikely that impacts on black cockatoos (or any other *EPBC Act* listed threatened or migratory species) which may occur as a result of development at any scale within the subject site will result in a “significant impact” as defined by the Commonwealth DotE (DotE 2013).

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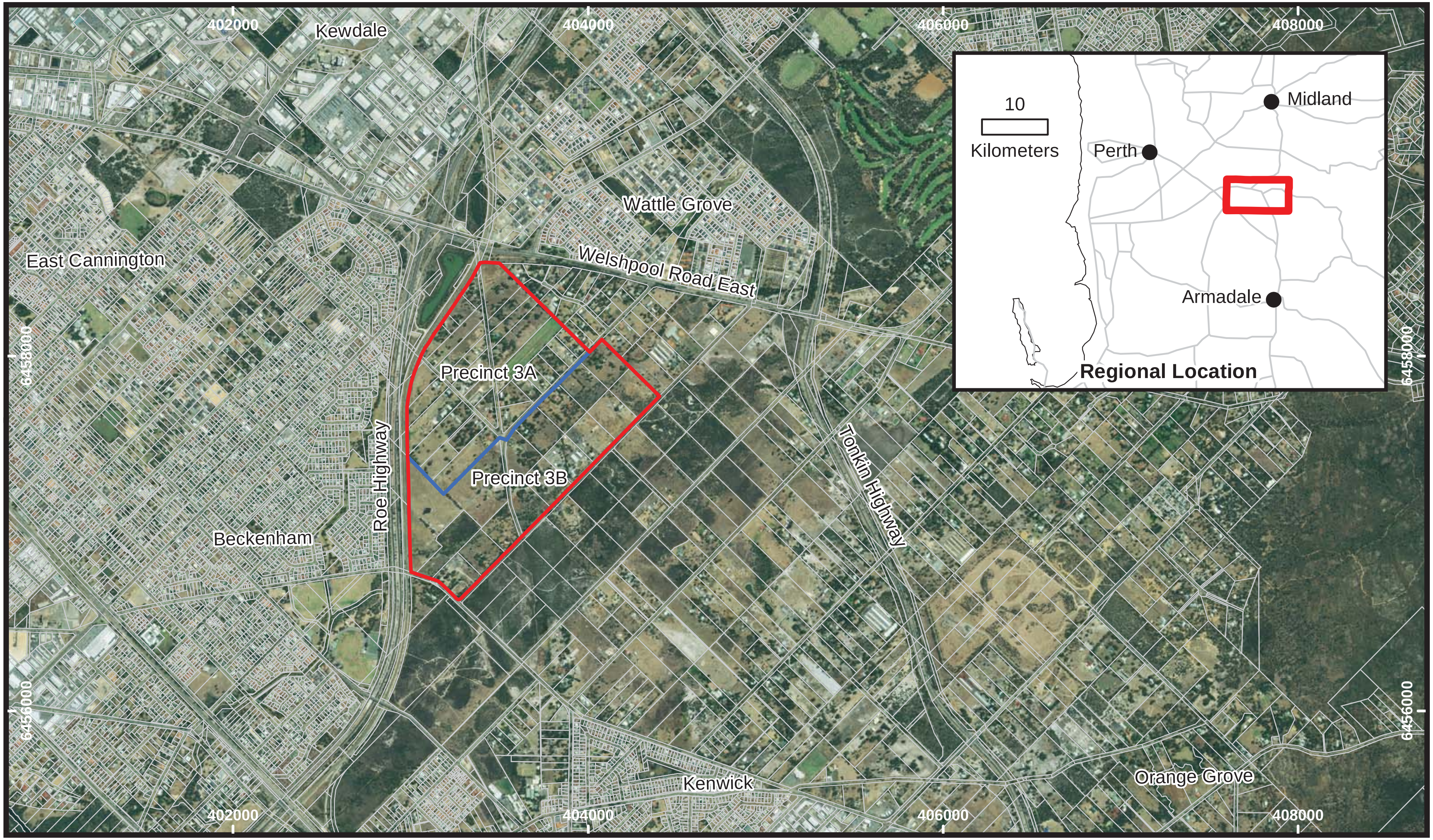
FIGURES



Legend

Site boundary

MKSEA precincts

Existing cadastral boundaries

0 0.5 1 1.5 2

Kilometres

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

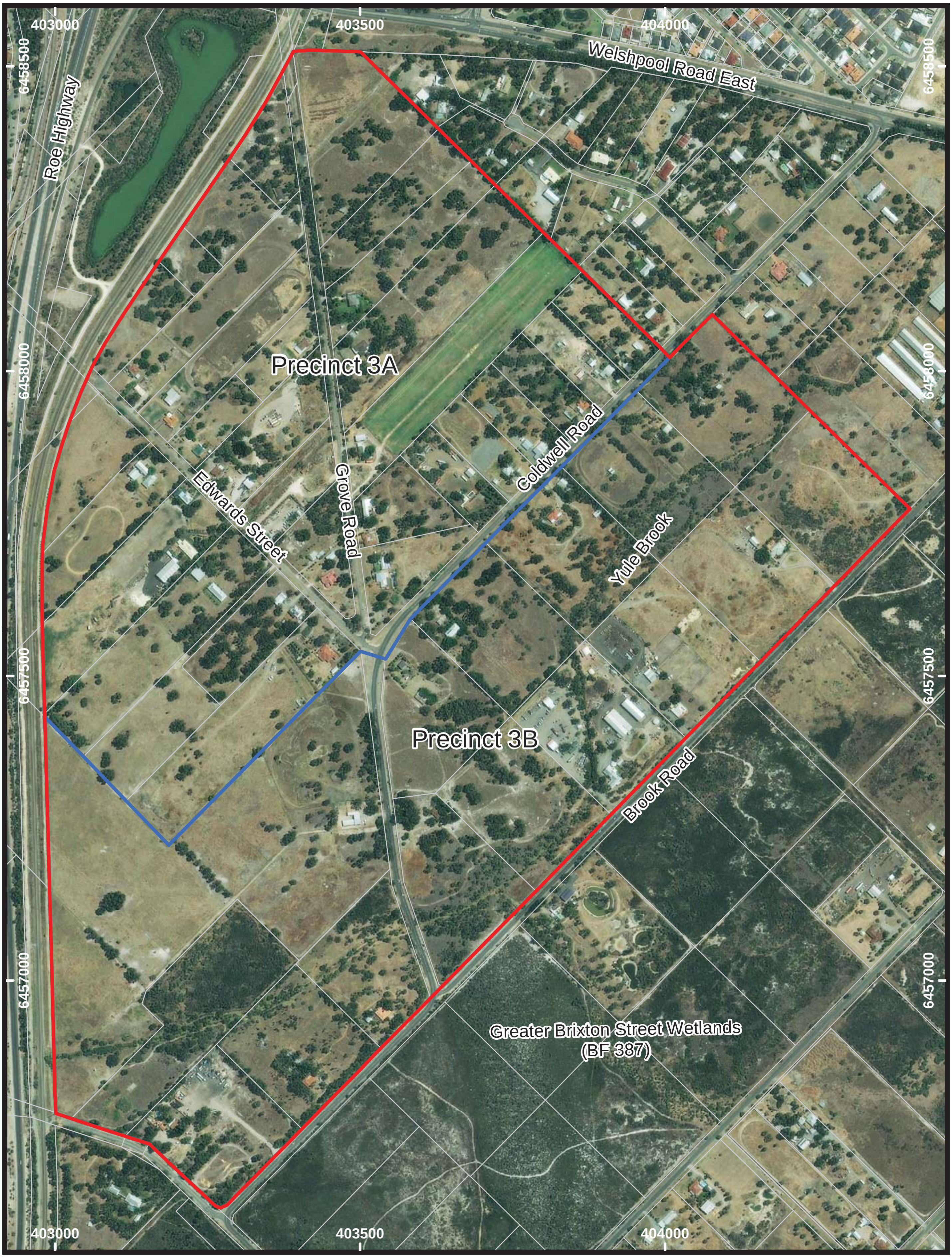
DATE : April 2016

SCALE: 1:30,000

Maddington Kenwick Strategic Employment Area - Precinct 3

Subject Site and Surrounds

Figure: 1



Legend

- Site boundary
- MKSEA precincts
- Existing cadastral boundaries

0 100 200 300 400
Metres
MGA Zone 50

Fauna Survey

DRAWN: G Harewood
DATE: April 2016
SCALE: 1:8,250

Maddington Kenwick Strategic Employment Area - Precinct 3

Subject Site Air Photo

Figure: 2

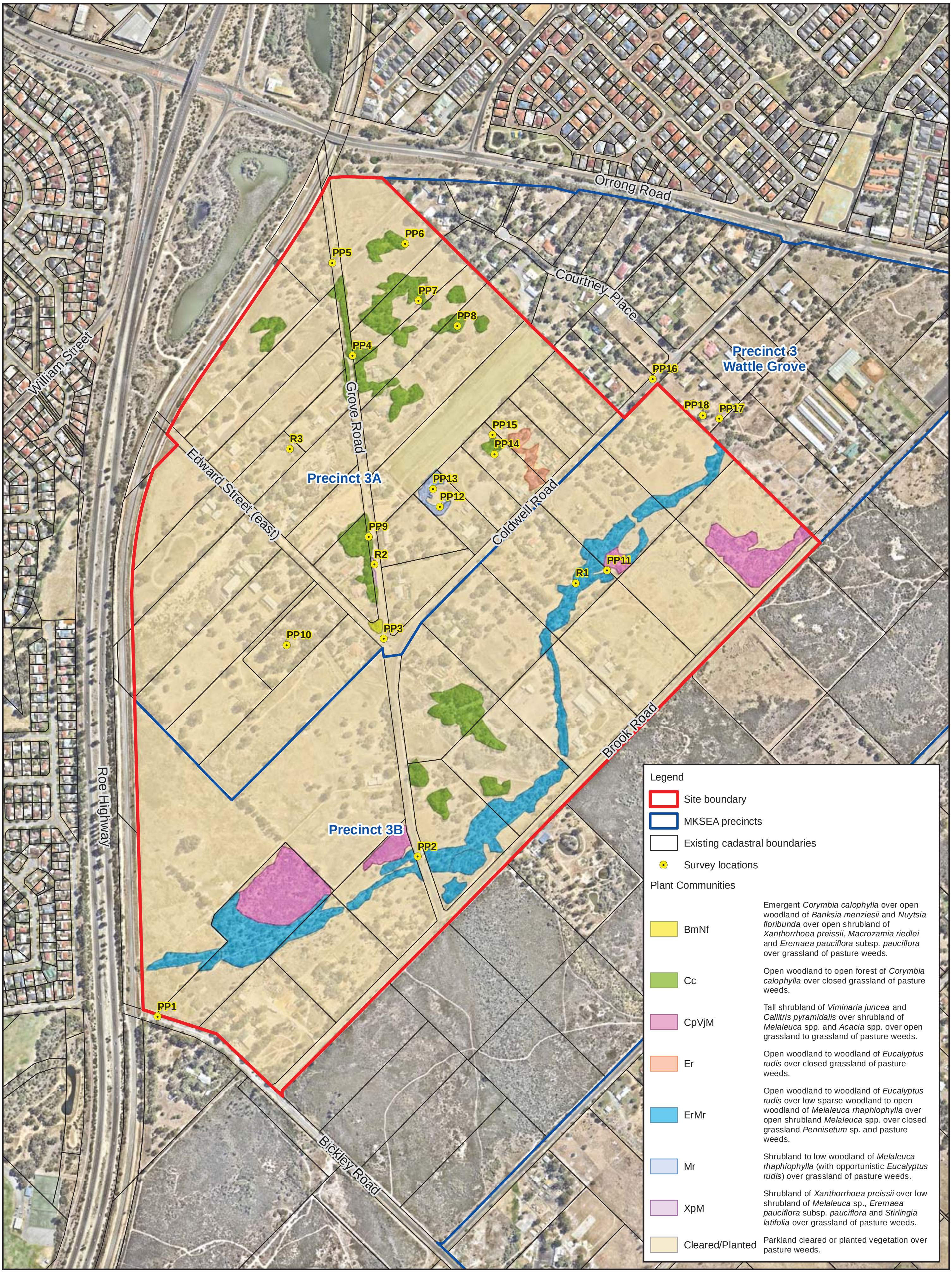


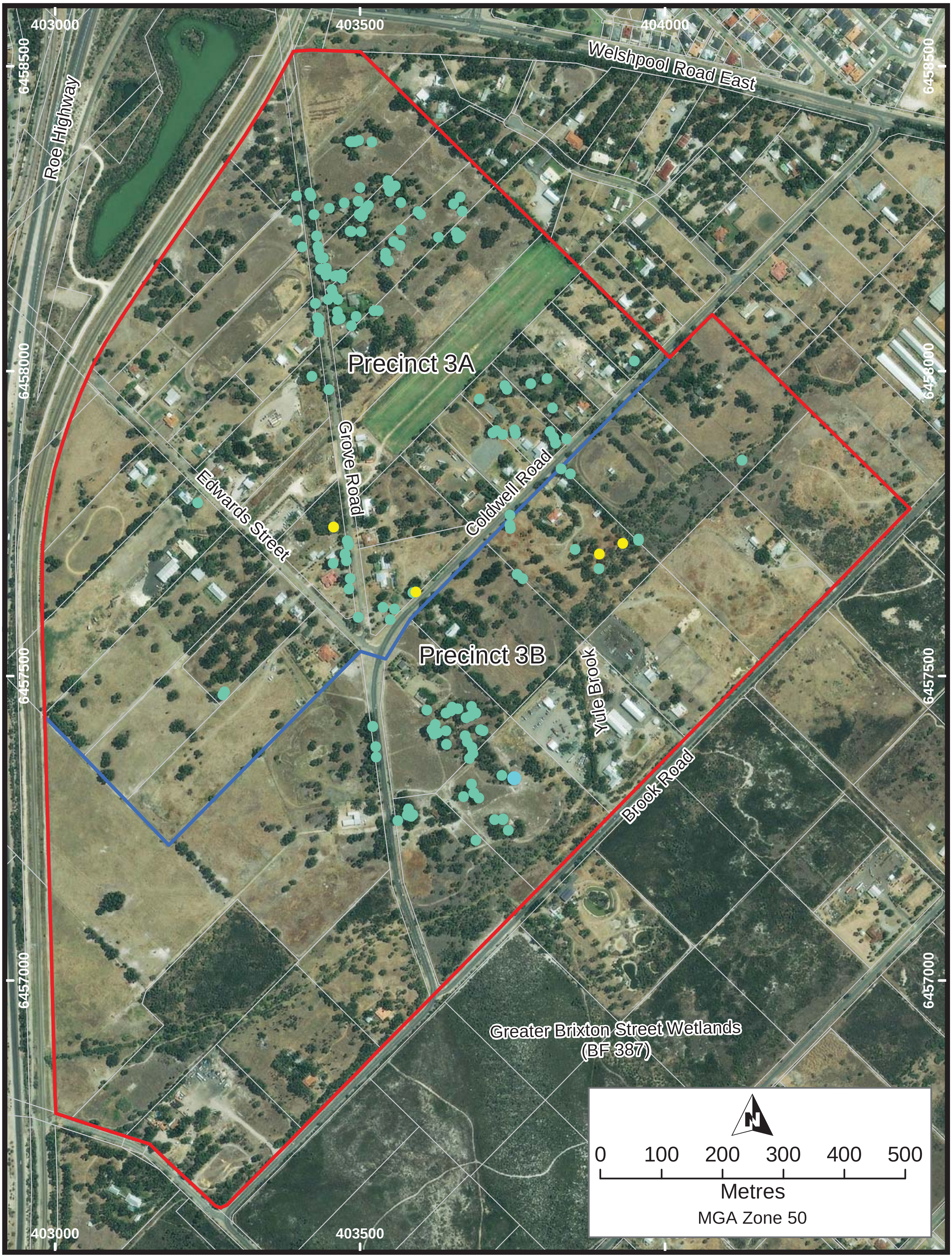
Figure 3:	**Plant Communities**
Project:	Fauna Survey MKSEA Precinct 3
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(04)--F49A

Drawn:	ADB	Date:	20/04/2016
Approved:	TA	Date:	20/04/2016
Checked:	TA	Scale:	1:10,000@A4

0 200 400 Metres

emerge ASSOCIATES
Integrated Science & Design



Legend

- Site boundary
- MKSEA precincts
- Existing cadastral boundaries
- Tree >50cm DBH, no hollows seen
- Tree >50cm DBH, one or more small hollows seen

Note: No hollows suitable for black cokatoos observed.

Fauna Survey

DRAWN:G Harewood

DATE : April 2016

SCALE: 1:8,250

Maddington Kenwick Strategic Employment Area - Precinct 3

Habitat Trees (DBH >50cm)

Figure: 4

APPENDIX A

CONSERVATION CATEGORIES

EPBC Act (1999) Threatened Fauna Categories

Threatened fauna may be listed under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) in any one of the following categories:

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	EW	A species (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically Endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation Dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the *EPBC Act*

Note: Only species in those categories marked with an asterix are matters of national environmental significance (NES) under the *EPBC Act*.

Wildlife Conservation (Specially Protected Fauna) Notice 2015 Categories

Published as Specially Protected under the *Wildlife Conservation Act 1950*, and listed under Schedules 1 to 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Code	Description
Schedule 1 Critically Endangered species	CR	Threatened species considered to be facing an extremely high risk of extinction in the wild.
Schedule 2 Endangered species	EN	Threatened species considered to be facing a very high risk of extinction in the wild.
Schedule 3 Vulnerable species	VU	Threatened species considered to be facing a high risk of extinction in the wild.
Schedule 4 Presumed extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
Schedule 5 Migratory birds protected under an international agreement	IA	Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds.
Schedule 6 Fauna that is of special conservation need as conservation dependent fauna	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
Schedule 7 Other specially protected fauna.	OS	Fauna otherwise in need of special protection to ensure their conservation.

Western Australian DPaW Priority Fauna Categories

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Code	Description
Priority 1 Poorly Known Species.	P1	Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2 Poorly Known Species.	P2	Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3 Poorly Known Species.	P3	Species that are known from several locations and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4 Rare, Near Threatened and other species in need of monitoring.	P4	(a) Rare: Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened: Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

*Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

IUCN Red List Threatened Species Categories

The *IUCN Red List of Threatened Species*™ is a checklist of taxa that have undergone an extinction risk assessment using the *IUCN Red List Categories and Criteria*.

Categories are summarized below.

Category	Code	Description
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or and as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing a high risk of extinction in the wild.
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.
Not Evaluated	NE	Taxa which has not been evaluated.

A full list of categories and their meanings are available at:

http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

APPENDIX B

FAUNA OBSERVED OR POTENTIALLY IN SUBJECT SITE

Fauna Observed or Potentially in Subject Site

MKSEA Precinct 3, W.A.

Approximate centroid = 32.013261°S 115.978398°E

Compiled by Greg Harewood - December 2015

Recorded (Sighted/Heard/Signs/Captured) = X

A = Harewood, G. (2016). Fauna Assessmnt Maddington Kenwick Strategic Employment Area Precinct 3. Unpublished report for Emerge Associates.

B = Turpin, J. and Bamford, M. (2009). Keane Road Strategic Link Armadale, Fauna Assessment. Unpublished report for the EnviroWorks Consulting.

C = ATA Environmental (2006). Vertebrate Fauna Assessment Brookdale Redevelopment Area. Unpublished report for the Armadale Redevelopment Authority.

D = ENV Australia (2005). Southern River Precinct 3 - Environmental Review. Unpublished report for the City of Gosnells.

E = ATA (1994). A Report of a Fauna Survey of Perth Airport. Report 93/78. Unpublished report for the Federal Airports Corporation.

How, R.A (1995). Objection Assessment of Fauna Values for Perth Airport. Unpublished report for the Australian Heritage Commission.

Dell, J. (pers.comm) (1994). Results of Western Australia Museum Surveys, December 1986 to April 1990.

Robson and Chester (1989). Report on the Aquatic Fauna of Munday Swamp as an Indicator of Environnmental Quality. Murdoch University.

Storey, A.W. et al (1993). Wetlands on the Swan Coastal Plain Volume 7. Waterbird Usage of Wetlands of the Swan Coastal Plain. EPA and Water Aurthority of WA.

F = DPaW (2015). NatureMap Database search. “By Circle” 115°58' 41" E, 32°00' 47" S – Study area (plus 10 km buffer). 22 December 2015.

Class / **Family** / *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Osteichthyes								
Galaxiidae								
Galaxias occidentalis	Western Minnow						X	X
Nannopercidae								
Edell vittata	Western Pygmy Perch						X	
Poeciliidae Livebearers								
Gambusia holbrooki	Mosquito Fish	Introduced					X	

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class / **Family** / *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Amphibia								
Myobatrachidae Ground or Burrowing Frogs								
Crinia georgiana	Quacking Frog	LC			X			X
Crinia glauerti	Clicking Frog	LC			X	X	X	X
Crinia insignifera	Squelching Froglet	LC		X	X	X	X	X
Geocrinia leai	Ticking Frog	LC						
Heleioporus eyrei	Moaning Frog	LC			X	X	X	X
Limnodynastes dorsalis	Western Banjo Frog	LC		X	X	X	X	X
Hylidae Tree or Water-Holding Frogs								
Litoria adelaidensis	Slender Tree Frog	LC		X	X	X	X	X
Litoria moorei	Motorbike Frog	LC			X	X		X
Reptilia								
Gekkonidae Geckoes								
Christinus marmoratus	Marbled Gecko				X			X
Pygopodidae Legless Lizards								
Aprasia repens	Sandplain Worm Lizard				X			X
Lialis burtonis	Burton’s Legless Lizard				X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Scincidae Skinks								
Acritoscincus trilineatum	Southwestern Cool Skink				X	X	X	
Cryptoblepharus buchananii	Fence Skink				X	X	X	X
Ctenotus fallens	West Coast Ctenotus						X	X
Egernia kingii	King's Skink							X
Hemiergis quadrilineata	Two-toed Mulch Skink						X	X
Lerista elegans	West Coast Four-toed Lerista				X	X	X	X
Menetia greyii	Dwarf Skink				X	X	X	X
Morethia lineoocellata	West Coast Pale-flecked Morethia				X			X
Morethia obscura	Shrubland Pale-flecked Morethia				X			X
Tiliqua rugosa	Bobtail			X	X	X	X	X
Elapidae Elapid Snakes								
Notechis scutatus	Tiger Snake				X	X		X
Pseudonaja affinis	Dugite				X	X	X	X

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Aves								
Phasianidae Quails, Pheasants								
Coturnix pectoralis	Stubble Quail	LC				X		X
Coturnix ypsilophora	Brown Quail	LC			X			
Anatidae Geese, Swans, Ducks								
Anas gracilis	Grey Teal	LC			X	X	X	X
Anas platyrhynchos	Mallard	Introduced				X		X
Anas superciliosa	Pacific Black Duck	LC	X	X	X	X	X	X
Chenonetta jubata	Australian Wood Duck	LC	X	X	X	X	X	X
Tadorna tadornoides	Australian Shelduck	LC	X	X	X	X	X	X
Ardeidae Herons, Egrets, Bitterns								
Ardea alba	Great Egret	S5 Mig CA JA					X	
Ardea ibis	Cattle Egret	S5 Mig CA JA						
Ardea novaehollandiae	White-faced Heron	LC			X	X	X	X
Ardea pacifica	White-necked Heron	LC			X	X		X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Threskiornithidae Iibises, Spoonbills								
Threskiornis molucca	Australian White Ibis	LC	X		X	X	X	X
Threskiornis spinicollis	Straw-necked Ibis	LC	X	X		X	X	X
Accipitridae Kites, Goshawks, Eagles, Harriers								
Accipiter cirrocephalus	Collared Sparrowhawk	Bp LC					X	X
Accipiter fasciatus	Brown Goshawk	Bp LC				X	X	X
Aquila audax	Wedge-tailed Eagle	Bp LC				X	X	X
Aquila morphnoides	Little Eagle	Bp LC					X	X
Circus approximans	Swamp Harrier	LC						X
Circus assimilis	Spotted Harrier	LC						X
Elanus caeruleus	Black-shouldered Kite	LC				X	X	X
Haliastur sphenurus	Whistling Kite	Bp LC			X			X
Hamirostra isura	Square-tailed Kite	Bp LC						

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Falconidae Falcons								
Falco berigora	Brown Falcon	Bp LC	X		X		X	X
Falco cenchroides	Australian Kestrel	LC		X	X	X	X	X
Falco longipennis	Australian Hobby	LC						X
Falco peregrinus	Peregrine Falcon	S7 Bp LC						X
Columbidae Pigeons, Doves								
Columba livia	Domestic Pigeon	Introduced				X		X
Ocyphaps lophotes	Crested Pigeon	LC		X	X	X	X	X
Phaps chalcoptera	Common Bronzewing	Bh LC		X	X	X	X	X
Streptopelia chinensis	Spotted Turtle-Dove	Introduced	X		X	X	X	X
Streptopelia senegalensis	Laughing Turtle-Dove	Introduced	X	X	X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Psittacidae Parrots								
Cacatua roseicapilla	Galah	LC	X	X	X	X	X	X
Cacatua sanguinea	Little Corella	LC				X		X
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	S3 VU Be VU A2c+3c+4c	X		X	X		X
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	S3 VU Bp VU C2a(ii)						X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	S2 EN Bp EN A2bcde+3bc	X		X	X	X	X
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	LC						X
Neophema elegans	Elegant Parrot	LC			X		X	X
Platycercus icterotis icterotis	Western Rosella (western ssp)	Bp LC						
Platycercus spurius	Red-capped Parrot	LC	X	X	X	X	X	X
Platycercus zonarius semitorquatus	Australian Ringneck Parrot	LC		X	X	X	X	
Polytelis anthopeplus	Regent Parrot	LC			X			X
Trichoglossus haematodus	Rainbow Lorikeet	Introduced	X	X	X	X		X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Cuculidae Parasitic Cuckoos								
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC			X			X
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC		X	X	X	X	X
Chrysococcyx lucidus	Shining Bronze Cuckoo	LC		X	X	X	X	X
Cuculus pallidus	Pallid Cuckoo	LC		X			X	
Strigidae Hawk Owls								
Ninox novaeseelandiae	Boobook Owl	LC			X			X
Tytonidae Barn Owls								
Tyto alba	Barn Owl	LC			X			X
Podargidae Frogmouths								
Podargus strigoides	Tawny Frogmouth	LC			X			X
Halcyonidae Tree Kingfishers								
Dacelo novaeguineae	Laughing Kookaburra	Introduced	X		X	X	X	X
Todiramphus sanctus	Sacred Kingfisher	LC	X		X	X	X	X
Meropidae Bee-eaters								
Merops ornatus	Rainbow Bee-eater	S5 Mig JA LC	X		X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Maluridae Fairy Wrens, GrassWrens								
Malurus splendens	Splendid Fairy-wren	Bh LC		X	X	X	X	X
Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces								
Acanthiza apicalis	Broad-tailed Thornbill	Bh LC		X	X	X	X	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh LC	X	X	X	X	X	X
Gerygone fusca	Western Gerygone	LC	X	X	X	X	X	X
Smicrornis brevirostris	Weebill	Bh LC	X	X	X			X
Pardalotidae Pardalotes								
Pardalotus punctatus	Spotted Pardalote	LC					X	X
Pardalotus striatus	Striated Pardalote	LC	X		X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Meliphagidae Honeyeaters, Chats								
Acanthorhynchus superciliosus	Western Spinebill	LC		X		X	X	X
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X	X
Anthochaera lunulata	Western Little Wattlebird	Bp LC		X	X	X	X	X
Epthianura albifrons	White-fronted Chat	LC					X	X
Lichenostomus virescens	Singing Honeyeater	LC	X	X	X	X	X	
Lichmera indistincta	Brown Honeyeater	LC	X	X	X	X	X	X
Manorina flavigula	Yellow-throated Miner	LC						X
Phylidonyris nigra	White-cheeked Honeyeater	Bp LC	X	X		X	X	X
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp LC		X		X	X	X
Petroicidae Australian Robins								
Microeca fascinans	Jacky Winter	LC						
Petroica multicolor	Scarlet Robin	Bh LC			X			X
Neosittidae Sitellas								
Daphoenositta chrysoptera	Varied Sittella	Bh LC					X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class Family Species	Common Name	Conservation Status	A	B	C	D	E	F
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers								
Colluricincla harmonica	Grey Shrike-thrush	Bh LC		X	X	X		X
Pachycephala pectoralis	Golden Whistler	Bh LC	X	X			X	X
Pachycephala rufiventris	Rufous Whistler	LC		X	X	X	X	X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo								
Grallina cyanoleuca	Magpie-lark	LC	X	X	X	X	X	X
Rhipidura fuliginosa	Grey Fantail	LC	X	X	X	X	X	X
Rhipidura leucophrys	Willie Wagtail	LC	X	X	X	X	X	X
Campephagidae Cuckoo-shrikes, Trillers								
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	X	X	X	X	X	X
Lalage tricolor	White-winged Triller	LC			X	X	X	X
Artamidae Woodswallows, Butcherbirds, Currawongs								
Artamus cinereus	Black-faced Woodswallow	Bp LC				X	X	X
Artamus cyanopterus	Dusky Woodswallow	Bp LC					X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Cracticidae Currawongs, Magpies & Butcherbirds								
Cracticus tibicen	Australian Magpie	LC	X	X	X	X	X	X
Cracticus torquatus	Grey Butcherbird	LC	X	X	X	X	X	X
Corvidae Ravens, Crows								
Corvus coronoides	Australian Raven	LC	X	X	X	X	X	X
Motacillidae Old World Pipits, Wagtails								
Anthus australis	Australian Pipit	LC		X	X		X	X
Dicaeidae Flowerpeckers								
Dicaeum hirundinaceum	Mistletoebird	LC			X		X	X
Hirundinidae Swallows, Martins								
Hirundo ariel	Fairy Martin	LC					X	X
Hirundo neoxena	Welcome Swallow	LC			X	X	X	X
Hirundo nigricans	Tree Martin	LC		X	X	X	X	X
Sylviidae Old World Warblers								
Cincloramphus cruralis	Brown Songlark	LC					X	X
Cincloramphus mathewsi	Rufous Songlark	LC					X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Zosteropidae White-eyes								
Zosterops lateralis	Silvereye	LC	X	X	X	X	X	X
Mammalia								
Peramelidae Bandicoots								
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P4 LC	X	X	X	X	X	
Phalangeridae Brushtail Possums, Cuscuses								
Trichosurus vulpecula	Common Brushtail Possum	LC			X			X
Molossidae Freetail Bats								
Ozimops kitcheneri	Southern Freetail-bat	LC						
Tadarida australis	White-striped Freetail-bat	LC						

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Class Family *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Vespertilionidae Ordinary Bats								
Chalinolobus gouldii	Gould's Wattled Bat	LC			X			X
Chalinolobus morio	Chocolate Wattled Bat	LC						X
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC			X			X
Nyctophilus gouldi	Gould's Long-eared Bat	LC						
Nyctophilus major major	Western Long-eared Bat	LC						
Vespadelus regulus	Southern Forest Bat	LC						X
Muridae Rats, Mice								
Mus musculus	House Mouse	Introduced			X	X	X	X
Rattus rattus	Black Rat	Introduced			X		X	X
Canidae Dogs, Foxes								
Canis lupus familiaris	Dog	Introduced		X	X			
Vulpes vulpes	Red Fox	Introduced	X	X	X	X	X	X
Felidae Cats								
Felis catus	Cat	Introduced		X	X	X		X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F
Leporidae Rabbits, Hares								
Oryctolagus cuniculus	Rabbit	Introduced	X	X	X	X	X	X

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APPENDIX C

DPaW & EPBC DATABASE SEARCH RESULTS

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Greg Harewood on 22/12/2015

Kingdom	Animalia
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115°58' 41'' E,32°00' 47'' S
Buffer	10km
Group By	Species Group

Species Group	Species	Records
Amphibian	14	420
Bird	277	42941
Fish	26	41
Invertebrate	327	1330
Mammal	34	654
Reptile	79	1056
TOTAL	**757**	**46442**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Amphibian					
1.	25398	*Crinia georgiana (Quacking Frog)*			
2.	25399	*Crinia glauerti (Clicking Frog)*			
3.	25400	*Crinia insignifera (Squelching Froglet)*			
4.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
5.		*Crinia sp.*			
6.	25409	*Heleioporus barycragus (Hooting Frog)*			
7.	25410	*Heleioporus eyrei (Moaning Frog)*			
8.	25412	*Heleioporus psammophilus (Sand Frog)*			
9.		*Heleioporus sp.*			
10.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
11.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
12.	25388	*Litoria moorei (Motorbike Frog)*			
13.	25420	*Myobatrachus gouldii (Turtle Frog)*			
14.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
Bird					
15.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
16.		*Acanthiza (Acanthiza) apicalis subsp. apicalis*			
17.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
18.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
19.	24262	*Acanthiza inornata (Western Thornbill)*			
20.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
21.		*Accipiter (Paraspizias) cirrocephalus subsp. cirrocephalus*			
22.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
23.	24281	*Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)*			
24.	25536	*Accipiter fasciatus (Brown Goshawk)*			
25.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
26.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
27.	24831	*Acrocephalus australis subsp. gouldi (Australian Reed Warbler)*			
28.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
29.		*Agapornis sp.*			Y
30.	24310	*Anas castanea (Chestnut Teal)*			
31.	24312	*Anas gracilis (Grey Teal)*			
32.	24313	*Anas platyrhynchos (Mallard)*			
33.	24315	*Anas rhynchotis (Australasian Shoveler)*			
34.		*Anas sp.*			
35.	24316	*Anas superciliosa (Pacific Black Duck)*			
36.	25553	*Anhinga melanogaster (Darter)*			
37.	24332	*Anhinga melanogaster subsp. novaehollandiae (Darter)*			
38.		*Anhinga novaehollandiae*			
39.		*Anser anser*			

NatureMap
Mapping Western Australia's biodiversity

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
40.		*Anser sp.*			
41.	24561	*Anthochaera carunculata (Red Wattlebird)*			
42.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
43.	25670	*Anthus australis (Australian Pipit)*			
44.	24599	*Anthus australis subsp. australis (Australian Pipit)*			
45.	24285	*Aquila audax (Wedge-tailed Eagle)*			
46.	25538	*Aquila morphnoides (Little Eagle)*			
47.	24337	*Ardea garzetta subsp. nigripes (Little Egret)*			
48.	25559	*Ardea intermedia (Intermediate Egret)*			
49.	41324	*Ardea modesta (Eastern Great Egret)*		IA	
50.	24340	*Ardea novaehollandiae (White-faced Heron)*			
51.	24341	*Ardea pacifica (White-necked Heron)*			
52.	25736	*Arenaria interpres (Ruddy Turnstone)*		IA	
53.		*Artamus (Angroyan) cinereus subsp. cinereus*			
54.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
55.	24352	*Artamus cinereus subsp. melanops (Black-faced Woodswallow)*			
56.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
57.	24318	*Aythya australis (Hardhead)*			
58.		*Barnardius zonarius*			
59.	24319	*Biziura lobata (Musk Duck)*			
60.	24345	*Botaurus poiciloptilus (Australasian Bittern)*		T	
61.	24359	*Burhinus grallarius (Bush Stone-curlew)*			
62.		*Cacatua (Cacatua) galerita*			
63.	25713	*Cacatua galerita (Sulphur-crested Cockatoo)*			
64.	25714	*Cacatua pastinator (Western Long-billed Corella)*			
65.	25715	*Cacatua roseicapilla (Galah)*			
66.	25716	*Cacatua sanguinea (Little Corella)*			
67.		*Cacatua sp.*			
68.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
69.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
70.	24427	*Cacomantis flabelliformis subsp. flabelliformis (Fan-tailed Cuckoo)*			
71.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
72.		*Cairina moschata*			
73.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
74.	25738	*Calidris canutus (Red Knot)*		IA	
75.	24784	*Calidris ferruginea (Curlew Sandpiper)*		T	
76.	24786	*Calidris melanotos (Pectoral Sandpiper)*		IA	
77.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
78.	24789	*Calidris subminuta (Long-toed Stint)*		IA	
79.	24790	*Calidris tenuirostris (Great Knot)*		T	
80.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
81.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
82.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo)*		T	
83.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
84.		*Calyptorhynchus sp.*			
85.	25625	*Carduelis carduelis (Goldfinch, European Goldfinch)*	Y		
86.	24480	*Carduelis carduelis subsp. britannica (Goldfinch)*	Y		
87.	24373	*Charadrius melanops (Black-fronted Dotterel)*			
88.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
89.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
90.		*Chroicocephalus novaehollandiae*			
91.	24431	*Chrysococcyx basalis (Horsfield's Bronze Cuckoo)*			
92.	25601	*Chrysococcyx lucidus (Shining Bronze Cuckoo)*			
93.	24432	*Chrysococcyx lucidus subsp. plagosus (Shining Bronze Cuckoo)*			
94.	24833	*Cincloramphus cruralis (Brown Songlark)*			
95.	24834	*Cincloramphus mathewsi (Rufous Songlark)*			
96.	24288	*Circus approximans (Swamp Harrier)*			
97.	24289	*Circus assimilis (Spotted Harrier)*			
98.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
99.	24396	*Climacteris rufa (Rufous Treecreeper)*			
100.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
101.	24613	*Colluricincla harmonica subsp. rufiventris (Grey Shrike-thrush)*			
102.		*Columba (Columba) livia*			Y
103.	24399	*Columba livia (Domestic Pigeon)*	Y		
104.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
105.	24362	*Coracina novaehollandiae subsp. novaehollandiae (Black-faced Cuckoo-shrike)*			
106.	25592	*Corvus coronoides (Australian Raven)*			
107.	24417	*Corvus coronoides subsp. perplexus (Australian Raven)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
108.		*Corvus sp.*			
109.	24671	*Coturnix pectoralis (Stubble Quail)*			
110.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
111.	25595	*Cracticus tibicen (Australian Magpie)*			
112.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
113.	25596	*Cracticus torquatus (Grey Butcherbird)*			
114.	24322	*Cygnus atratus (Black Swan)*			
115.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
116.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
117.	24606	*Daphoenositta chrysoptera subsp. pileata (Varied Sittella, Black-capped Sitella)*			
118.	24325	*Dendrocygna eytoni (Plumed Whistling Duck)*			
119.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
120.		*Egretta garzetta*			
121.		*Egretta novaehollandiae*			
122.		*Elanus axillaris*			
123.	24290	*Elanus caeruleus subsp. axillaris (Australian Black-shouldered Kite)*			
124.		*Elseyornis melanops*			
125.		*Eolophus roseicapillus*			
126.	24651	*Eopsaltria australis subsp. griseogularis (Western Yellow Robin)*			
127.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
128.	24567	*Epthianura albifrons (White-fronted Chat)*			
129.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
130.		*Eurostopodus (Eurostopodus) argus*			
131.		*Falco (Falco) longipennis subsp. longipennis*			
132.		*Falco (Tinnunculus) cenchroides*			
133.	25621	*Falco berigora (Brown Falcon)*			
134.	24471	*Falco berigora subsp. berigora (Brown Falcon)*			
135.	25622	*Falco cenchroides (Australian Kestrel)*			
136.	24472	*Falco cenchroides subsp. cenchroides (Australian Kestrel)*			
137.	25623	*Falco longipennis (Australian Hobby)*			
138.	24474	*Falco longipennis subsp. longipennis (Australian Hobby)*			
139.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
140.	24475	*Falco peregrinus subsp. macropus (Australian Peregrine Falcon)*		S	
141.	25727	*Fulica atra (Eurasian Coot)*			
142.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
143.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
144.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
145.	24764	*Gallinula ventralis (Black-tailed Native-hen)*			
146.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
147.	24765	*Gallirallus philippensis subsp. mellori (Buff-banded Rail)*			
148.		*Gallus gallus*			
149.	42314	*Gavicalis virescens (Singing Honeyeater)*			
150.	24401	*Geopelia cuneata (Diamond Dove)*			
151.	25530	*Gerygone fusca (Western Gerygone)*			
152.	24735	*Glossopsitta porphyrocephala (Purple-crowned Lorikeet)*			
153.	24443	*Grallina cyanoleuca (Magpie-lark)*			
154.	24487	*Haematopus longirostris (Pied Oystercatcher)*			
155.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*		IA	
156.	24295	*Haliastur sphenurus (Whistling Kite)*			
157.	25734	*Himantopus himantopus (Black-winged Stilt)*			
158.	24489	*Hirundo ariel (Fairy Martin)*			
159.	24491	*Hirundo neoxena (Welcome Swallow)*			
160.	25629	*Hirundo nigricans (Tree Martin)*			
161.	24492	*Hirundo nigricans subsp. nigricans (Tree Martin)*			
162.		*Hydroprogne caspia*			
163.		*Ixobrychus dubius*			
164.	24348	*Ixobrychus minutus subsp. dubius (Australian Little Bittern)*		P4	
165.	24367	*Lalage tricolor (White-winged Triller)*			
166.	24511	*Larus novaehollandiae subsp. novaehollandiae (Silver Gull)*			
167.	25659	*Lichenostomus leucotis (White-eared Honeyeater)*			
168.		*Lichmera (Lichmera) indistincta*			
169.	25661	*Lichmera indistincta (Brown Honeyeater)*			
170.	24582	*Lichmera indistincta subsp. indistincta (Brown Honeyeater)*			
171.	30932	*Limosa lapponica (Bar-tailed Godwit)*		IA	
172.	25741	*Limosa limosa (Black-tailed Godwit)*		IA	
173.		*Lophoictinia isura*			
174.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
175.		*Malurus (Malurus) splendens*			
176.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
177.	25651	*Malurus lamberti (Variegated Fairy-wren)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
178.		*Malurus sp.*			
179.	25654	*Malurus splendens (Splendid Fairy-wren)*			
180.	24583	*Manorina flavigula (Yellow-throated Miner)*			
181.	25758	*Megalurus gramineus (Little Grassbird)*			
182.	25663	*Melithreptus brevirostris (Brown-headed Honeyeater)*			
183.	24587	*Melithreptus chloropsis (Western White-naped Honeyeater)*			
184.	24736	*Melopsittacus undulatus (Budgerigar)*			
185.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
186.		*Microcarbo melanoleucos*			
187.	25610	*Myiagra inquieta (Restless Flycatcher)*			
188.	25686	*Neochmia temporalis (Red-browed Finch)*	Y		
189.	24738	*Neophema elegans (Elegant Parrot)*			
190.	24739	*Neophema petrophila (Rock Parrot)*			
191.	25747	*Ninox connivens (Barking Owl)*			
192.	25748	*Ninox novaeseelandiae (Boobook Owl)*			
193.	24820	*Ninox novaeseelandiae subsp. boobook (Boobook Owl)*			
194.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
195.	24350	*Nycticorax caledonicus subsp. hilli (Rufous Night Heron)*			
196.	24742	*Nymphicus hollandicus (Cockatiel)*			
197.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
198.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
199.	25679	*Pachycephala pectoralis (Golden Whistler)*			
200.	24623	*Pachycephala pectoralis subsp. fuliginosa (Golden Whistler)*			
201.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
202.	24624	*Pachycephala rufiventris subsp. rufiventris (Rufous Whistler)*			
203.		*Pandion cristatus*			
204.	25543	*Pandion haliaetus (Osprey)*			
205.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
206.	24625	*Pardalotus punctatus subsp. punctatus (Spotted Pardalote)*			
207.	25682	*Pardalotus striatus (Striated Pardalote)*			
208.	24630	*Pardalotus striatus subsp. westraliensis (Striated Pardalote)*			
209.	25687	*Passer domesticus (House Sparrow)*	Y		
210.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
211.		*Petrochelidon (Hylochelidon) nigricans*			
212.	24659	*Petroica goodenovii (Red-capped Robin)*			
213.	24660	*Petroica multicolor subsp. campbelli (Scarlet Robin)*			
214.	25697	*Phalacrocorax carbo (Great Cormorant)*			
215.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
216.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
217.	25699	*Phalacrocorax varius (Pied Cormorant)*			
218.	24409	*Phaps chalcoptera (Common Bronzewing)*			
219.	25587	*Phaps elegans (Brush Bronzewing)*			
220.	24594	*Phylidonyris melanops (Tawny-crowned Honeyeater)*			
221.	25669	*Phylidonyris nigra (White-cheeked Honeyeater)*			
222.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
223.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
224.	24842	*Platalea regia (Royal Spoonbill)*			
225.	25720	*Platycercus icterotis (Western Rosella)*			
226.	24745	*Platycercus icterotis subsp. icterotis (Western Rosella)*			
227.	24747	*Platycercus spurius (Red-capped Parrot)*			
228.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
229.	24751	*Platycercus zonarius subsp. zonarius (Port Lincoln Parrot)*			
230.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
231.	24383	*Pluvialis squatarola (Grey Plover)*		IA	
232.	25703	*Podargus strigoides (Tawny Frogmouth)*			
233.	24679	*Podargus strigoides subsp. brachypterus (Tawny Frogmouth)*			
234.	25704	*Podiceps cristatus (Great Crested Grebe)*			
235.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
236.	30854	*Polytelis anthopeplus subsp. westralis (Regent Parrot)*			
237.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
238.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
239.		*Porzana (Porzana) tabuensis subsp. tabuensis*			
240.	24769	*Porzana fluminea (Australian Spotted Crake)*			
241.	25732	*Porzana pusilla (Baillon's Crake)*			
242.	24770	*Porzana pusilla subsp. palustris (Baillon's Crake)*			
243.	24771	*Porzana tabuensis (Spotless Crake)*			
244.	24702	*Pterodroma brevirostris (Kerguelen Petrel)*			
245.	24703	*Pterodroma lessonii (White-headed Petrel)*			
246.	25710	*Pterodroma macroptera (Great-winged Petrel)*			
247.	24711	*Puffinus assimilis subsp. assimilis (Little Shearwater)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
248.	24716	*Puffinus pacificus (Wedge-tailed Shearwater)*		IA	
249.		*Purpureicephalus spurius*			
250.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
251.		*Rhipidura (Sauloprocta) leucophrys*			
252.	25613	*Rhipidura fuliginosa (Grey Fantail)*			
253.	24452	*Rhipidura fuliginosa subsp. preissi (Grey Fantail)*			
254.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
255.	24454	*Rhipidura leucophrys subsp. leucophrys (Willie Wagtail)*			
256.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
257.	30948	*Smicrornis brevirostris (Weebill)*			
258.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
259.	24522	*Sterna bergii (Crested Tern)*			
260.	24523	*Sterna caspia (Caspian Tern)*		IA	
261.	24525	*Sterna fuscata subsp. nubilosa (Sooty Tern)*			
262.	25643	*Sterna hybrida (Whiskered Tern)*			
263.	25644	*Sterna nereis (Fairy Tern)*			
264.	24329	*Stictonetta naevosa (Freckled Duck)*			
265.	25655	*Stipiturus malachurus (Southern Emu-wren)*			
266.	25597	*Strepera versicolor (Grey Currawong)*			
267.		*Streptopelia (Spilopelia) senegalensis*			
268.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
269.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
270.	30950	*Streptopelia senegalensis subsp. senegalensis (Laughing Turtle-Dove)*	Y		
271.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
272.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
273.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
274.		*Thalasseus bergii*			
275.	24844	*Threskiornis molucca (Australian White Ibis)*			
276.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
277.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
278.	24309	*Todiramphus sanctus subsp. sanctus (Sacred Kingfisher)*			
279.		*Tribonyx ventralis*			
280.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
281.	24755	*Trichoglossus haematodus subsp. moluccanus (Rainbow Lorikeet)*	Y		
282.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
283.	24808	*Tringa nebularia (Common Greenshank)*		IA	
284.	24849	*Turnix varia subsp. varia (Painted Button-quail)*			
285.	24851	*Turnix velox (Little Button-quail)*			
286.	25762	*Tyto alba (Barn Owl)*			
287.	24852	*Tyto alba subsp. delicatula (Barn Owl)*			
288.	24855	*Tyto novaehollandiae subsp. novaehollandiae (Masked Owl (southern subsp))*		P3	
289.	24386	*Vanellus tricolor (Banded Lapwing)*			
290.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			
291.	24856	*Zosterops lateralis subsp. gouldi (Grey-breasted White-eye)*			

Fish

292.		*Afurcagobius suppositus*			
293.		*Amniataba caudavittata*			
294.		*Anguilla australis*			
295.		*Arenigobius bifrenatus*			
296.		*Atherinosoma wallacei*			
297.		*Bostockia porosa*			
298.		*Carassius auratus*			
299.		*Cleidopus gloriamaris*			
300.	34028	*Galaxias occidentalis (Western Minnow)*			
301.		*Galaxias sp.*			
302.		*Gerres oyena*			
303.		*Gymnapistes marmoratus*			
304.		*Hemiramphus robustus*			
305.		*Lesueurina sp.*			
306.		*Nannoperca vittata*			
307.		*Nematalosa vlaminghi*			
308.		*Ophisurus serpens*			
309.		*Ostorhinchus rueppellii*			
310.		*Papillogobius punctatus*			
311.		*Phalloceros caudimaculatus*			
312.		*Phyllopteryx taeniolatus*			
313.		*Platycephalus westraliae*			
314.		*Pseudogobius olorum*			
315.		*Sutorectus tentaculatus*			

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area[1]
316.	*Terapon sp.*			
317.	*Urocampus carinirostris*			

Invertebrate

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area[1]
318.	*Acantholophus amycteroides*			
319.	*Acantholophus suturalis*			
320.	*Acercella falcipes*			
321.	*Acrotrichis sp.*			Y
322.	*Adelium breviusculum*			
323.	*Adversaeschna brevistyla*			
324.	*Aganippe rhaphiduca*			
325.	*Akamptogonus novarae*			
326.	*Allothereua maculata*			
327.	*Amblyomma triguttatum*			
328.	*Amitermes conformis*			
329.	*Amitermes obeuntis*			
330.	*Anachloris tofocolorata*			Y
331.	*Aname mainae*			
332.	*Aname sp.*			
333.	*Aname tepperi*			
334.	*Anax papuensis*			
335.	*Ancylis acromochla*			Y
336.	*Anisopheidole antipodum*			
337.	*Antichiropus variabilis*			
338.	*Antipodia dactyliota subsp. dactyliota*			
339.	*Antiporus hollingsworthi*			Y
340.	*Aphodius lividus*			
341.	*Apsilochorema urdalum*			
342.	*Araneus cyphoxis*			
343.	*Araneus eburneiventris*			
344.	*Araneus eburnus*			
345.	*Araneus senicaudatus*			
346.	*Araneus talipedatus*			
347.	*Archaeosynthemis occidentalis*			
348.	*Archiargiolestes pusillus*			
349.	*Ardozyga dysclyta*			Y
350.	*Argiope trifasciata*			
351.	*Artema atlanta*			
352.	*Arthritica helmsi*			
353.	*Artoria linnaei*			
354.	*Artoria taeniifera*			
355.	*Artoriopsis eccentrica*			
356.	*Artoriopsis expolita*			
357.	*Artoriopsis joergi*			
358.	*Asadipus kunderang*			
359.	*Austracantha minax*			
360.	*Austrammo harveyi*			
361.	*Austroaeschna (Austroaeschna) anacantha*			
362.	*Austroagrion cyane*			
363.	*Austrogomphus (Austrogomphus) collaris*			
364.	*Austrogomphus sp.*			
365.	*Austrolestes aleison*			
366.	*Austrolestes analis*			
367.	*Austrolestes annulosus*			
368.	*Austrolestes aridus*			
369.	*Austrolestes io*			
370.	*Austropeplea sp.*			
371.	*Austrosynthemis cyanitincta*			
372.	*Austrothemis nigrescens*			
373.	*Backobourkia heroine*			
374.	*Badumna insignis*			
375.	*Ballarra longipalpus*			
376.	*Blackburnium reichei*			
377.	*Breda jovialis*			
378.	*Camponotus consobrinus*			
379.	*Camponotus minimus*			
380.	*Camponotus sp.*			
381.	*Camponotus terebrans*			
382.	*Cantareus apertus*			
383.	*Castiarina anchoralis*			
384.	*Castiarina crenata*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
385.		*Castiarina crocicolor*			
386.		*Castiarina mustelamajor*			
387.		*Castiarina phaeopus*			
388.		*Celaenia excavata*			
389.		*Cerapachys princeps*			
390.		*Cercophonius granulosus*			
391.		*Cercophonius sulcatus*			
392.		*Cercyon (Cercyon) nigriceps*			
393.		*Ceryerda cursitans*			
394.	33939	*Cherax cainii (Marron)*			
395.		*Cherax destructor*			
396.		*Cherax quinquecarinatus*			
397.		*Coelostoma (Coelostoma) fabricii*			
398.		*Colobomatus sp.*			Y
399.		*Coptotermes acinaciformis subsp. raffrayi*			
400.		*Coptotermes michaelseni*			
401.		*Cormocephalus aurantiipes*			
402.		*Cormocephalus novaehollandiae*			
403.		*Cormocephalus rubriceps*			
404.		*Cormocephalus strigosus*			
405.		*Cormocephalus turneri*			
406.		*Cricotopus sp.*			
407.		*Crypsiphona ocultaria*			
408.		*Cryptoerithus quobba*			
409.		*Cyclosa trilobata*			
410.		*Cypericoccus sp.*			Y
411.		*Darwinocoris australicus*			
412.		*Delena cancerides*			
413.		*Deretaphrus gracilis*			
414.		*Diaspidiotus loranthi*			Y
415.		*Dichromodes leptozona*			Y
416.		*Dingosa murata*			
417.		*Dingosa serrata*			
418.		*Dinocambala ingens*			
419.		*Diphucrania tyrrhena*			
420.		*Diplacodes bipunctata*			
421.		*Diplacodes haematodes*			
422.		*Diplotrema cornigravei*			Y
423.		*Dolichoderus parvus*			
424.		*Dolichoderus ypsilon*			
425.		*Drepanocanthoides neglectus*			
426.		*Ecnomus pansus*			
427.		*Ectropis sp.*			
428.		*Eodelena lapidicola*			
429.		*Epicoccus acaciae*			
430.		*Epopostruma kangarooensis*			Y
431.		*Ereiconastes butyrea*			Y
432.		*Eriophora biapicata*			
433.		*Ethonion roei*			
434.		*Eucyrtops latior*			
435.		*Eulechria sp.*			
436.		*Euoplos inornatus*			
437.		*Eupograpta kottae*			
438.		*Eurytion incisunguis*			Y
439.		*Exometoeca nycteris*			
440.		*Ferrissia (Pettancylus) petterdi*			
441.		*Garrha oncospila*			Y
442.		*Gea theridioides*			
443.		*Geloptera sp.*			
444.		*Grandidierella sp.*			
445.		*Harpobittacus similis*			
446.		*Helicoverpa punctigera*			
447.		*Hellyethira litua*			
448.		*Hellyethira malleoforma*			
449.		*Hemicloea sp.*			
450.		*Hemicordulia australiae*			
451.		*Hemicordulia tau*			
452.		*Henicops dentatus*			
453.		*Hesperenoeca leucostemma*			Y
454.		*Heterotermes platycephalus*			

	Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area[1]
455.		*Hoggicosa storri*			
456.		*Hogna crispipes*			
457.		*Hogna immansueta*			
458.		*Holasteron perth*			
459.		*Holasteron wamuseum*			Y
460.		*Holconia westralia*			
461.		*Holocnemus pluchei*			
462.		*Homadaula poliodes*			Y
463.		*Hudsonema aptus*			
464.		*Hyderodes crassus*			
465.		*Hydroptila losida*			
466.		*Hylaeus sp.*			
467.		*Hyperoedesipus plumosus*			Y
468.		*Hyperoedesipus sp.*			Y
469.		*Hypoblemum sp.*			Y
470.		*Idiommata blackwalli*			
471.		*Idiosoma hirsutum*			
472.		*Idiosoma sigillatum*			
473.		*Iridomyrmex conifer*			
474.		*Iridomyrmex discors*			
475.		*Iridomyrmex exsanguis*			
476.		*Iridomyrmex purpureus*			
477.		*Ischnura aurora subsp. aurora*			
478.		*Isopeda leishmanni*			
479.		*Isopeda magna*			
480.		*Isopedella cana*			
481.		*Ixodes australiensis*			
482.		*Kalotermes aemulus*			
483.		*Kangarosa properipes*			
484.		*Karaops ellenae*			
485.		*Karaops jarrit*			
486.		*Kawanaphila nartee*			
487.	33980	*Kawaniphila pachomai (cricket)*		P1	
488.		*Kobonga umbrimargo*			
489.		*Lampona cylindrata*			
490.		*Lasioglossum (Chilalictus) hemichalceum*			
491.		*Lasioglossum (Chilalictus) oblitum*			
492.		*Lasioglossum (Chilalictus) seminitens*			
493.		*Latrodectus hasselti*			Y
494.		*Latrodectus hasseltii*			
495.		*Leioproctus (Lamprocolletes) chalybeatus*			
496.	33981	*Leioproctus bilobatus (bee)*		P2	
497.	33983	*Leioproctus douglasiellus (bee)*		T	
498.		*Limnadia sp.*			
499.		*Lipotriches (Austronomia) australica*			
500.		*Longepi woodman*			
501.		*Lycidas chlorophthalmus*			
502.		*Lycidas michaelseni*			
503.		*Lycosa ariadnae*			
504.		*Lycosa godeffroyi*			
505.		*Lycosa leuckartii*			
506.		*Lynceus tatei*			
507.		*Maconellicoccus lanigerus*			
508.		*Maratus pavonis*			
509.		*Masasteron maini*			
510.		*Melita matilda*			Y
511.		*Micramicta amolgaea*			Y
512.		*Miniargiolestes minimus*			
513.		*Missulena granulosa*			
514.		*Missulena hoggi*			
515.		*Missulena occatoria*			
516.		*Mituliodon tarantulinus*			
517.		*Mitzoruga insularis*			
518.		*Motasingha dirphia*			
519.		*Motasingha trimaculata subsp. occidentalis*			
520.		*Myandra bicincta*			
521.		*Myandra cambridgei*			
522.		*Myrmecia clarki*			
523.		*Myrmecia mandibularis*			
524.		*Myrmecia sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area[1]
525.		*Myrmecia vindex*			
526.		*Nannophya dalei*			
527.	33984	*Neopasiphae simplicior (bee)*		T	
528.		*Neosparassus sp.*			
529.		*Nephila edulis*			
530.		*Nicodamus mainae*			
531.		*Notiasemus glauerti*			
532.		*Nunciella aspera*			
533.		*Occasitermes occasus*			
534.		*Occiperipatoides gilesii*			
535.		*Oecetis pechana*			
536.		*Oecobius navus*			
537.		*Ommatoiulus moreleti*			
538.		*Ommatoiulus moreletii*			
539.		*Onchidina australis*			
540.		*Onthophagus ferox*			
541.		*Onthophagus haagi*			
542.		*Opopaea sp.*			
543.		*Orchamoplatus citri*			Y
544.		*Orthetrum caledonicum*			
545.		*Ostearius melanopygius*			
546.		*Oxidus gracilis*			
547.		*Oxyethira (Trichoglene) retracta*			
548.		*Oxyopes gracilipes*			
549.		*Oxyops sp.*			
550.		*Pachysaga australis*			
551.		*Paracapritermes kraepelinii*			
552.		*Paracymus pygmaeus*			
553.		*Paradorydium viridis*			
554.		*Paralampona marangaroo*			
555.		*Paramphisopus sp.*			
556.		*Pediana occidentalis*			
557.		*Petalura hesperia*			
558.		*Phanerozancla sp.*			Y
559.		*Pheidole megacephala*			
560.		*Phenasteron longiconductor*			
561.		*Phlyctinus callosus*			
562.		*Pholcus phalangioides*			
563.		*Phoracantha odewahnii*			
564.		*Phoracantha semipunctatus*			
565.		*Phryganoporus candidus*			
566.		*Phryganoporus gausapatus subsp. occidentalis*			Y
567.		*Phyllotocus ustulatus*			
568.		*Pinkfloydia harveii*			
569.		*Plesiotrochus monachus*			
570.		*Poltys laciniosus*			
571.		*Polygonarea repanda*			Y
572.		*Prietocella barbara*			
573.		*Procephaleus bulbosa*			Y
574.		*Pseudaulacaspis eugeniae*			Y
575.		*Raveniella cirrata*			
576.		*Raveniella peckorum*			
577.		*Rhytidoponera rufonigra*			
578.		*Rybaxis hortensis*			
579.		*Scolopendra laeta*			
580.		*Scolopendra morsitans*			
581.		*Scoloplos simplex*			
582.		*Scytodes thoracica*			
583.		*Simplisetia aequisetis*			
584.		*Siphonaria laciniosa*			
585.		*Siphonaria zelandica*			
586.		*Smeringopus natalensis*			
587.		*Smeringopus natalensis?*			Y
588.		*Smicrophylax australis*			
589.		*Smiliopus quadrinotatus*			Y
590.		*Solaenodolichopus pruvoti*			
591.		*Sphaerotrichopus ramosus*			
592.		*Spisula (notospisula)*			
593.		*Steatoda capensis*			
594.		*Steatoda grossa*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
595.		*Stigmodera gratiosa*			
596.		*Stigmodera sp.*			
597.		*Storena formosa*			
598.		*Storena sinuosa*			
599.		*Strepsicrates ejectana*			
600.		*Succinea sp.*			
601.		*Supunna funerea*			
602.		*Supunna picta*			
603.		*Synemon sp.*			
604.		*Synothele durokoppin*			
605.		*Synothele rastelloides*			
606.		*Synsphyronus magnus*			
607.		*Tamopsis facialis*			
608.		*Tamopsis perthensis*			
609.		*Tasmanicosa leuckartii*			
610.		*Tatea huonensis*			
611.		*Tatea rufilabris*			
612.		*Tegenaria atrica*			Y
613.		*Temognatha flavocincta*			
614.		*Temognatha secularis*			
615.		*Tetragnatha demissa*			
616.		*Thalycrodes calvatum*			Y
617.		*Theba pisana*			
618.		*Thelohania parastaci*			Y
619.		*Thrips imaginis*			
620.		*Tranes vigorsii*			
621.		*Trichocolletes erythrurus*			
622.		*Trichocyclus balladong*			
623.		*Trichocyclus nullarbor*			
624.		*Triplectides australicus*			
625.		*Triplectides australis*			
626.		*Tumulitermes apiocephalus*			
627.		*Tumulitermes westraliensis*			
628.		*Tympanophora similis*			
629.		*Ulomoides tetraspilotus*			
630.		*Urodacus manicatus*			
631.		*Urodacus novaehollandiae*			
632.		*Urodacus planimanus*			
633.		*Urodacus sp.*			
634.		*Urodacus woodwardii*			
635.		*Venator immansueta*			
636.		*Venator sp.*			
637.		*Venatrix arenaris*			
638.		*Venatrix pullastra*			
639.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		T	
640.		*Westrarchaea spinosa*			
641.		*Zachria flavicoma*			
642.		*Zaletta lesmurdiensis*			Y
643.		*Zebraplatys fractivittata*			
644.		*unknown unknown*			Y

Mammal

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
645.	25449	*Antechinus flavipes (Yellow-footed Antechinus)*			
646.	24088	*Antechinus flavipes subsp. leucogaster (Yellow-footed Antechinus, Mardo)*			
647.	24162	*Bettongia penicillata subsp. ogilbyi (Woylie, Brush-tailed Bettong)*		T	
648.	24251	*Bos taurus (European Cattle)*	Y		
649.	25454	*Canis lupus (Dog, Dingo)*	Y		
650.	30883	*Canis lupus subsp. familiaris (Dog)*	Y		
651.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
652.	24187	*Chalinolobus morio (Chocolate Wattled Bat)*			
653.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
654.	24041	*Felis catus (Cat)*	Y		
655.	30916	*Funambulus pennanti (Indian Palm Squirrel)*	Y		
656.	24215	*Hydromys chrysogaster (Water-rat)*		P4	
657.	25478	*Isoodon obesulus (Southern Brown Bandicoot)*		P5	
658.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
659.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
660.	24133	*Macropus irma (Western Brush Wallaby)*		P4	
661.	24223	*Mus musculus (House Mouse)*	Y		
662.	24042	*Mustela putorius (European Polecat, Ferret)*	Y		
663.	24146	*Myrmecobius fasciatus (Numbat, Walpurti)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
				T	
664.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
665.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
666.	25508	*Phascogale tapoatafa (Brush-tailed Phascogale)*			
667.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*		T	
668.	24234	*Pseudomys delicatulus (Delicate Mouse)*			
669.	24173	*Pteropus scapulatus (Little Red Flying-fox)*			
670.	24243	*Rattus fuscipes (Western Bush Rat)*			
671.	24245	*Rattus rattus (Black Rat)*	Y		
672.		*Sminthopsis murina*			
673.	24259	*Sus scrofa (Pig)*	Y		
674.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
675.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
676.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
677.	24206	*Vespadelus regulus (Southern Forest Bat)*			
678.	24040	*Vulpes vulpes (Red Fox)*	Y		

Reptile

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
679.	25242	*Acanthophis antarcticus (Southern Death Adder)*		P3	
680.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
681.	25448	*Antaresia stimsoni (Stimson's Python)*			
682.	25241	*Antaresia stimsoni subsp. stimsoni (Stimson's Python)*			
683.	24990	*Aprasia pulchella (Granite Worm-lizard)*			
684.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
685.	42380	*Brachyurophis fasciolatus subsp. fasciolatus (Narrow-banded Shovel-nosed Snake)*			
686.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
687.	43380	*Chelodina colliei (Oblong Turtle)*			
688.	24980	*Christinus marmoratus (Marbled Gecko)*			
689.	24918	*Crenadactylus ocellatus subsp. ocellatus (Clawless Gecko)*			
690.	30893	*Cryptoblepharus buchananii*			
691.	25020	*Cryptoblepharus plagiocephalus*			
692.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
693.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
694.	25027	*Ctenotus australis*			
695.	25035	*Ctenotus delli (Dell's Ctenotus, Darling Range Heath Ctenotus)*		P4	
696.	25039	*Ctenotus fallens*			
697.	25040	*Ctenotus gemmula (Jewelled South-west Ctenotus (Swan Coastal Plain pop P3), skink)*			
698.	25047	*Ctenotus impar*			
699.	25049	*Ctenotus labillardieri*			
700.	41641	*Ctenotus ora (Coastal Plains Skink)*		P3	
701.		*Ctenotus sp.*			
702.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
703.	24999	*Delma grayii*			
704.		*Delma sp.*			
705.	25296	*Demansia psammophis subsp. reticulata (Yellow-faced Whipsnake)*			
706.	25325	*Dendrelaphis punctulata (Green Tree Snake)*			
707.	24929	*Diplodactylus granariensis subsp. granariensis*			
708.	24939	*Diplodactylus polyophthalmus*			
709.	24940	*Diplodactylus pulcher*			
710.		*Diplodactylus sp.*			
711.	25096	*Egernia kingii (King's Skink)*			
712.	25100	*Egernia napoleonis*			
713.	25250	*Elapognathus coronatus (Crowned Snake)*			
714.	24959	*Gehyra variegata*			
715.	25232	*Hemidactylus frenatus (Asian House Gecko)*	Y		
716.	25115	*Hemiergis initialis subsp. initialis*			
717.	25475	*Hemiergis peronii*			
718.	25119	*Hemiergis quadrilineata*			
719.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
720.	25131	*Lerista distinguenda*			
721.	25133	*Lerista elegans*			
722.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
723.	25148	*Lerista lineopunctulata*			
724.	25165	*Lerista praepedita*			
725.	25005	*Lialis burtonis*			
726.	42414	*Lucasium alboguttatum*			
727.	25184	*Menetia greyii*			
728.	25240	*Morelia spilota subsp. imbricata (Carpet Python)*		S	
729.	25191	*Morethia lineoocellata*			

NatureMap
Mapping Western Australia's biodiversity

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
730.	25192	*Morethia obscura*			
731.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
732.	25249	*Neelaps calonotos (Black-striped Snake)*		P3	
733.	25252	*Notechis scutatus (Tiger Snake)*			
734.	25253	*Parasuta gouldii*			
735.	25255	*Parasuta nigriceps*			
736.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
737.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
738.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
739.	25261	*Pseudechis australis (Mulga Snake)*			
740.	25345	*Pseudemydura umbrina (Western Swamp Turtle, tortoise)*		T	
741.	25511	*Pseudonaja affinis (Dugite)*			
742.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
743.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			
744.	25263	*Pseudonaja modesta (Ringed Brown Snake)*			
745.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
746.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
747.	24943	*Strophurus spinigerus subsp. inornatus*			
748.	24942	*Strophurus spinigerus subsp. spinigerus*			
749.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
750.	25519	*Tiliqua rugosa*			
751.	25204	*Tiliqua rugosa subsp. aspera*			
752.	25207	*Tiliqua rugosa subsp. rugosa*			
753.	24983	*Underwoodisaurus milii (Barking Gecko)*			
754.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
755.	25225	*Varanus rosenbergi (Heath Monitor)*			
756.	25526	*Varanus tristis (Racehorse Monitor)*			

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.

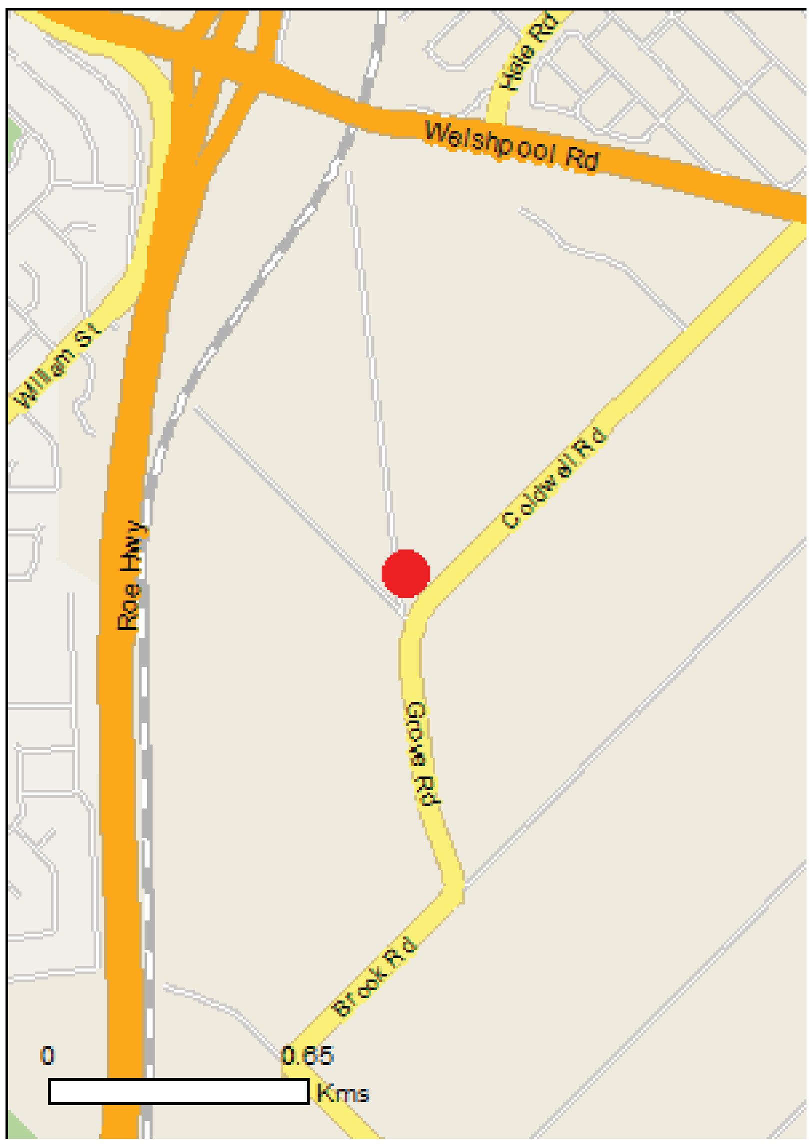
EPBC Act Protected Matters Report

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: 22/12/15 16:48:41



Coordinates
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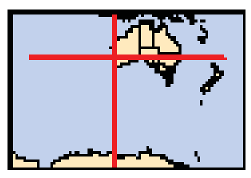

Summary

Matters of National Environmental Significance

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

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

Other Matters Protected by the EPBC Act

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

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

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:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	9
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	37
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir [25911]	Vulnerable	Species or species habitat may occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Banksia mimica Summer Honeypot [82765]	Endangered	Species or species habitat likely to 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
Calytrix breviseta subsp. breviseta Swamp Starflower [23879]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
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 may occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat known to occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat may occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Synaphea sp. Fairbridge Farm (D.Papenfus 696) Selena's Synaphea [82881]	Critically 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
Migratory Terrestrial Species		
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		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 may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

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 may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species

Name	Status	Type of Presence
		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
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

Name	Status	Type of Presence
		habitat likely to occur within area
Plants		
Anredera cordifolia		
Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus 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 monspessulana		
Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		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
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 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		

Name	Status	Type of Presence
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

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

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

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

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

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

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-32.01326 115.9784

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:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Parks and Wildlife Commission NT, Northern Territory Government
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian 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
- Forestry Corporation, 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 D

BLACK COCKATOO HABITAT TREE DETAILS

Habitat Trees (DBH >500mm)
Datum: GDA 94

Waypoint Number	Zone	mE	mN	Tree Species	DBH (mm)	Tree Height (m)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Lot Number	Comments
wpt001	50H	403931	6457717	Dead Flooded Gum	>500	10-15	1	Fissure	<5					Bees	No Signs	No		Near Dead
wpt002	50H	403957	6457724	Flooded Gum	>500	10-15	0							No Signs	No Signs	No		
wpt003	50H	403957	6457722	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt004	50H	403893	6457699	Marri	>500	10-15	3	Branch	5-12	Spout Branch	5-12	Spout Branch	5-12	No Signs	No Signs	No		
wpt005	50H	403892	6457675	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt006	50H	403853	6457707	Tuart (Planted)	>500	15-20	0							No Signs	No Signs	No		
wpt007	50H	403746	6457763	Tuart (Planted)	>500	15-20	0							No Signs	No Signs	No		
wpt009	50H	403746	6457747	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt010	50H	403747	6457741	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt011	50H	403758	6457666	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt012	50H	403767	6457659	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt013	50H	403830	6457839	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt014	50H	403845	6457831	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt016	50H	403557	6457609	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt017	50H	403538	6457612	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt018	50H	403550	6457592	Flooded Gum	>500	0-5	0							No Signs	No Signs	No		
wpt019	50H	403497	6457595	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt020	50H	403482	6457642	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt021	50H	403484	6457659	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt022	50H	403481	6457715	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt023	50H	403480	6457720	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt024	50H	403479	6457721	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt026	50H	403660	6458218	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt027	50H	403665	6458221	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt028	50H	403658	6458227	Tuart (Planted)	>500	20+	0							No Signs	No Signs	No		
wpt029	50H	403668	6458262	Marri	>500	10-15	0							No Signs	No Signs	No		
wpt030	50H	403654	6458274	Marri	>500	15-20	0							No Signs	No Signs	No		Dying
wpt031	50H	403664	6458285	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt032	50H	403396	6458287	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt034	50H	403278	6457473	Flooded Gum	>500	10-15	0							No Signs	No Signs	No		
wpt035	50H	403275	6457468	Flooded Gum	>500	10-15	0							No Signs	No Signs	No		
wpt036	50H	403234	6457783	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		Dying
wpt038	50H	403592	6457637	Tuart (Planted)	>500	20+	1	Fissure	<5					No Signs	No Signs	No		
wpt039	50H	403587	6457636	Tuart (Planted)	>500	0-5	0							No Signs	No Signs	No		
wpt040	50H	403755	6457897	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt041	50H	403754	6457903	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt042	50H	403734	6457895	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt043	50H	403724	6457902	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt044	50H	403718	6457898	Flooded Gum	>500	20+	0							No Signs	No Signs	No		
wpt045	50H	403696	6457954	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt046	50H	403738	6457975	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt047	50H	403741	6457970	Marri	>500	15-20	0							No Signs	No Signs	No		
wpt048	50H	403780	6457979	Flooded Gum	>500	20+	0							No Signs	No Signs	No		
wpt049	50H	403807	6457987	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt050	50H	403816	6457939	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		

Waypoint Number	Zone	mE	mN	Tree Species	DBH (mm)	Tree Height (m)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Lot Number	Comments
wpt051	50H	403812	6457900	Flooded Gum	>500	20+	0							No Signs	No Signs	No		
wpt052	50H	403818	6457890	Flooded Gum	>500	20+	0							No Signs	No Signs	No		
wpt053	50H	403821	6457881	Flooded Gum	>500	20+	0							No Signs	No Signs	No		
wpt054	50H	403839	6457888	Flooded Gum	>500	15-20	0							No Signs	No Signs	No		
wpt055	50H	403950	6458016	Tuart (Planted)	>500	15-20	0							No Signs	No Signs	No		
360 - 1	50H	403456	6457684	Marri	1082.3											No	5	
360 - 2	50H	403478	6457688	Marri	834.0											No	5	
360 - 3	50H	403476	6457698	Marri	827.6											No	5	
360 - 4	50H	403476	6457699	Marri	671.6											No	5	
360 - 5	50H	403457	6457743	Marri	980.4		2	Spout Branch	5-12	Branch	5-12			Galahs		No	5	
360 - 6	50H	404127	6457853	Flooded Gum	954.9											No	67	
360 - 7	50H	403743	6457246	Marri	773.5											No	74	
360 - 8	50H	403721	6457263	Marri	709.8											No	74	
360 - 9	50H	403734	6457263	Marri	993.1											No	74	
360 - 10	50H	403735	6457265	Marri	544.3											No	74	
360 - 11	50H	403695	6457299	Marri	662.1											No	74	
360 - 12	50H	403670	6457301	Marri	588.9											No	74	
360 - 13	50H	403687	6457307	Marri	573.0											No	74	
360 - 14	50H	403683	6457322	Marri	668.5											No	74	
360 - 15	50H	403754	6457330	Marri	560.2											No	74	
360 - 16	50H	403754	6457331	Marri	681.2											No	74	
360 - 17	50H	403733	6457336	Marri	560.2											No	74	
360 - 18	50H	403680	6457364	Marri	604.8											No	74	
360 - 19	50H	403685	6457372	Marri	662.1											No	75	
360 - 20	50H	403684	6457382	Marri	652.5											No	75	
360 - 21	50H	403642	6457387	Marri	888.1											No	75	
360 - 22	50H	403676	6457391	Marri	748.0											No	75	
360 - 23	50H	403673	6457401	Marri	830.8											No	75	
360 - 24	50H	403622	6457404	Marri	869.0											No	75	
360 - 25	50H	403627	6457406	Marri	751.2											No	75	
360 - 26	50H	403641	6457409	Marri	1324.2											No	75	
360 - 27	50H	403702	6457409	Marri	557.0											No	75	
360 - 28	50H	403618	6457411	Marri	1031.3											No	75	
360 - 29	50H	403698	6457411	Marri	636.6											No	75	
360 - 30	50H	403624	6457420	Marri	>500											No	75	
360 - 31	50H	403674	6457430	Marri	687.6											No	75	
360 - 32	50H	403682	6457434	Marri	706.7											No	75	
360 - 33	50H	403641	6457438	Marri	706.7											No	75	
360 - 34	50H	403690	6457438	Marri	668.5											No	75	
360 - 35	50H	403650	6457442	Marri	690.7											No	75	
360 - 36	50H	403610	6457443	Marri	700.3											No	75	
360 - 37	50H	403661	6457445	Marri	509.3											No	75	
360 - 38	50H	403651	6457448	Marri	662.1											No	75	
360 - 39	50H	403683	6457449	Marri	611.2											No	75	
360 - 40	50H	403690	6457230	Marri	773.5											No	76	
360 - 41	50H	403562	6457262	Marri	945.4											No	76	
360 - 42	50H	403584	6457269	Marri	942.2											No	76	
360 - 43	50H	403578	6457271	Marri	636.6											No	76	
360 - 44	50H	403584	6457271	Marri	553.9											No	76	
360 - 45	50H	403587	6457272	Marri	592.1											No	76	
360 - 46	50H	403579	6457273	Marri	531.6											No	76	

Waypoint Number	Zone	mE	mN	Tree Species	DBH (mm)	Tree Height (m)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Lot Number	Comments
360 - 47	50H	403580	6457281	Marri	700.3											No	76	
360 - 48	50H	403450	6458267	Marri	557.0											No	200	
360 - 49	50H	403474	6458275	Marri	846.7											No	200	
360 - 50	50H	403497	6458278	Marri	583.1											No	200	
360 - 51	50H	403500	6458300	Marri	573.0											No	200	
360 - 52	50H	403520	6458375	Marri	604.8											No	200	
360 - 53	50H	403485	6458376	Marri	595.2											No	200	
360 - 54	50H	403487	6458376	Marri	598.4											No	200	
360 - 55	50H	403492	6458376	Marri	1317.8											No	200	
360 - 56	50H	403498	6458378	Marri	1333.7											No	200	
360 - 57	50H	403486	6458074	Marri	636.6											No	301	
360 - 58	50H	403463	6458084	Marri	531.6											No	301	
360 - 59	50H	403468	6458086	Marri	662.1											No	301	
360 - 60	50H	403494	6458089	Marri	728.9											No	301	
360 - 61	50H	403463	6458097	Marri	598.4											No	301	
360 - 62	50H	403448	6458117	Marri	859.4											No	301	
360 - 63	50H	403464	6458117	Marri	576.1											No	301	
360 - 64	50H	403456	6458125	Marri	639.8											No	301	
360 - 65	50H	403454	6458133	Marri	>500											No	301	
360 - 66	50H	403470	6458152	Marri	>500											No	301	
360 - 67	50H	403459	6458155	Marri	>500											No	301	
360 - 68	50H	403444	6458157	Marri	>500											No	301	
360 - 69	50H	403547	6458180	Marri	703.5											No	301	
360 - 70	50H	403542	6458185	Marri	779.9											No	301	
360 - 71	50H	403542	6458193	Marri	999.5											No	301	
360 - 72	50H	403566	6458205	Marri	846.7											No	301	
360 - 73	50H	403555	6458212	Marri	757.6											No	301	
360 - 74	50H	403629	6458219	Marri	604.8											No	301	
360 - 75	50H	403567	6458231	Marri	757.6											No	301	
360 - 76	50H	403599	6458257	Marri	754.4											No	301	
360 - 77	50H	403595	6458261	Marri	954.9											No	301	
360 - 78	50H	403461	6458156	Marri	732.1											No	302	
360 - 79	50H	403470	6458158	Marri	1464.2											No	302	
360 - 80	50H	403445	6458163	Marri	738.5											No	302	
360 - 81	50H	403445	6458168	Marri	751.2											No	302	
360 - 82	50H	403436	6458185	Marri	608.0											No	302	
360 - 83	50H	403440	6458185	Marri	783.0											No	302	
360 - 84	50H	403486	6458228	Marri	875.4											No	302	
360 - 85	50H	403502	6458228	Marri	1050.4											No	302	
360 - 86	50H	403484	6458229	Marri	643.0											No	302	
360 - 87	50H	403503	6458253	Marri	525.2											No	302	
360 - 88	50H	403504	6458254	Marri	684.4											No	302	
360 - 89	50H	403499	6458257	Marri	719.4											No	302	
360 - 90	50H	403509	6458264	Marri	748.0											No	302	
360 - 91	50H	403509	6458267	Marri	916.7											No	302	
360 - 92	50H	403514	6458271	Marri	795.8											No	302	
360 - 93	50H	403567	6458276	Marri	792.6											No	302	
360 - 94	50H	403549	6458295	Marri	592.1											No	302	
360 - 95	50H	403546	6458303	Marri	604.8											No	302	
360 - 96	50H	403558	6458303	Marri	875.4											No	302	
360 - 97	50H	403546	6458312	Marri	783.0											No	302	

Waypoint Number	Zone	mE	mN	Tree Species	DBH (mm)	Tree Height (m)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Lot Number	Comments
360 - 98	50H	403523	6458098	Marri	668.5											No	500	
360 - 99	50H	403530	6458098	Marri	550.7											No	500	
360 - 100	50H	403527	6457366	Marri	550.7											No	Road	
360 - 101	50H	403526	6457383	Marri	862.6											No	Road	
360 - 102	50H	403521	6457416	Marri	713.0											No	Road	
360 - 103	50H	403521	6457416	Marri	722.6											No	Road	
360 - 104	50H	403449	6457969	Marri	1142.7											No	Road	
360 - 105	50H	403421	6457991	Marri	>500											No	Road	
360 - 106	50H	403433	6458064	Marri	>500											No	Road	
360 - 107	50H	403433	6458064	Marri	>500											No	Road	
360 - 108	50H	403432	6458072	Marri	>500											No	Road	
360 - 109	50H	403432	6458073	Marri	>500											No	Road	
360 - 110	50H	403433	6458084	Marri	>500											No	Road	
360 - 111	50H	403430	6458087	Marri	>500											No	Road	
360 - 112	50H	403427	6458110	Marri	770.3											No	Road	
360 - 113	50H	403435	6458166	Marri	913.6											No	Road	
360 - 114	50H	403436	6458167	Marri	811.7											No	Road	
360 - 115	50H	403435	6458186	Marri	576.1											No	Road	
360 - 116	50H	403432	6458196	Marri	604.8											No	Road	
360 - 117	50H	403405	6458203	Marri	>500											No	Road	
360 - 118	50H	403431	6458204	Marri	722.6											No	Road	
360 - 119	50H	403429	6458221	Marri	608.0											No	Road	
360 - 120	50H	403397	6458247	Marri	>500											No	Road	
360 - 121	50H	403425	6458256	Marri	658.9											No	Road	
360 - 122	50H	403425	6458256	Marri	700.3											No	Road	
360 - 123	50H	403420	6458287	Marri	891.3											No	Road	
360 - 124	50H	403418	6458292	Marri	681.2											No	Road	

APPENDIX E

SIGNIFICANT SPECIES PROFILES

Unnamed Cricket *Kawaniphila pachomai*

Status and Distribution: Listed as Priority 1 by DPaW. Full distribution is not known. The NatureMap database lists only two records, one near Witchcliffe and one north of Armadale near Perth (DPaW 2015b).

Habitat: The species apparently occurs in moist, shaded uncleared forests and gullies in the south-west, mostly the Tingle forests along the South Coast (DPaW 2015b).

Likely presence in subject site: It is very unlikely that this species of cricket utilises the subject site due to its overall degraded nature and lack of favoured habitat.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Unnamed Bee *Leioproctus bilobatus*

Status and Distribution: Listed as Priority 2 by DPaW. This species of native bee has been collected only from the Stirling Ranges and from Kenwick (DPaW 2015b).

Habitat: Life history and habits are unknown. It has been recorded only on the flowers of *Gompholobium aristatum* on which it may be dependent. Possible threats include clearing for housing and altered fire regimes (DPaW 2015b).

Likely presence in subject site: It is very unlikely that this species of bee utilises the subject site due to its overall degraded nature and lack of favoured plant species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Unnamed Bee *Leioproctus douglasiellus*

Status and Distribution: Listed as Scheduled 2 under the *WC Act*. It is known only from specimens collected at Pearce and Forrestdale Lake.

Habitat: This species of native bee appears to be dependent on the flowers of *Goodenia filiformis*.

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded and do not contain the necessary plant species for a population of this species to persist. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Short-tongued Bee *Neopasiphae simplicior*

Status and Distribution: Listed as Scheduled 2 under the *WC Act* and as Critically Endangered under the *EPBC Act*. It is currently only known from bushland adjacent to Forrestdale Lake and Armadale Golf Course, although the holotype was collected from Cannington in 1954 (DPaW 2015b).

Habitat: This species of native bee has been collected on flowers of *Goodenia filiformis*, *Lobelia tenulor*, *Angianthus preissianus* and *Velleia* sp.

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded and do not contain the necessary plant species for a population of this species to persist. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Carter's Freshwater Mussel *Westralunio carteri*

Status and Distribution: Listed as Schedule 3 under the *WC Act* and as Vulnerable (A2c+4c) by the ICUN. Carter's freshwater mussel is the only freshwater mussel species endemic to south-western WA, ranging from the Moore River south to the Frankland River (Morgan *et al.* 2011).

Habitat: Occurs in greatest abundance in slower flowing streams with stable sediments that are soft enough for burrowing amongst woody debris and exposed tree roots. Salinity tolerance quite low (Morgan *et al*. 2011).

Likely presence in subject site: Yule Brook is too degraded to support individuals of this species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Perth Lined Lerista *Lerista lineata*

Status and Distribution: Listed as Priority 3 by DPaW. Found in the lower west coast from Perth south to Leschenault Peninsula/Kemerton. It has also been found at Rottnest Island and Garden Island (Storr *et al.* 1999) and in some suburban areas of Perth (Bush *et al.* 2002).

Habitat: This small species of skink inhabits white sands (Storr *et al*. 1999) under areas of shrubs and heath where it inhabits loose soil and leaf litter (Nevill 2005) particularly in association with banksias (Bush *et al.* 2002).

Likely presence in subject site: The subject site is outside of this species current documented range and habitat appears too degraded. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat is considered likely.

Darling Range Heath Ctenotus *Ctenotus delli*

Status and Distribution: Listed as Priority 4 by DPaW. Main distribution is in the Darling Range from the Darlington/Mundaring area to near Collie (Storr *et al.* 1999).

Habitat: Humid zone, mainly laterite and clays (Storr *et al.* 1999) supporting jarrah/marri woodland with a shrub dominated understorey, sheltering in dense vegetation, inside grass trees and beneath rocks, sometimes in burrows (Nevill 2005). Occasionally found on granite outcrops (Bush *et al*. 2010).

Likely presence in subject site: The subject site is outside of this species current documented range and it contains no suitable habitat for this species to utilise. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Coastal Plains Skink *Ctenotus ora*

Status and Distribution: Listed as Priority 3 by DPaW. *Ctenotus ora* is a recently described species of medium sized skink with a restricted range in the south-west of Western Australia, most of which has been cleared for agriculture and urban development. It cannot reliably be distinguished from the more widespread *C. labillardieri* except by DNA sequences, but the two species appear to have disjunct distributions. Based on only five specimens reliably identified as *Ctenotus ora*, the species is apparently restricted to the southern Swan Coastal Plain and Cape Naturaliste area, as far north as Pinjarra and south as far as Yallingup (Kay & Keogh 2012).

Habitat: Sandy substrates with low vegetation (including heath) in open *Eucalyptus/Corymbia* woodland over *Banksia* (Kay & Keogh 2012). Individuals have been found sheltering under *Banksia* logs on white sand, and trapped in eucalypt woodland with *Banksia* or peppermint mid-storey, or heath (Bamford *et al.* 2010). Open eucalypt woodland over *Banksia* and low vegetation on sandy coastal plain and coastal dunes (Wilson and Swan 2013).

Likely presence in subject site: The subject site is outside of this species current documented range and habitat appears too degraded. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Black-striped Snake *Neelaps calonotos*

Status and Distribution: Listed as Priority 3 by DPaW. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al*. 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded fragmented and are unlikely to support a population/individuals of this species. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Southern Death Adder *Acanthophis antarcticus*

Status and Distribution: The Southern Death Adder is classified as Priority 3 by DPaW. Now locally confined to the Darling Range between Mt Helena and Jarrahdale (Bush *et al*. 2002).

Habitat: In the Darling Range this species is typically found within Jarrah woodlands adjacent to granite outcrops and along densely vegetated creeks (Bush *et al.* 1995).

Likely presence in subject site: The subject site is outside of this species current documented range and it contains no suitable habitat for this species to utilise. Not listed as a potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Malleefowl *Leipoa ocellata*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as Vulnerable under the *EPBC Act (1999)*. Originally common, but now generally rare to uncommon and patchily distributed.

Current distribution mainly southern arid and semi-arid zones, north to Shark Bay, Jingemarra, Colga Downs and Yeelirrie, east to Earnest Giles Range, Yeo Lake, lower Ponton Creek and to Eucla and west and south to Cockleshell Gully, the Wongan Hills, Stirling Range, Beaufort Inlet, Hatters Hill, Mt Ragged and Point Malcolm (Johnstone and Storr 1998).

Habitat: Mainly scrubs and thickets of mallee *Eucalyptus* spp., boree *Melaleuca lanceolata* and bowgada *Acacia linophylla*, also dense litter forming shrublands.

Likely presence in subject site: This species is regionally extinct and would never, under normal circumstances occur anywhere on the Swan Coastal Plain. Not listed as a potential species.

Potential impact of development: No impact on this species will occur as it is unlikely to be present.

Australasian Bittern *Botaurus poiciloptilus*

Status and Distribution: Classified as Schedule 2 under the *WC Act* and as Endangered under the *EPBC Act*. The species is uncommon to rare (Morcombe 2004), but locally common in wetter parts of south west (Johnstone and Storr 1998). Occurs north to Moora and east to Mt Arid (Johnstone and Storr 1998).

Habitat: Freshwater wetlands, occasionally estuarine; prefers heavy vegetation (Morcombe 2004) such as beds of tall dense *Typha*, *Baumea* and sedges in freshwater swamps (Johnstone and Storr 1998).

Likely presence in subject site: Yule Brook appears too degraded to support individuals of this species and the subject site contains no other suitable wetland habitat.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Little Bittern *Ixobrychus minutus*

Status and Distribution: Listed as Priority 4 by DPaW. Occurs north to Moora and east to Two Peoples Bay; accidental or on migration further north and east and on Rottnest Island and central district (Condingup district) (Johnstone and Storr 1998).

Habitat: Dense vegetation surrounding/within freshwater pools, swamps and lagoons, well screened with trees. Shelters in dense beds of *Typha*, *Baumea* and tall rushes in freshwater swamps around lakes and along rivers (Johnstone and Storr 1998).

Likely presence in subject site: Yule Brook appears too degraded to support individuals of this species and the subject site contains no other suitable wetland habitat.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Great Egret *Ardea alba*

Status and Distribution: This species of egret is listed as Schedule 5 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Great Egret is common and very widespread in any suitable permanent or temporary habitat (Morcombe 2004).

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe 2004).

Likely presence in subject site: This species may occasionally utilise Yule Brook and flooded/waterlogged paddocks in the subject site but these appear to represent marginal habitat at best. It would not breed onsite.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Cattle Egret *Ardea ibis*

Status and Distribution: This species of egret is listed as Schedule 5 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Cattle Egret is common in the north sections of its range but is an irregular visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe 2004).

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe 2004).

Likely presence in subject site: Very marginal habitat. It may occur very occasionally in paddock areas with livestock. It would not breed onsite.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Glossy Ibis *Plegadis falcinellus*

Status and Distribution: This species is listed as Schedule 5 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Glossy Ibis frequents swamps and lakes throughout much of the Australian mainland, but is most numerous in the north. It is a non-breeding visitor to Tasmania and the south-west of Western Australia. The Glossy Ibis is both migratory and nomadic. Its range expands inland after good rains, but its main breeding areas seem to be in the Murray-Darling Basin of New South Wales and Victoria, the Macquarie Marshes in New South Wales, and in southern Queensland. Glossy Ibis often move north in autumn, then return south to their main breeding areas in spring and summer (Pizzey & Knight 2012).

Habitat: Well vegetated wetlands, wet pastures, rice fields, floodwaters, floodplains, brackish or occasionally saline wetlands, mangroves, mudflats, occasionally dry grasslands (Pizzey & Knight 2012).

Likely presence in subject site: No suitable habitat. Not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Painted Snipe *Rostratula benghalensis*

Status and Distribution: This species is listed as Schedule 2 under the *WC Act* and as Endangered and Migratory under the *EPBC Act*. Sparsely distributed in better watered regions: Kimberley, North West and South Western divisions. Also eastern Australia and Tasmanian (Johnstone and Storr 1998).

Habitat: Well vegetated shallows and margins of wetlands, dams, sewerage ponds, wet pastures, marshy areas, irrigation systems, lignum, tea tree scrub, open timber. Requires dense low cover (Morcombe 2004).

Likely presence in subject site: No suitable habitat. Not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Other Migratory Shorebirds/Wetland Species

A number of migratory shorebirds/wetland species are listed as potentially occurring in the general area. Specific species are not discussed.

Status and Distribution: Migratory shorebirds are listed under the Schedule 5 of the WC Act, the *EPBC Act 1999* and under international agreements to which Australia is a signatory. All species are either widespread summer migrants to Australia or residents. State and Federal conservation status varies between species.

Habitat: Varies between species but includes beaches and permanent/temporary wetlands varying from billabongs, swamps, lakes, floodplains, sewerage farms, saltwork ponds, estuaries, lagoons, mudflats sandbars, pastures, airfields, sports fields and lawns.

Likely presence in subject site: No suitable habitat. None listed as a potential species.

Potential impact of development: No significant impact on these species or their preferred habitat will occur.

Blue-billed Duck *Oxyura australis*

Status and Distribution: Recently listed as Priority 4 by DPaW (DPaW 2015b). Rare to moderately common (most plentiful on the Swan Coastal Plain and in the Great Southern). South-western: north to Lake Pinjarrega and east to Esperance; vagrant further north and east (as far as Thundelarra and Kalgoorlie). Also south-eastern Australian and Tasmania (Johnstone and Storr 1998).

Habitat: Well vegetated freshwater swamps, large dams and lakes, winters on more open water (Morcombe 2004). Occasionally salt lakes and estuaries freshened by floodwaters (Johnstone and Storr 1998).

Likely presence in subject site: No suitable habitat. Not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

White-bellied Sea Eagle *Haliaeetus leucogaster*

Status and Distribution: This species is listed as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. White-bellied sea eagles are moderately common to common on Kimberley and Pilbara islands, coasts and estuaries, on Bernier, Dorre and Dirk Hartog Is., in Houtman Abrolhos and in the Archipelago of the Recherche; rare to uncommon elsewhere (Johnstone and Storr 1998). Also found in New Guinea, Indonesia, China, southeast Asia and India. Scarce near major coastal cities (Morcombe 2003).

Habitat: They nest and forage usually near the coast over islands, reefs, headlands, beaches, bays, estuaries, mangroves, but will also live near seasonally flooded inland swamps, lagoons and floodplains, often far inland on large pools of major rivers. Established pairs usually sedentary, immatures dispersive (Morcombe 2003). White-bellied Sea-Eagles build a large stick nest, which is used for many seasons in succession.

Likely presence in subject site: No suitable habitat. Not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Osprey *Pandion haliaetus*

Status and Distribution: This species is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. Moderately common to very common in sheltered seas around the north and west coast islands south to 31°S; uncommon to common on mainland coasts, estuaries and large rivers north of tropic, rare to uncommon elsewhere (Johnstone and Storr 1998).

Habitat: Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers (Pizzey & Knight 2012). Construct nests on prominent headland, large trees, communication towers (Simpson & Day 2010).

Likely presence in subject site: No suitable habitat. Not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Peregrine Falcon *Falco perigrinus*

Status and Distribution: This species is listed as Schedule 7 under the *WC Act*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2004). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in subject site: This species potentially utilises some sections of the subject site as part of a much larger home range. No evidence of nesting was observed and the probability of this species breeding within the subject site can be considered to be very low.

Potential impact of development: Loss or modification of some habitat. However, no significant impact on this species is considered likely.

Masked Owl *Tyto novaehollandae novaehollandae*

Status and Distribution: Listed as Priority 3 by DPaW. Found north to Yanchep and east to Yealering, Gnowangerup and Albany, casual further north. Locally common in south west but generally uncommon (Johnstone and Storr 1998).

Habitat: Roosts and nests in heavy forest, hunts over open woodlands and farmlands (Morcombe, 2003). Probably breeding in forested deep south west with some autumn–winter wanderings northwards (Johnstone and Storr 1998).

Likely presence in subject site: Status on-site and in the general area is difficult to determine. May occasionally be present but not listed as a potential species as the frequency of occurrence would be very low and only for limited periods.

Potential impact of development: No impact on this species will occur.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The Fork-tailed Swift is listed as Schedule 5 under the *WC Act* an as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. This species breeds in Siberia and the Himalayas and migrates to Australia in October, returning to the breeding grounds by May or June (Morcombe 2003).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2004).

Likely presence in subject site: It is potentially an occasional summer visitor to the subject site but is entirely aerial and largely independent of terrestrial habitats. Not listed as a potential species as frequency of occurrence would be very low and then only for very brief periods of time.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Rainbow Bee-eater *Merops ornatus*

Status and Distribution: This species is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe 2003).

Habitat: Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe 2003). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.

Likely presence in subject site: A single individual was observed foraging in paddock areas during the field survey. This species is a common seasonal visitor to south west. It possibly breeds in some sections of the subject site where ground conditions permit (e.g. sandy areas) though population levels would not be significant as it usually breeds in pairs, rarely in small colonies (Johnstone and Storr 1998).

Potential impact of development: No significant impact on this species is anticipated as individuals' present onsite at any one time would not under any circumstances represent a substantial proportion of the population. It can be expected to continue to utilise the area, as it does now, despite any future development.

Grey Wagtail *Motacilla cinerea*

Status and Distribution: The grey wagtail is listed as Schedule 3 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. A rarely recorded, accidental vagrant that has on a few occasions been recorded on widely separated parts of the Australian coastline (Pizzey & Knight 2012).

Habitat: In Australia, near running water in disused quarries, sandy, rocky streams in escarpments and rainforest, sewerage ponds, ploughed fields and airfields (Pizzey & Knight 2012).

Likely presence in subject site: Cleared paddock areas may represent suitable habitat for this species but as it is an "accidental vagrant" the likelihood of occurrence is extremely low. Not listed as potential species as it would only occur very rarely, if ever and then only for brief periods.

Potential impact of development: No impact on this species will occur.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Found in the humid and subhumid south west, mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Habitat: Eucalypt forests, feeds on Marri, Jarrah, Blackbutt, Karri, Sheoak and Snottygobble. The forest red-tailed black cockatoo nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the Forest Red-tailed Black Cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter and the depth is one to five metres (Johnstone and Storr 1998).

Breeding commences in winter/spring. There are few records of breeding in the forest red-tailed black cockatoo (Johnstone and Storr 1998), but eggs are laid in October and

November (Johnstone 1997; Johnstone and Storr 1998). Recent data however indicates that breeding in all months of the year occurs with peaks in spring and autumn–winter (Ron Johnstone pers comms). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in subject site: Some foraging evidence attributed to this species found during field survey (chewed marri fruits). Most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Potential impact of development: Potential for the loss of areas of foraging habitat and potential “breeding habitat” trees (i.e. DBH >50cm).

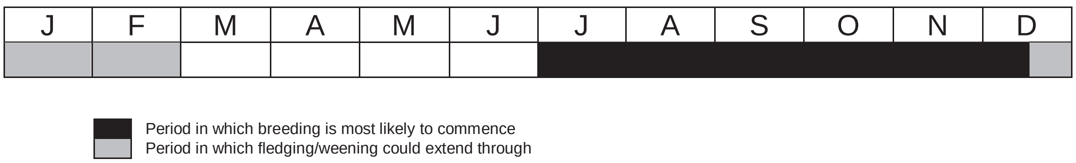
Carnaby’s Black- Cockatoo *Calyptorhynchus latirostris*

Status and Distribution: Carnaby’s Black Cockatoo is listed as Scheduled 2 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on Banksia, Hakeas and Marri. Carnaby’s Cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5 to 12m above the ground, an entrance from 23-30cm diameter and a depth of 0.1-2.5m (Johnstone and Storr, 1998).

Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe, 2003). Judging from breeding records in the Storr – Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forests of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including Yanchep, Lake Clifton and near Bunbury and possibly also in the Lancelin region. Carnaby’s Black Cockatoo have also been known to breed close to the town of Mandurah, as well as at Dawesville, Lake Clifton and Baldivis (pers. comm., Ron Johnstone, WA Museum) and there are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Carnaby's Black-Cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Most of the breeding is in September through to December (Ron Johnstone pers comms). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).



Likely presence in subject site: Some foraging evidence attributed to this species found during field survey (chewed marri fruits and pine cones). Most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

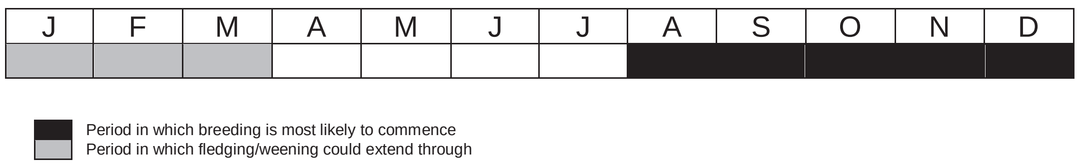
Potential impact of development: Potential for the loss of areas of foraging habitat and potential "breeding habitat" trees (i.e. DBH >50cm).

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning, Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998). On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2004), *Banksia, Hakeas* and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998). This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974).

Baudin's Black-Cockatoo breeds in late winter and spring, from August to November or December (Gould 1972; Johnstone 1997; Saunders 1974; Saunders *et al*. 1985). Eggs laid in October (Johnstone and Storr 1998). Based on observations at currently known nest sites breeding mainly occurs within the October-December period (Ron Johnstone pers comms). Incubation is 28 – 30 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).



Likely presence in subject site: No evidence of this species utilising the site observed though most of the remnant native vegetation present (i.e. marri trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (>50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Potential impact of development: Potential for the loss of areas of foraging habitat and potential “breeding habitat” trees (i.e. DBH >50cm).

Chuditch *Dasyurus geoffroii*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act.* Formerly occurred over nearly 70 per cent of Australia. The Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest Western Australia. Also occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

Habitat: Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road sides in the wheatbelt (CALM 1994). The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3-4 km^2 (Sorena and Soderquist 1995).

Likely presence in subject site: This species requires relatively large continuous areas of vegetation to persist and as a consequence it is rarely recorded on any section of the coastal plain given the extent of clearing and fragmentation that has occurred. Occasional records in the Perth area are transient individuals that have originated from the Darling Range where it is known to persist. Not listed as potential species.

Potential impact of development: No impact on this species or its preferred habitat is anticipated.

Southern Brush-tailed Phascogale *Phascogale tapoatafa tapoatafa*

Status and Distribution: Listed as Scheduled 3 under the *WC Act (1950)*. Present distribution is believed to have been reduced to approximately 50 per cent of its former range. Now known from Perth and south to Albany, west of Albany Highway. Occurs at low densities in the northern Jarrah forest. Highest densities occur in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton (DEC information pamphlet). Records are less common from wetter forests.

Habitat: This subspecies has been observed in dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover. A nocturnal carnivore relying on tree hollows as nest sites. The home range for a female Brush-tailed Phascogale is estimated at between 20 and 70 ha, whilst that for males is given as twice that of females. In addition, they tend to utilise a large number (approximately 20) of different nest sites throughout their range (Soderquist, 1995).

Likely presence in subject site: Current status in the wider area uncertain but fragmented nature of the vegetation remnants and limited number of hollow trees would suggest it is unlikely to occur. Not listed as potential species

Potential impact of development: No impact on this species or its preferred habitat is anticipated.

Numbat *Myrmecobius fasciatus*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Once occurred across much of arid and semi arid southern Australia, now restricted to a few remnant forests of Wandoo, Powderbark Wandoo or jarrah in South west WA (Menkhorst & Knight 2011). Rare, scattered. Found only at Dryandra, Perup and six other translocation sites (van Dyck & Strahan 2008).

Habitat: Generally dominated by eucalypts that provide hollow logs and branches for shelter and termites for food (van Dyck & Strahan 2008).

Likely presence in subject site: This species is locally extinct. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated.

Southern Brown Bandicoot *Isoodon obesulus fusciventer*

Status and Distribution: Listed as Priority 4 by DPaW. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (DPaW information pamphlet) and Nambung National Park (DPaW pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DPaW information pamphlet).

Likely presence in subject site: Evidence of the southern brown bandicoot (a dead individual and some diggings) was observed at some locations in the subject site where ground vegetation was relatively dense (i.e. Yule Brook and some paddocks with dense grasses). Most of the subject site is however unsuitable for this species to persist.

Potential impact of development: Potential for the loss of small areas of marginal natural habitat.

Western Ringtail Possum *Pseudocheirus occidentalis*

Status and Distribution: Listed as Scheduled 2 under the *WC Act* and as Vulnerable under the *EPBC Act.* Common in suitable habitat (de Tores 2008). The highest densities of this species are recorded in Peppermint habitat near Busselton area; relatively high densities are found in Jarrah/Marri forest at Perup (de Tores 2008).

The Western Ringtail Possum has a restricted distribution in south-western Western Australia. Most known populations (natural and translocated) are now restricted to near coastal areas of the south west from the Dawesville area to the Waychinicup National Park. Inland, it is also known to be relatively common in a small part of the lower Collie River valley, the Perup Nature Reserve and surrounding forest blocks near Manjimup.

Habitat: The Western Ringtail Possum was once located in a variety of habitats including Coastal Peppermint, Coastal Peppermint-Tuart, Jarrah-Marri associations, Sheoak woodland, and eucalypt woodland and mallee. Coastal populations mostly inhabit Peppermint-Tuart associations with highest densities in habitats with dense, relatively lush vegetation. Inland, the largest known populations occur in the Upper Warren area east of Manjimup (Wayne *et al* 2005). In this area the peppermint tree is naturally absent and jarrah-marri associations constitute the species refuge and foraging habitat. In areas where Peppermint is absent or rare WRPs have been observed feeding predominately on young Jarrah, *Nuytsia floribunda* and *Allocasuarina fraseriana* (G Harewood pers. obs.*).*

Likely presence in subject site: This species is locally extinct. Not listed as potential species.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Woylie *Bettongia penicillata ogibyi*

Status and Distribution: Listed as Schedule 1 under the *WC Act* and as Endangered under the *EPBC Act*. Restricted to remnant habitat patches in south west WA where populations are managed by way of fox control and reintroduction programs (e.g. Avon Valley, Walyunga National Park and Paruna Sanctuary).

Habitat: Open forest and woodland with a low, dense, understorey of tussock grasses or woody scrub. Formerly occurred in a wider range of habitats including spinifex hummock grasslands.

Likely presence in subject site: No suitable habitat and locally extinct on coastal plain. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated.

Western Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by DPaW. The Western Brush Wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid (DPaW information pamphlet).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (DPaW information pamphlet).

Likely presence in subject site: Bushland within and surrounding the subject site is too small and/or fragmented to support a population of this species. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated as it is unlikely to be present.

Water Rat *Hydromys chrysogaster*

Status and Distribution: Listed as Priority 4 by DPaW. The water rat is widely distributed around Australia and its offshore islands, New Guinea and some adjacent islands. It occurs in fresh brackish water habitats in the south-west of Western Australia, but occurs in marine environments along the Pilbara coastline and offshore islands. Previous survey work in the south west suggested this species was relatively common and widespread though difficult to capture (Christensen *et al.* 1985, How *et al.* 1987).

Habitat: The water rat occupies habitat in the vicinity of permanent water, fresh, brackish or marine. Likely to occur in all major rivers and most of the larger streams as well as bodies of permanent water in the lower south west (Christensen *et al.* 1985).

Likely presence in subject site: While the Yule Brook passes through the subject site it appears to be too degraded to support individuals of this species. There is also a lack of recent, local records. Based on this information this species is therefore considered unlikely to occur.

Potential impact of development: No impact on this species or its preferred habitat will occur.

DISCLAIMER

This fauna assessment report (“the report”) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood (“the Author”). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

In preparing the report, the Author has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report (“the data”). Except as otherwise stated in the report, the Author has not verified the accuracy of completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (“conclusions”) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. The Author will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to the Author.

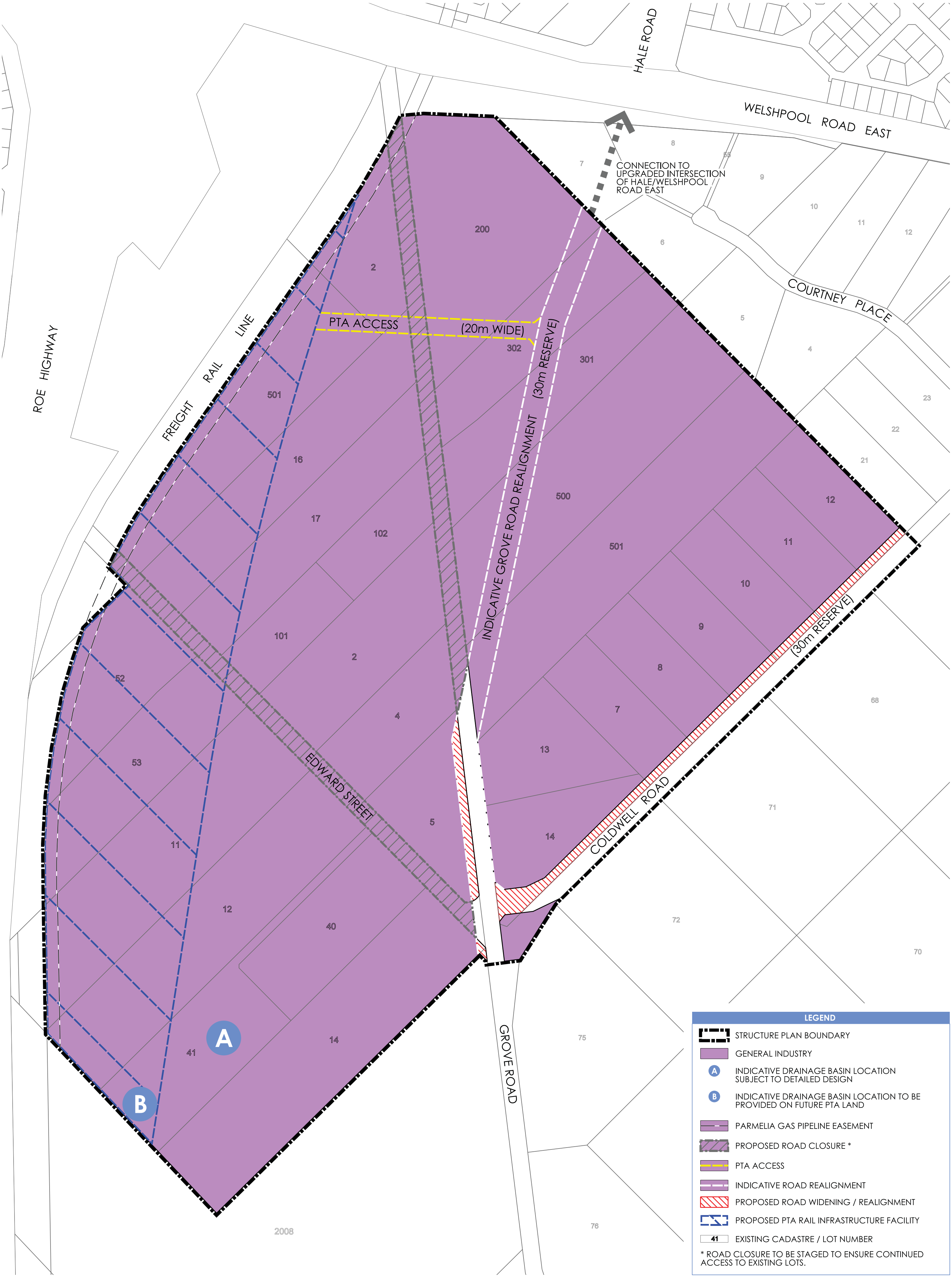
The report has been prepared for the benefit of the Client and no other party. The Author assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of the Author or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

The Author will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

APPENDIX D

emerge ASSOCIATES
Integrated Science & Design

PRECINCT 3A STRUCTURE PLAN (TBB 2016)



PLAN 1 | STRUCTURE PLAN

Maddington - Kenwick Strategic Employment Area - Precinct 3A

A LINC PROPERTY PROJECT

s: 1:2,000@A1
d: 3 May 2016
p: 15/073/024K

Taylor Burrell Barnett Town Planning and Design
187 Roberts Road Subiaco Western Australia 6008
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APPENDIX 2
BUSHFIRE MANAGEMENT PLAN

BUSHFIRE MANAGEMENT PLAN

MKSEA PRECINCT 3A STRUCTURE PLAN

Project Number EP14-056(07)

Prepared for Linc Property Pty Ltd
September 2016

Document Control

DOC NAME	BUSHFIRE MANAGEMENT PLAN MKSEA PRECINCT 3A STRUCTURE PLAN				
DOC NO.	EP14-056(07)—011G				
REVISION	DATE	AUTHOR		REVIEWER	
1	December 2015	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Draft report for submission to client/project team				
1A	March 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised to align with updated Structure Plan.				
1B	April 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised to align with updated Structure Plan.				
1C	May 2016	Andreas Biddiscombe	ADB	Jason Hick	JDH
	Revised to align with updated Structure Plan.				
2	July 2016	Andreas Biddiscombe Chrystal King	ADB CKK	Jason Hick	JDH
	Report restructured.				
2A	July 2016	Chrystal King	ADB CKK	Jason Hick	JDH
	Amendment to Figure				
3	September 2016	Carli Turner Chrystal King	CJT CKK	Jason Hick	JDH
	Revised based on DFES comments.				
3A	September 2016	Chrystal King	CKK	Jason Hick	JDH
	Amendment to Figure				

Executive Summary

This Bushfire Management Plan (BMP) has been prepared on behalf of Linc Property Pty Ltd to support the preparation of a Structure Plan for Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA). Precinct 3A of the MKSEA (herein referred to as 'the site') is located within the City of Gosnells (CoG) approximately 12 km south-east of the Perth Central Business District and incorporates 29 land parcels.

The site is currently zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and CoG Town Planning Scheme (TPS) No. 6 respectively. An amendment to the MRS (no. 1302/57) is currently being progressed by the Western Australian Planning Commission (WAPC) to rezone the site to 'Industrial'. This amendment has been supported by a Bushfire Management Plan prepared by Essential Environmental (2016).

The site is identified as bushfire prone in the state-wide *Map of Bush Fire Prone Areas* (Office of Bushfire Risk Management (OBRM) 2016). The identification of bushfire prone areas within any portion of a landholding requires further assessment of the bushfire hazard implications on any proposed development, in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC *et al*. 2015).

The aim of the BMP is to assess bushfire hazard levels within and in the vicinity of the site (within 100 m) and to ensure the threat posed by the identified bushfire hazards can be mitigated to acceptable levels, appropriate with industrial development as defined in the *Guidelines for Planning in Bushfire Prone Areas* (WAPC *et al.* 2015). In doing so, this BMP aims to minimise the potential impact of bushfires on industrial development within the site, and reduce the threat to life, property and the environment.

A bushfire hazard assessment was undertaken to inform this BMP, which identified portions of the site as containing classified Grassland and Woodland vegetation representing 'Moderate' and 'Extreme' bushfire hazards respectively. Importantly most vegetation within the site, in addition to adjacent areas incorporating other MKSEA precincts, will be removed to facilitate industrial development. In the post-development scenario, classified vegetation within 100 m of the site includes Scrub vegetation located within the adjacent Roe Highway road reserve and the Woodlupine Brook Reserve which poses a permanent 'Extreme' bushfire hazard, as well as unmanaged Grassland within the Welshpool Road reserve and the rail reserve which poses a permanent 'Moderate' bushfire hazard.

Classified Grassland and Woodland vegetation within rural land holdings to the north-east, south-east and south-west within the broader MKSEA, pose only a temporary 'Moderate' and 'Extreme' bushfire hazard as these landholdings will be developed for industrial purposes and bushfire hazards will be removed.

Given the site is identified as bushfire prone and some limited areas of bushfire hazard in proximity to the site are expected to be retained in the post-development scenario, development in proximity to these areas should consider mitigation strategies to minimise bushfire risk. This has been achieved through the consideration of the performance criteria and acceptable solutions outlined in the *Guidelines for Planning in Bushfire Prone Areas* (WAPC *et al.* 2015). Specifically, bushfire risk mitigation strategies include:

- Siting of development to ensure the site is not exposed to an unacceptable level of radiant flux (i.e. Bushfire Attack Level 29 (BAL-29)). As industrial development is expected to proceed within landholdings to the north-east, south-east and south-west of Precinct 3A, classified vegetation within these landholdings is temporary and will be removed to facilitate development of the broader MKSEA. In the event that buildings are constructed prior to the removal of temporary hazards within and adjacent to the site as a result of the staging of the different MKSEA precincts and also staging of development within the site, the proposed large industrial lots are readily able to accommodate the required Asset Protection Zones (APZs) between industrial buildings and classified vegetation to ensure that BAL-29 is not exceed. The minimum APZ which will be provided between built form and classified vegetation will include a 14 m-wide separation for Woodland vegetation, and an 8 m-wide separation for Grassland vegetation in accordance with AS3959.

- An interconnected public road network, which facilitates vehicular movements to at least two egress points at all times.
- Providing a reticulated water supply and fire hydrants (to Water Corporation standards) to ensure emergency services are able to respond to a bushfire event.

This BMP sets out the roles and responsibilities of the future developer/s, future landowners and tenants, the CoG and other stakeholders in order to ensure the bushfire risk mitigation strategies outlined in this BMP are implemented.

Based on the outcomes of the BMP, the following conclusions and recommendations are provided:

- A site specific bushfire hazard assessment identifies the site as bush fire prone, in accordance with the *Map of Bush Fire Prone Areas* (OBRM 2015). Bushfire hazards identified within the site are expected to be removed following the implementation of the post-development scenario detailed in this report.
- The proposed industrial development of the site, as set out in the Structure Plan, will facilitate the construction of industrial type buildings, to which the increased construction standards (as set out in AS 3959) are not applicable. As such, the imposition of Bushfire Attack Levels on buildings within the site is not required and will not occur.
- Proposed industrial land uses within the site will be provided with adequate separation to classified vegetation to ensure that future industrial buildings are not exposed to an unacceptable radiant heat flux (i.e. BAL-29 is not exceeded).Future industrial buildings will be separated from permanent and temporary classified Grassland and Woodland by a minimum of 8 m and 14 m respectively..
- This BMP should be implemented in accordance with **Table 2**, which outlines the responsibilities of relevant stakeholders.
- This BMP should be updated as required at future planning stages, as additional detailed design of the proposed industrial development is progressed.

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Appendices

1 Introduction

1.1 Background

Linc Property Pty Ltd (Linc Property) have prepared a Structure Plan to guide industrial development across Precinct 3A of the *Maddington Kenwick Strategic Employment Area* (MKSEA). Precinct 3A of the MKSEA, herein referred to as 'the site', is located within the City of Gosnells (CoG) approximately 12 km south-east of the Perth Central Business District, as shown in **Figure 1**. The site incorporates 29 land parcels, as shown in **Figure 2**.

The site is currently zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and CoG Town Planning Scheme (TPS) No. 6 respectively, as shown in **Figure 3**. An amendment to the MRS (no. 1302/57) is currently being progressed by the Western Australian Planning Commission (WAPC) to rezone the site to 'Industrial'. A local scheme amendment to rezone the site to 'General Industry' has recently been initiated by the CoG.

The site is identified as a "Bushfire Prone Area" within the state-wide *Map of Bush Fire Prone Areas* (Office of Bushfire Risk Management (OBRM) 2016), which has been prepared on behalf of the Fire and Emergency Services Commissioner (FES Commissioner). The Bushfire Prone Area applicable to the site is shown in **Figure 2**. *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) sets out the requirement for further assessment of bushfire hazard implications on development proposed within areas identified as bushfire prone by the FES Commissioner. The Guidelines (WAPC *et al*. 2015) have been prepared to assist in the implementation of SPP 3.7. The bushfire management framework, as generally detailed within SPP 3.7 and the Guidelines has been outlined in **Plate 1**.

A Bushfire Management Plan has been prepared by Essential Environmental (2016) for the City of Gosnells to support MRS amendment no. 1302/57 consistent with the Guidelines. This report has been recently endorsed by the Department of Planning and the Department of Fire and Emergency Services. In accordance with the bushfire management framework this BMP has been prepared to support structure planning and seeks to provide additional detail on the management of bushfire risk.

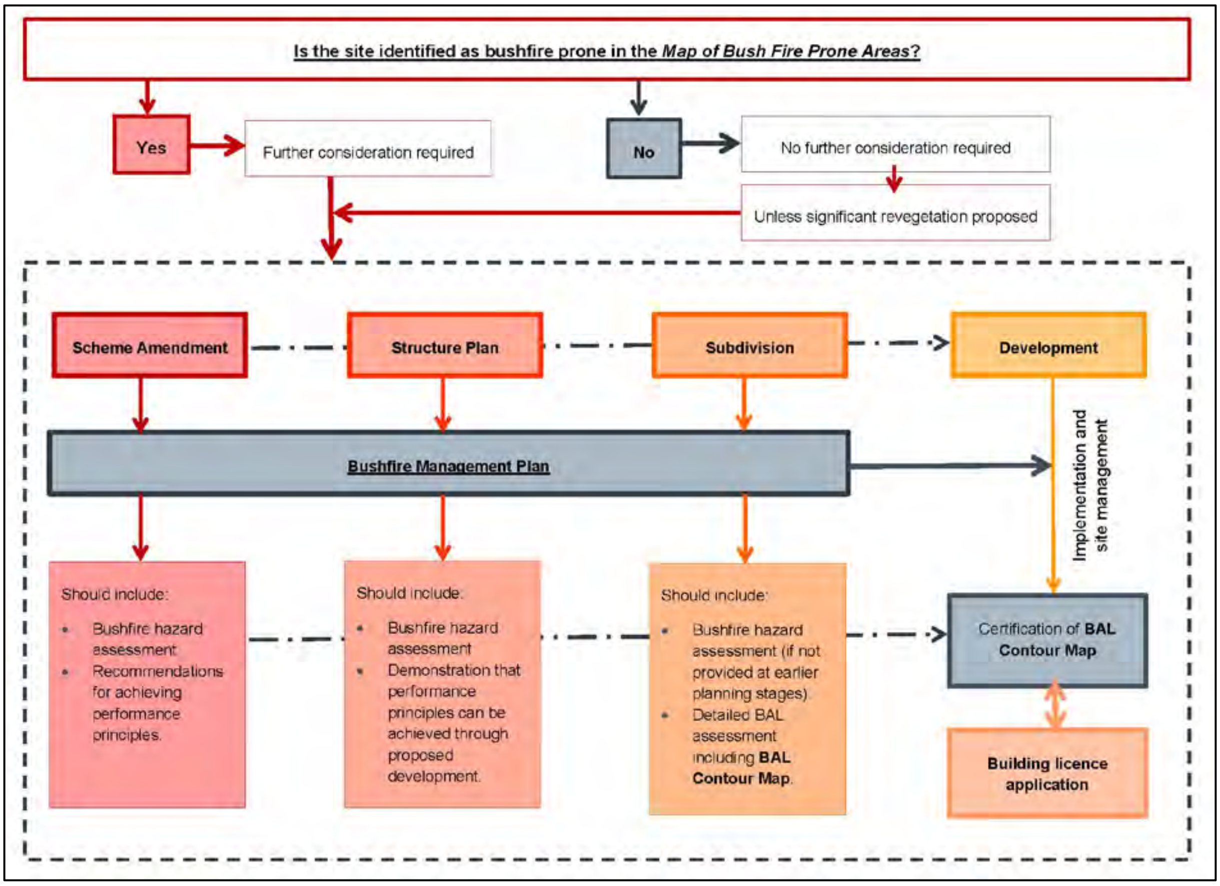

Plate 1: Bushfire planning and assessment process, based on SPP 3.7 (WAPC 2015) and the Guidelines for Planning in Bushfire Prone Areas (WAPC et al. 2015)

1.2 Accreditation

This BMP has been prepared jointly by Emerge Associates and Bushfire Safety Consulting. Bushfire Safety Consulting is owned and operated by Rohan Carboon, an experienced bushfire consultant to the urban planning industry. Rohan has provided technical input and review for the bushfire risk assessment included within this BMP. Rohan has undergraduate degrees in Environmental Management and postgraduate qualifications in Bushfire Protection and has been providing bushfire risk and hazard assessment and mitigation advice to the urban planning and development industry for more than six years. He first worked professionally in community bushfire safety education in 1999 and has been involved in land management including bushfire suppression since 1993.

Bushfire Safety Consulting is a Corporate Bronze Member of the Fire Protection Association of Australia. Rohan is in the process of obtaining Bushfire Planning and Design (BPAD) Level 1 Bushfire Attack Level (BAL) Assessor accreditation under the Fire Protection Association of Australia's new Western Australian accreditation scheme and will also progress to Level 2 and Level 3 accreditation over time as this system is developed.

Emerge Associates has been working jointly with Bushfire Safety Consulting for more than four years to undertake detailed bushfire assessments to support the land use development industry. Emerge Associates is also in the process of obtaining BPAD Level 1 BAL Assessor accreditation, and will progress to Level 2 accreditation as the Western Australian system is developed.

1.3 Aim of this document

The aim of this BMP is to assess bushfire hazard levels in the vicinity of the site (within 100 m) and to ensure any threat posed by any identified bushfire hazard can be mitigated within the site to acceptable levels appropriate for an industrial development. In doing so, this BMP aims to minimise the potential impact of bushfires on development within the site, and reduce the threat to life, property and the environment. The bushfire risk will be mitigated to acceptable levels as outlined in the Guidelines (WAPC *et al.* 2015).

1.4 Statutory policy and framework

The following key legislation, policies and guidelines are relevant to the preparation of a bushfire management plan.

1.4.1 *Fire and Emergency Services Act 1998*

Areas within Western Australia are designated as bushfire prone by the Fire and Emergency Services (FES) Commissioner through the *Map of Bush Fire Prone Areas* (OBRM 2016). The *Fire and Emergency Services Act 1998* (FES Act) enables the statutory delineation of Bushfire Prone Areas, which are areas within 100 m of classified bushfire prone vegetation. In turn, Bushfire Prone Areas enable the implementation of the regulations and guidelines outlined below. The *Map of Bush Fire Prone Areas* (OBRM 2016) as currently mapped for the site is shown in **Figure 3.**

1.4.2 *Bush Fires Act 1954*

The *Bush Fires Act 1954* (Bush Fires Act) sets out provisions to prevent, control and extinguish bushfire and to reduce the dangers resulting from bushfires, amongst other purposes. The Bush Fires 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 to establish and maintain bushfire brigades.

Pursuant to the Bush Fires Act, the CoG publishes an Annual Fire Hazard Reduction Notice which can be accessed from: http://www.gosnells.wa.gov.au/Your_property/Community_safety/Fire_prevention.

1.4.3 Planning and Development (Local Planning Scheme Amendment) Regulations 2015

The *Planning and Development (Local Planning Scheme Amendment) Regulations 2015* (WAPC 2015a) (the Regulations) include deemed provisions which reference the FES Commissioner's power to designate bushfire prone areas, and provide a mechanism to apply *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015) and the related assessment requirements through planning and development decisions.

1.4.4 Building Regulations 2012

All building work in Western Australia is required to comply with the requirements of the Building Code of Australia (BCA). The Building Regulations 2012 recognise that properties that are located within designated bushfire prone areas (within the *Map of Bush Fire Prone Areas* (OBRM 2016)) may require additional assessment for bushfire risk and for construction of dwellings to be in accordance with *Australian Standard (AS) 3959-2009 Construction of buildings in bushfire prone areas* (Standards Australia 2009) (AS 3959).

1.4.5 State Planning Policy 3.7 Planning in Bushfire Prone Areas

The Department of Planning and WAPC have released *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (2015). SPP 3.7 aims to:

- Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.
- Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.
- Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.
- Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values and landscape amenity, with consideration of the potential impacts of climate change.

SPP 3.7 makes provision for further detailed bushfire hazard assessment to be undertaken for areas identified as bushfire prone within the state *Map of Bush Fire Prone Areas*. It also outlines the information that is required to support the various stages of planning and the potential for bushfire conditions to be applied.

1.4.6 Guidelines for Planning in Bushfire Prone Areas (WAPC *et al.* 2015)

The Guidelines have been prepared by the WAPC and DFES, to assist in the interpretation of SPP 3.7 and provide advice on planning, designing or assessing a proposal within a bushfire prone area. The Guidelines are the predominant document to be used by decision-making authorities and referral agencies when considering the appropriateness of strategic planning proposals, subdivisions, and development applications.

The Guidelines address important bushfire risk management and planning issues and outline performance criteria and acceptable solutions to minimise the risk of bushfires in new subdivisions and developments. The Guidelines also address management issues including location, siting and design of the development (and consideration of Bushfire Attack Level (BAL) ratings, where applicable), vehicular access and water requirements.

1.4.7 Australian Standard AS 3959 – 2009 Construction of buildings in bushfire prone areas

AS 3959 specifies requirements for the construction of certain building types in bushfire prone areas in order to improve their resistance to bushfire attack from embers, radiant heat, flame contact, and combinations of these attack forms.

AS 3959 is applicable to residential buildings identified as Class 1, Class 2, Class 3 or Class 10a under the Building Code of Australia which are constructed within 100 m of classified bushfire prone vegetation (i.e. within a bushfire prone area). The construction of such buildings requires consideration of the need for increased construction standards to address bushfire risks to life and property (built form). This can be specifically assessed in these areas by determining the relevant Bushfire Attack Levels (BALs) and subsequent construction standard requirements for exposed areas of a development.

The future development of the site in accordance with the proposed Structure Plan will ultimately result in the construction of industrial type facilities within the site, identified as either Class 4, Class 5, Class 6, Class 7 or Class 8 under the Building Code of Australia. AS 3959 does not apply to these classes of building, and as such increased construction standards specified in AS 3959 are not applicable to industrial development within the site.

Notwithstanding, AS 3959 provides a suitable framework to classify vegetation with regard to structure and fuel loads, and as such has been utilised during the preparation of this BMP to identify bushfire hazards.

The objective of AS 3959 is to provide detailed methods of assessing bushfire attack and to prescribe particular construction details for buildings to reduce the risk of ignition from a bushfire, appropriate to the:

- Potential for ignition caused by burning embers, radiant heat or flame generated by a bushfire.
- Intensity of the bushfire attack on the building.

Two separate methods are outlined in AS 3959 for determining the impact of bushfire on buildings and have been summarised below:

- **Method 1** (outlined in Section 2 and Appendix A of AS 3959) allows for a basic assessment of radiant heat flux which calculates the required setback to achieve a certain level of radiant heat exposure (i.e. BAL-29) based on an assessment of classified vegetation within 100 m of a site. This method uses the standard fuel loads outlined in AS 3959, and considers the effective slope beneath vegetation.
- **Method 2** (outlined in Appendix B of AS 3959) provides a framework for a more rigorous and site specific assessment of radiant heat flux exposure for a site, involving bushfire engineering analysis and modelling using site specific data (e.g. climate/weather conditions during fire season, actual onsite fuel loads associated with classified vegetation etc.).

A BAL assessment has been undertaken to support this BMP in accordance with Method 1 of AS 3959 (Standards Australia 2009), to demonstrate that the performance criteria of SPP 3.7 is met and that BAL-29 is not exceeded within the site (even though BAL ratings will not be applied to future industrial buildings within the site).

This form of assessment involves the evaluation of the site characteristics using the standard conditions assumed for Western Australia in AS 3959, in order to determine fire behaviour adjacent to the site, and has included:

- An assessment of classified vegetation (in accordance with Table 2.3 of AS 3959) to determine the assumed fuel loads adjacent to the site and the impact this would have on bushfire behaviour.
- An assessment of the effective slope beneath areas of classified vegetation.

Vegetation that does not trigger a BAL assessment (i.e. low threat) according to Clause 2.2.3.2 of AS 3959 includes the following:

a) Vegetation of any type more than 100 m from the site.
b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site or each other.

d) 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.
e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.
f) 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.

2 Proposal and Objectives

The Structure Plan for the site, provided in **Appendix A**, has been prepared by Taylor Burrell Barnett Town Planning and Design (TBB) on behalf of Linc Property. The Structure Plan guides the future industrial development within the site and sets out:

- Areas to be developed for 'General Industry'
- A Public Transport Authority rail infrastructure facility
- The Parmelia Mainline gas pipeline easement
- The proposed internal road network.

The land uses set out in the proposed Structure Plan are shown in **Figure 5** and generally align with the *Indicative Local Structure Plan* for the MKSEA prepared by CoG (2014). As such, the progression of industrial development within Precinct 3A of the MKSEA as set out in the proposed Structure Plan is in accordance with the established planning framework.

The main objective of this BMP is to address bushfire management considerations for the proposed development of the site in accordance with SPP 3.7 and the Guidelines, to ensure that the site can adequately accommodate industrial development without unacceptable risk to life and property from bushfire.

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.
- Development is sited and designed to minimise the effects of a bushfire.

This document sets out the roles and responsibilities of the future developer/s, future land owners/tenants and the CoG. It is important that the measures and procedures outlined in this BMP are adopted across the various stages of the land use planning and dwelling construction approvals processes. This BMP provides:

- Identification of those portions of the site designated as Bushfire Prone Areas within the state-wide *Map of Bush Fire Prone Areas* (OBRM 2016)
- 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
- Identification of determined site specific Bushfire Prone Areas based on the assessment of classified vegetation within the site and surrounding 100 m
- A description of the proposed road network and how this addresses vehicular access for bushfire risk purposes
- An outline of the water supply requirements within the site for firefighting purposes
- An outline of the requirements for the internal siting of buildings to include asset protection zones
- A BAL assessment to demonstrate the acceptability of the siting and design of the proposed development in accommodating appropriate bushfire hazard mitigation measures (i.e. demonstrating that BAL-29 is not exceeded).

3 Description of the Area

3.1 General

The site comprises a total area of 72.6 ha and is generally bound by Coldwell Road, rural-residential land uses along Courtney Place, Roe Highway and the adjacent freight railway line, as shown in **Figure 2**.

The site is currently used for a combination of general rural, rural residential and light industrial land uses. The majority of the site was cleared of native vegetation prior to 1953 to support such land uses, with existing vegetation limited to areas of remnant and planted vegetation in the form of small patches or scattered trees.

3.2 Climate and fire weather

The behaviour of bushfires is significantly affected by weather conditions. Fires burn more aggressively when high temperatures combine with low humidity and strong winds. In Perth and the 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 (Blanchi *et al.* 2010). The Bureau of Meteorology (BoM) (2014) states that extreme fire weather conditions in the Perth region typically occur with strong easterly or north-easterly winds, usually as a result of a strong high pressure system over South Australia. 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 occur 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 Gosnells City weather station (BoM Station number 9016) located approximately 3 km south of the site, indicates the area experiences warm dry summers and cool wet winters and is classified as a Mediterranean climate. The area receives an average annual rainfall of 825 mm of (**Plate 2**), and mean maximum temperatures vary from 32.8°C in February to 18.3°C in July (**Plate 3**) (BoM 2015).

Data from the Gosnells City weather station indicates that the predominant winds near the study site in the summer months at 3 pm are generally south-westerly (**Plate 4**). Easterly and south-easterly winds are more common in February than the other summer months.

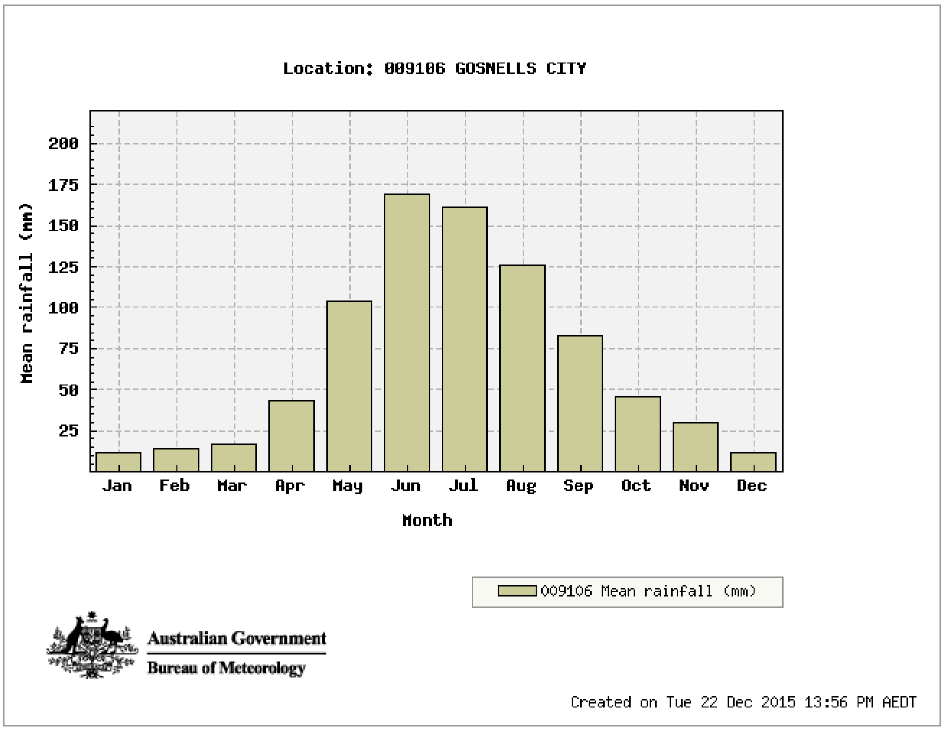

Plate 2: Mean rainfall for the Gosnells City BoM weather station between 1961 - November 2015 (Bureau of Meteorology 2015)

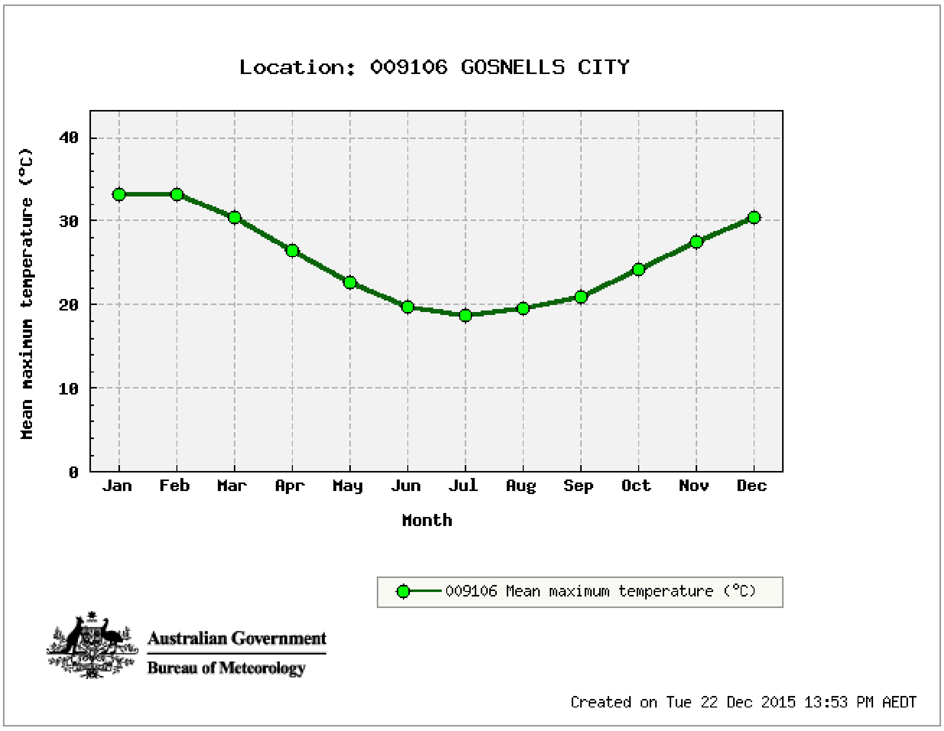

Plate 3: Mean maximum temperatures for the Gosnells City BoM weather station between 1991 - November 2015 (Bureau of Meteorology 2015)

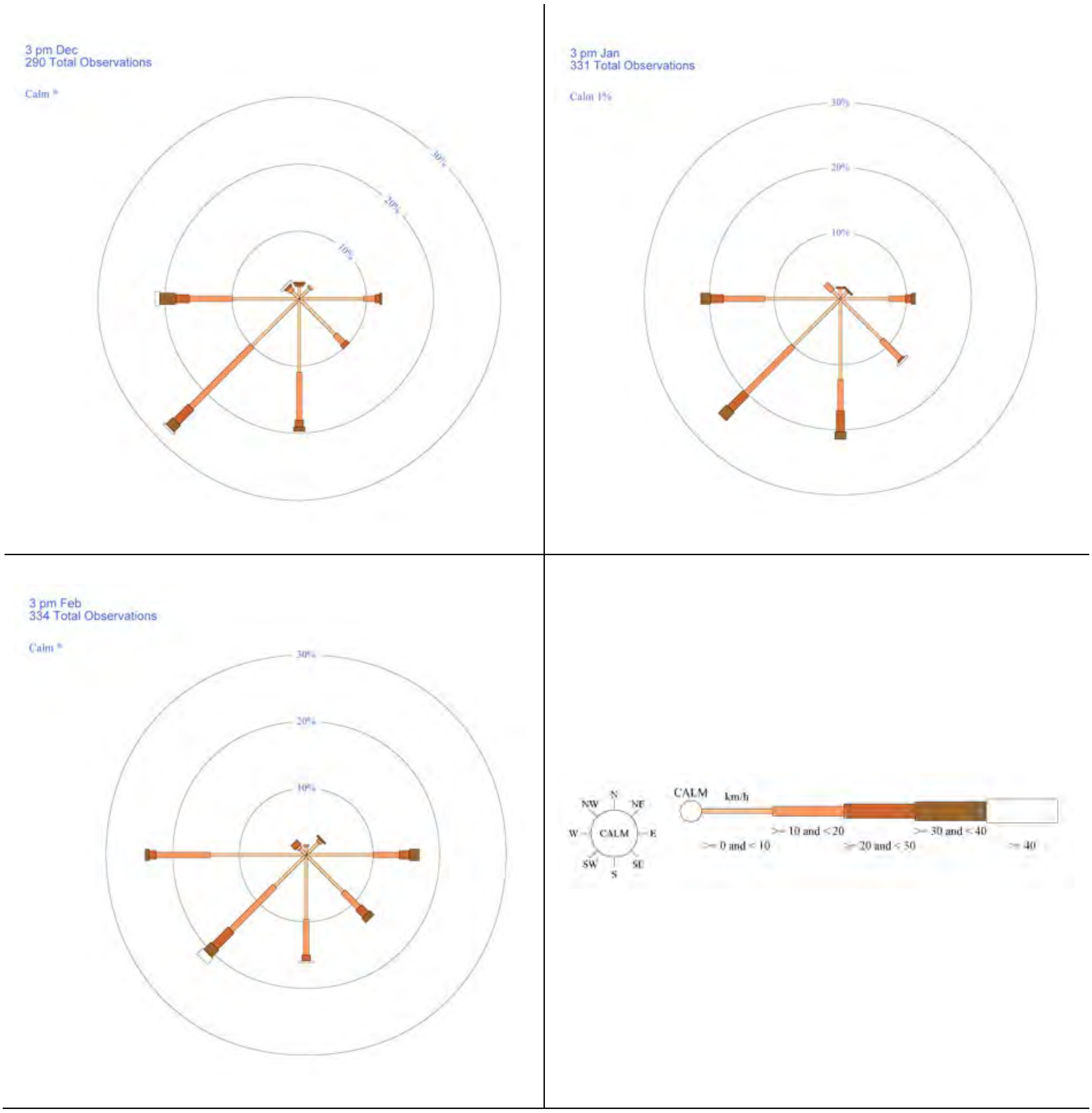

Plate 4: Rose of average wind direction and wind speed in km/h for December, January and February from 1991 to 2010 at the Gosnells City weather station (BoM 2015).

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 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).

3.3 Topography

The site is generally flat and low-lying, with elevation ranging from approximately 9 m Australian Height Datum (AHD) in the south west to 13 m AHD in the north east (DoW 2008). On this basis, the site exhibits a very minor south-westerly aspect.

Topographical contours are shown in **Figure 6**, indicating the elevation characteristics of the site.

3.4 Bushfire fuels

The site is dominated by grassland vegetation with discrete patches of woodland vegetation and scattered paddock trees. Similar fuels occur in adjacent areas to the south, east and north of the site. On the western side of the freight railway reserve, scrub and grassland fuels occur. The long term bushfire hazard implications for development within the site are discussed further in **Section 4.3**.

3.5 Land use

The site is currently used for a combination of general rural, rural residential and light industrial land uses. The majority of the site was historically cleared to support former agricultural land uses.

Following the implementation of the pending MRS and CoG TPS No. 6 amendments, the site will be suitably zoned to allow for the implementation of the Structure Plan and associated development of industrial land uses.

3.6 Assets

The implementation of the proposed Structure Plan (attached in **Appendix A**) will result in the development of industrial land uses within the site, in addition to a Public Transport Authority rail infrastructure facility and an internal road network. Future land uses exposed to any bushfire hazard will be those located within 100 m of permanently retained classified vegetation (or within 50 m of permanently retained classified Grassland vegetation).

3.7 Access

The road network of the Structure Plan is shown in **Figure 5**. The network integrates with the existing Grove Road to the south (which provides access to Brook Road, Bickley Road and Roe Highway), in addition to Coldwell Road to the north-east (which provides access to Welshpool Road). The Structure Plan also provides for the realignment of Grove Road in order to allow for the construction of a four-way controlled intersection with Welshpool Road and Hale Road. Based on both the current and future road network, two access points to the site will be provided at all times to the public and emergency personnel in the form of public roads. The road network shown in the Structure Plan will ensure full connectivity and permeability with the existing surrounding road network and will provide an additional egress point in the event of a bushfire. This is discussed further in **Section 0**.

3.8 Water supply

The site will be supplied with scheme water potable and non-potable uses. Fire hydrants will also be installed by the developer/s to meet the specifications of Water Corporation (Design Standard DS 63) and DFES. The Water Corporation would be responsible for all hydrant maintenance and repairs.

4 Bushfire Context and Current Situation

4.1 Bushfire history

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

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.

Bushfires are common in the City of Gosnells, and as such this BMP plays an important role in ensuring that the development of the land appropriately mitigates the risk and threat posed from bushfire.

4.2 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. bushfire prone 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 standalone site specific risk assessment in accordance with AS/NZS ISO 31000:2009 as part of this BMP, as risk has been considered in the context of the bushfire hazard assessment that has been undertaken (as outlined in **Section 4.3**) in accordance with AS 3959 and the Guidelines (WAPC *et al.* 2015).

The vulnerability of assets, such as dwellings, is impacted by several factors. Some factors relate to the way a bushfire behaves at a site, other factors are related 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 as relevant to bushfire behaviour:

- 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.

The site is identified as bushfire prone within the *Map of Bush Fire Prone Areas* (OBRM 2016), as shown in **Figure 2**, and as such a Bushfire Management Plan is required to demonstrate how the bushfire protection criteria specified in Appendix 4 of the Guidelines are achieved by the proposed development, in addition to the specification of any particular management requirements for 'high risk land uses'.

4.3 Bushfire hazard

Assessing bushfire hazards takes into account the classes of vegetation within the site and surrounding area for a minimum of 100 m, in accordance with AS 3959. The assignment of vegetation classifications is based on an assessment of vegetation structure, which includes consideration of the various fuel layers of different vegetation types. For example, fuel layers in a typical forest environment can be broken-down into five segments as illustrated in **Plate 5** below. These defined fuel layers are used in the following descriptions regarding vegetation types, fuel structure and bushfire hazard levels.

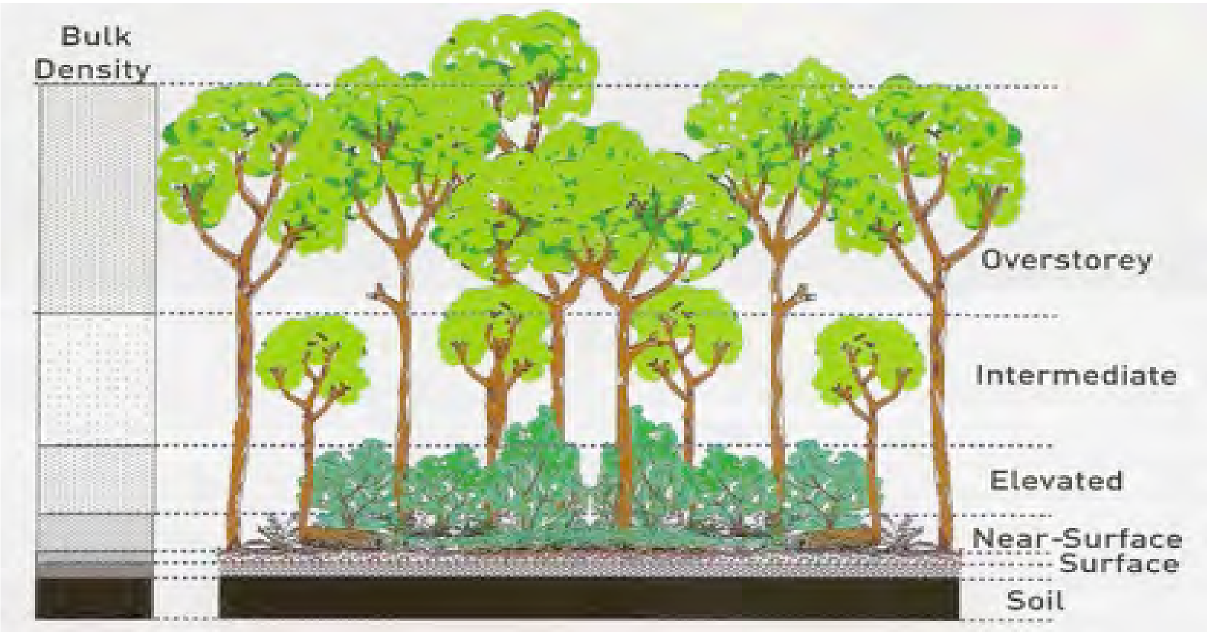

Plate 5: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

4.3.1 Existing vegetation types and structure

A flora and vegetation survey incorporating the site was undertaken by Emerge Associates in December 2015 to inform the *MKSEA Precinct 3A Flora and Vegetation Assessment* (Emerge Associates 2015). The assessment determined the vast majority of vegetation within the site to be in 'Completely Degraded' condition according to the Keighery (1994) vegetation condition scale (Emerge Associates 2015), with some remnant areas identified to be in 'Degraded' condition. Vegetation in 'Completely Degraded' or 'Degraded' condition is typically heavily disturbed from its natural form, with intermediate and elevated layers commonly thinned or cleared, and as such generally provide lower fuel loads compared to more intact vegetation in a greater condition.

In addition to the botanical survey, the field survey also involved the classification of existing vegetation in accordance with Table 2.3 of AS 3959. The associated classifications of vegetation within the site are shown in **Figure 7** and described below.

4.3.1.1 Vegetation within the site

The majority of vegetation within the site comprises a grassland structure, characterised by near-surface introduced pasture weeds, with no elevated, intermediate or overstorey vegetation. At the time of the survey, most of these areas were subject to active management measures (as shown in **Plate 6**) by land owners/tenants (such as slashing or horse grazing) and as such would likely be consistent with low threat vegetation in accordance with Clause 2.2.3.2(f) of AS 3959 and would not pose a bushfire hazard. However, given the uncertainty around the frequency and reliability of this management, all areas which appeared to be actively managed have been considered classified Grassland (Class G) for the purpose of a conservative hazard assessment (as shown in **Figure 7**).

The exception to this is an irrigated turf farm, located centrally within the site, which meets the definition of low threat vegetation in accordance with Clause 2.2.3.2(f) of AS3959 and is regularly harvested and actively managed as part of a commercial activity (as shown in **Figure 7**). The turf farm is actively managed year round and there is certainty around the frequency and reliability of this management similar to a commercial nursery or golf course as defined in AS3959.

In addition, there are some areas of vegetation within the site with a grassland structure were not identified to be subject to any management measures, and as such are consistent with classified as Grassland (Class G) vegetation and provide surface level fuel loads and associated bushfire hazards (as shown in **Plate 7**).

Plate 6: Managed grassland within the Structure Plan area (see photo point 1 (PP1) ***Figure 7****)*

Plate 7: Unmanaged Grassland within a Rural land holding (see PP2, ***Figure 7****)*

Small patches of remnant and planted Woodland vegetation (Class B) were also observed across the site as shown in **Plate 8.** These areas generally comprise of an overstorey of marri (*Corymbia calophylla*) and non-endemic planted species, with limited intermediate and elevated vegetation, over near-surface grasslands of introduced pasture weeds.

The remainder of the site is identified as a non-vegetated area in accordance with Clause 2.2.3.2(e) of AS 3959 and as such does not pose a bushfire hazard. These areas include the existing road network, built form and areas of exposed mineral earth.

*Plate 8: Classified Woodland vegetation at the corner of Edward Street and Grove Road (see PP3, **Figure 7**)*

4.3.1.2 Vegetation surrounding the site (within 100 m)

Vegetation adjacent to the north-western boundary of the site, on the western side of the freight railway, was observed to comprise a Scrub structure (Class D), with thick elevated and near-surface vegetation, as shown in **Plate 9**. These areas were observed within the Roe Highway road reserve and within the Woodlupine Brook Reserve. Areas immediately adjacent to the freight railway contain patches of grass fuels generally less than 1 m in height (as shown in **Plate 9**) which may be subject to management in the summer months. These areas have been considered unmanaged, classified Grassland (Class G) for the purpose of a conservative assessment.

Other areas surrounding the site (within 100 m) are considered to contain vegetation consistent with classified Grassland (Class G) vegetation. Grassland vegetation exists within rural land holdings as well as the Welshpool Road reserve to the north of the site, as shown in **Plate 10**.

Areas of classified Woodland vegetation (Class B) occur to the north-east and south-east of the site within existing rural-residential land parcels, as shown in **Plate 11**. The composition of this vegetation is similar to Woodland vegetation within the site.

The remainder of areas within 100 m of the site comprise of non-vegetated areas in accordance with Clause 2.2.3.2(e) of AS 3959 (including roads, driveways, railways, footpaths, areas of mineral earth and buildings) and low threat vegetation in accordance with Clause 2.2.3.2(f) of AS 3959 (managed grasslands with open areas of scattered paddock trees). An example of managed grassland south-east of the site is shown in **Plate 12**. As with managed grasslands discussed in **Section 4.3.1.1**, given the uncertainty around the frequency and reliability of management actions, all areas which appeared to be actively managed at the time of the vegetation assessment have been considered classified Grassland (Class G) for the purpose of a conservative hazard assessment (as shown in **Figure 7**).

Plate 9: Grassland vegetation within the rail reserve (foreground) and Scrub vegetation to the west of the rail reserve (background) (see PP4, ***Figure 7****)*

Plate 10: Grassland vegetation within the Welshpool Road reserve, north of the site (see PP6, ***Figure 7****)*

Plate 11: Classified Woodland vegetation on the eastern side of Coldwell Road (see PP5, ***Figure 7****)*

Plate 12: Managed grassland with scattered paddock trees on the eastern side of Coldwell Road (see PP7, ***Figure 7****)*

4.3.2 Bushfire hazard assessment – existing site conditions

As part of the bushfire hazard assessment process, the bushfire hazard rating based on existing site conditions and the applicable vegetation types identified within and immediately surrounding the site was determined using Appendix Two of the Guidelines, as shown in **Figure 8** and summarised below:

- 'Low' bushfire hazards are represented by low threat vegetation and non-vegetated areas.
- 'Moderate' bushfire hazards are represented by classified Grassland (Class G) vegetation..
- 'Extreme' bushfire hazards are represented by areas of classified Woodland (Class B) and Scrub (Class D) vegetation.

In accordance with Appendix Two of the Guidelines, areas of 'Low' bushfire hazard which are located within 100 m of 'Moderate' or 'Extreme' hazards have been identified as 'Moderate' hazards to reflect the increased level of risk associated with adjacent hazards, as shown in **Figure 8**.

4.3.3 Post-development vegetation types and structure

With regard to existing vegetation and associated bushfire hazards, the implementation of the proposed Structure Plan will result in the following post-development scenario:

- The vast majority of vegetation within the site will be removed to facilitate industrial development (there may be opportunities for retention of scattered mature trees where possible and practical).
- Vegetation adjacent to the site, but within other MKSEA precincts, will be removed in the short-medium term for industrial development, However, this vegetation has been included in the

post-development scenario (**Figure 9**) to demonstrate that the development is acceptable even with the consideration of temporary bushfire hazards.

- Vegetation adjacent to the western and north-western boundaries of the site to be retained within the Roe Highway road reserve and the Woodlupine Brook Reserve.

The predicted post-development scenario for the site (which includes temporary classified vegetation) with regard to AS 3959 vegetation classifications is shown in **Figure 9**.

4.3.4 Bushfire hazard assessment – post development site conditions

The post-development bushfire hazard ratings change substantially compared to the existing pre-development conditions due to the future removal of classified vegetation to accommodate industrial development. The temporary and permanent post-development bushfire hazard ratings within and immediately surrounding the site are shown in **Figure 10** and summarised below.

- “Low” bushfire hazards are represented by non-vegetated areas (roads, footpaths, built-form and areas of exposed mineral earth) associated with future industrial land uses to be development within the site, in addition to areas within adjacent MKSEA precincts to the south, east and north in the short-medium term.
- “Moderate” bushfire hazards are represented by areas within the site that are located within 100 m of “Moderate” or “Extreme” bushfire hazards as well as Grassland vegetation within the freight railway reserve and Welshpool Road reserve.
- “Extreme” bushfire hazards are represented by retained areas of classified Scrub vegetation within the Roe Highway road reserve and the Woodlupine Brook Reserve.

Temporary “Moderate” and “Extreme” bushfire hazards posed from classified Grassland and Woodland vegetation (respectively) will result from the staging of the different MKSEA industrial development precincts, as well as staging of development within the Structure Plan area. Temporary bushfire hazards are addressed in **Section 5.1.2**.

4.3.5 Effective slope

The effective slope under temporary and permanent classified vegetation in the post-development scenario relative to the site is shown in **Figure 11** and is described as:

- Downslope 5-10 degrees under the portion of classified Scrub vegetation situated on the sloping bank of the Woodlupine Brook.
- Effectively flat or upslope under the remainder of the classified Scrub vegetation adjacent to the western boundary of the site within the Roe Highway road reserve and under classified Grassland vegetation within rural landholdings to the north-east, south-east and south-west of the site.

4.4 Summary of bushfire threat

Based on the post-development scenario, the only areas of classified vegetation within 100 m of the site which pose a permanent bushfire hazard are Scrub vegetation within the adjacent Roe Highway road reserve and Woodlupine Brook Reserve as well as Grassland vegetation within the freight railway reserve and Welshpool Road reserve. This classified vegetation is located adjacent to the western boundary of the site and has been identified as having an ‘Extreme’ and ‘Moderate’ bushfire hazard rating respectively. In order to demonstrate that no future industrial land uses within the site will be exposed to an unacceptable level of bushfire risk (i.e. BAL-29 is not exceeded), a BAL assessment has been undertaken and is detailed within **Section 5.1.2**.

All other areas of vegetation within the site or within the 100 m assessment area represent a 'Low' bushfire hazard in the post-development scenario and will not pose a threat to the proposed industrial development of the site. As outlined in **Section 4.3.4** temporary bushfire hazards may result from the staging of the different MKSEA industrial development precincts, as well as staging of development within the Structure Plan area the industrial development. These temporary hazards are expected to be considered through the future planning process.

5 Bushfire Mitigation Strategy

This BMP provides an outline of the mitigation strategies that will ensure that as the proposed Structure Plan is implemented development is progresses in accordance with the proposed subdivision, an acceptable solution and/or performance-based system of control is adopted for each bushfire hazard management issue. This approach is consistent with Appendix Four of the Guidelines (WAPC *et al.* 2015). The management issues addressed as part of this BMP are:

- Location of the development
- Siting and design of the development
- Vehicular access
- Water supply.

For the proposed residential development of the site, acceptable solutions are proposed for all four management issues in accordance with the Guidelines (WAPC *et al*. 2015), and is discussed in **Section 5.1** below.

5.1 Bushfire risk management

As previously discussed, it is not necessary to undertake a specific bushfire risk assessment as per AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*. Land use planning bushfire risk mitigation are detailed in the following sections and provide responses to the bushfire protection performance criteria outlined in Appendix Four of the Guidelines (WAPC *et al.* 2015). The compliance checklist is attached as **Appendix B**.

5.1.1 Element: Location

5.1.1.1 Intent

To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.

5.1.1.2 Acceptable Solution A1.1 Development location

The proposed industrial development of the site set out in the Structure Plan will meet Acceptable Solution A1.1, as no future industrial buildings will be exposed to an unacceptable level of radiant heat flux (i.e. BAL-29 is not exceeded) based on the outcomes of the BAL assessment. This is detailed further in **Section 5.1.2**.

5.1.2 Element: Siting and design of development

5.1.2.1 Intent

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

5.1.2.2 Background

The extent of post-development classified vegetation within 100 m of the site which poses a permanent bushfire hazard to the site is restricted to areas of Scrub within the adjacent Roe Highway road reserve and Woodlupine Brook Reserve to the west of the site, as well as Grassland vegetation within the freight railway reserve and Welshpool Road reserve to the west and north of the site, as shown in **Figure 9**.

Staging of the different MKSEA industrial development precincts, as well as staging of development within the Structure Plan area the industrial development may result in temporary bushfire hazards posed from classified Grassland and Woodland vegetation within rural landholdings within and surrounding the site (within 100 m). Areas subject to future industrial development (and therefore temporary hazards) are shown in **Figure 9**.

5.1.2.3 Building siting and potential management considerations

AS 3959 has six BAL categories which trigger varying degrees of increased construction standards for certain types of building (as detailed in **Section 1.4.7**) within 100 m of classified vegetation. Whilst BAL ratings do not apply to industrial type buildings, the proposed Structure Plan is still required to demonstrate that industrial buildings will not be located within areas where BAL-29 is exceeded in accordance with the Guidelines. Therefore, the proposed development meets the performance principle and associated acceptable solution.

5.1.2.4 Methodology and assumptions

A Method 1 BAL assessment has been undertaken in order to determine the maximum level of radiant heat flux to which the Structure Plan area could be exposed, and has been carried out based on the post development vegetation classification (and outlined management measures) and effective slope outlined in **Section 4.3**. The criteria used to undertake the BAL assessment is as follows:

- Designated FDI: 80
- Flame temperature: 1090
- Effective slope: flat/upslope, downslope 5-10
- Vegetation classification: Woodland, Scrub, Grassland
- Setback distances: As per Table 2.4.3 of AS 3959, and shown in **Table 1** below.

5.1.2.5 BAL outcome

The Method 1 BAL assessment determined that the only areas within the site that are permanently exposed to a BAL rating greater than BAL-29, are areas adjacent to classified Grassland to the west and north of the site(following the removal of temporary hazards within and surrounding the site to facilitate future industrial development), With the provision of setbacks (as detailed in **Section 5.1.2.6**), the proposal will achieve the performance criteria and associated acceptable solutions outlined in the Guidelines.

The BAL Contour Map is shown in **Figure 12** which demonstrates that BAL-LOW applies across the majority of the site with BAL-29 being exceeded permanently only in areas within 8 m of the western and northern site boundaries. These areas are generally contained within the proposed PTA rail infrastructure facility and can be readily accommodated given the large size of the proposed lots without compromising compliance with the Guidelines.

Temporary BAL-ratings are shown in **Figure 12** which are associated with classified Woodland and Grassland vegetation in adjacent rural landholdings to the north-east and south-east of the site (subject to future industrial development within the MKSEA area). Although only temporary, these BAL ratings have been given consideration to ensure that the development can accommodate the required setbacks from temporary classified vegetation outlined in **Table 1** and discussed in **Section 5.1.2.6** below.

Table 1 details the required setbacks between built form and classified vegetation to achieve acceptable BAL ratings. The provision of hazard separation and APZs are discussed in **Sections 5.1.2.6 and 5.1.2.7**.

Table 1: Results of BAL assessment

AREA OF CLASSIFIED VEGETATION	VEGETATION CLASSIFICATION	EFFECTIVE SLOPE	SETBACK	BAL ACHIEVED
Roe Highway road reserve, west of site	Scrub	Flat/ upslope	13- <19 metres	BAL-29
			19- <27 metres	BAL-19
			27- <100 metres	BAL-12.5
Bank of Woodlupine Brook, north-west of site	Scrub	Downslope 5-10	15- <22 metres	BAL-29
			22- <31 metres	BAL-19
			31- <100 metres	BAL-12.5
Freight railway reserve and Welshpool road reserve, west and north of the site	Grassland	Flat/ upslope	8- <12 metres	BAL-29
			12 - <17 metres	BAL-19
			17- <50 metres	BAL-12.5
Rural landholdings, Grove Road reserve and Coldwell Road reserve to the north-east, south-east and south-west of the site*	Woodland	Flat/ upslope	14- <20 metres	BAL-29
			20 - <29 metres	BAL-19
			29-<100 metres	BAL-12.5
	Grassland		8- <12 metres	BAL-29
			12 - <17 metres	BAL-19
			17- <50 metres	BAL-12.5

* Classified vegetation within rural landholdings, Grove Road reserve and Coldwell Road reserve to the north-east, south-east and south-west of the site will be removed to facilitate industrial development in the short to medium term and therefore only poses a temporary bushfire hazard. As such, BAL ratings associated with this vegetation have been shown in **Figure 12** as temporary only.

5.1.2.6 Acceptable solution A2.1: Asset Protection Zone

One of the most important bushfire protection measures influencing the safety of people and property is to create an Asset Protection Zone (APZ) around buildings. The APZ is a low fuel area immediately surrounding a building. Non-flammable features such as irrigated landscapes, gardens, driveways and roads can form part of an APZ.

The provision of a perimeter APZ where the site is adjacent to areas of identified bushfire hazard will ensure fuel loads in close proximity to any built form near the edge of the site are managed to reduce the likelihood of ignition fuels adjacent to dwellings. Managing vegetation in the APZ 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.

As outlined in the Guidelines, an APZ must be wide enough to ensure that the maximum BAL rating for a development adjacent to classified vegetation will not exceed BAL-29. As shown in **Figure 12**, only areas within 8 m of the western and northern site boundary are permanently exposed to radiant heat flux greater than 29kW/m² (BAL-29). These areas are generally contained within the Parmelia gas pipeline easement and the proposed PTA facility which can readily accommodate APZs if future development necessitates this. APZs can also be readily accommodated in the event that temporary bushfire hazards exist at the time of development, as discussed below.

In the event that buildings are constructed prior to the removal of temporary hazards within and adjacent to the site as a result of the staging of the different MKSEA precincts and also staging of development within the site, the large industrial lots are readily able to accommodate the required APZs between industrial buildings and classified vegetation to ensure that BAL-29 is not exceed. The minimum APZ which will be provided between built form and classified vegetation will include a 14 m-wide separation for Woodland vegetation, and an 8 m-wide separation for Grassland vegetation in accordance with AS3959in order to achieve a BAL rating of BAL-29 or less.

The presence of classified vegetation and the requirement for an APZ will be confirmed at subsequent planning stages (subdivision/ amalgamation or development application).

Overall, the provision of APZs where required in accordance with AS 3959 will ensure that A2.1 is achieved and Performance Principle P2 under the Guidelines is met.

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

- A minimum of 8 m or 14 m (to Grassland and Woodland respectively).
- Fine fuel load: reduced to and maintained at two tonnes per hectare
- Trees (crowns) are a minimum distance of ten metres apart. A small group of trees within close proximity to one another may be treated as one crown provided the combined crowns do not exceed the area of a large or mature crown size for that species
- No tall shrubs or trees located within two metres of a building
- No tree crowns overhang the building
- Fences within the APZ are constructed using non-combustible materials (e.g. iron, brick, limestone, metal post and wire).

5.1.2.7 Acceptable solution A2.2: Hazard Separation Zone

A Hazard Separation Zone (HSZ) is a fuel managed zone to create separation between buildings and bushfire hazards. This generally extends out to 100 m from buildings. The BAL assessment within this BMP demonstrates that these provisions will achieve acceptable levels of risk for the development, and that future industrial buildings will not be located in areas where BAL-29 is exceeded.

5.1.3 Element: Vehicular access

5.1.3.1 Intent

To ensure vehicular access serving a subdivision/development is available and safe during a bushfire event.

5.1.3.2 Acceptable solution A3.1: Two access routes

The indicative road network of the proposed Structure Plan is shown in **Figure 5**. The network integrates with the existing Grove Road to the south (which provides access to Brook Road and Bickley Road) in addition to Coldwell Road to the north-east (which provides access to Welshpool Road). The Structure Plan also provides for the realignment of Grove Road in order to allow for the construction of a four-way controlled intersection with Welshpool Road and Hale Road. This will effectively provide three points of access through the site, to the north-west, south and north north-west.

Industrial development is likely to involve the closure of the existing Grove Road and Edward Street and the amalgamation of lots. All future industrial lots will be connected to the internal road network, which, based upon the Structure Plan will result in improved access than that of the current road network which contains two long cul-de-sacs.

Based on the current and proposed road network, a minimum of two access points to the site will be provided at all times to both the public and emergency personnel in the form of public roads.

Conversations with the Public Transport Authority (PTA) (Miranda Ludlow, Environment Manager PTA) **have confirmed that appropriate emergency access planning has been considered as part of the planning for the proposed rail infrastructure** facility. The PTA have confirmed that in addition to the access shown on the Structure Plan (see **Figure 5**), the PTA will also provide an internal road running north/south which will connect through to Bickley road south of the Structure Plan area (within the PTAs reservation). This will provide two points of access for the PTA reserve.

5.1.3.3 Acceptable solution A3.2: Public roads

In accordance with the Guidelines, surrounding public roads and all new public roads and laneways within the site will comply with the following minimum standards:

- Minimum trafficable surface: 6 metres
- Horizontal clearance: 6 metres
- Vertical clearance: 4.5 metres
- Maximum grades over <50 metres: 1 in 10
- Minimum weight capacity: 15 tonnes
- Maximum crossfall: 1 in 33
- Minimum inner radius of curves: 8.5 metres.

5.1.3.4 Bushfire/Emergency Evacuation Plan

Industrial facilities are generally required to prepare a suitable emergency evacuation plan in order to attain a building licence. These are generally produced in accordance with ISO AS/NZ 31000:2009 *Risk Management Standard and the Occupational Health and Safety Health Act 1984* and/or *Evacuation Planning Handbook 4 3rd Edition* (Attorney General's Department 2003).

In consideration of the above, it is expected that future industrial facilities developed within the site (in accordance with the proposed Structure Plan) will prepare such a plan which will also consider bushfire risk and associated mitigation strategies identified in this BMP. The plan should address the following:

- A map clearly identifying access routes and alternate routes or designated Fire Safe Areas (FSAs)/Community Fire Refuges (CFRs) in the event of an emergency, and the steps to be taken to implement the evacuation plan.
- Contact numbers for local bushfire control, local police and ambulance etc.

Environmental regulation under Part V on the EP Act is also likely to ensure environmental controls on industrial land uses within the site, through the requirement for Works Approvals and operating Licences for certain industrial facilities identified as 'prescribed premises' within Schedule 1 of the Environmental Protection Regulations 1987. This may involve provisions for the minimisation of risk through building design and location, in addition to operational restrictions, such as the amount and location of hazardous material storage. These considerations are likely to contribute to reducing the bushfire risk within the site.

The BMP prepared for the MRS amendment (Essential Environmental 2016) noted that high risk land uses should not be located within 100 m of classified vegetation. According to the Guidelines, these high risk land uses include but are not limited to: '*service stations, landfill sites, bulk storage of hazardous materials, fuel depots and certain heavy industries as well as military bases, power generating land uses, saw-mills, highways and railways, among other uses meeting the definition*.'

If these land uses are proposed within 100 m of classified vegetation (as shown on **Figure 1**), the management of risk is expected to be addressed in accordance with Policy Provision 6.6 of SPP 3.7 which states:

'Subdivision and development applications for vulnerable or high-risk land uses in areas between BAL-12.5 to BAL-29 will not be supported unless they are accompanied by a Bushfire Management Plan jointly endorsed by the relevant local government and the State authority for emergency services. Subdivision applications should make provision for emergency evacuation. Development applications should include an emergency evacuation plan for proposed occupants and/or a risk management plan for any flammable on-site hazards.'

5.1.4 Element: Water

5.1.4.1 Intent

To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

5.1.4.2 Acceptable Solution A4.1: Reticulated water

The development is located within an Emergency Services Levy (ESL) Category 1 area, which indicates that emergency bushfire response is provided by a network of metropolitan career fire and rescue service stations and the State Emergency Service. Fire response services require ready access to an adequate water supply during bushfire emergencies.

The site will be supplied with scheme water potable and non-potable uses. Fire hydrants will also be installed by the developer/s to meet the specifications of Water Corporation (Design Standard DS 63) and DFES. The Water Corporation would be responsible for all hydrant maintenance and repairs.

5.2 Future development

The outcomes of the BMP will be implemented through the implementation of the proposed Structure Plan, throughout the ongoing development of the site.

5.3 Access and fire breaks

Although management of the existing rural landholdings has not been assumed for the purpose of this assessment, compliance with the CoG *Annual Fire Hazard Reduction Notice* and the Shire of Kalamunda *Firebreak and Fuel Load Notice* is expected and therefore an additional level of hazard reduction exists in areas within and surrounding the site than that which has been assumed for the purpose of this assessment. The CoG *Annual Fire Hazard Reduction Notice* requires that rural properties:

- Clear and maintain the land free of all flammable matter to a height no greater than 10cm; or
- Maintain a mineral earth firebreak immediately inside all external boundaries of each lot on the land and maintain a mineral earth firebreak within 20m of all haystacks and stockpiled flammable matter.

For lots to the north-east of the site greater than 5,000m^2, the shire of Kalamunda *Firebreak and Fuel Load Notice* requirements include (but are not limited to):

- Have all inflammable matter except living trees, shrubs, plants under cultivation and lawns, slashed, mowed or trimmed down by other means to a height no greater than 50mm across the entire property.
- Install bare earth firebreaks three (3) metres wide immediately inside and along all boundarie of land in a continuous form, including on boundaries adjacent to roads, rail and drain reserves and all public open space reserves, with all overhanging branches, trees, limbs etc. to be trimmed back from over the firebreak area to a minimum height of four (4) metres. Driveways must also be maintained to these conditions.

Compliance with the CoG *Annual Fire Hazard Reduction Notice* (Attached in **Appendix C**) is required across the entire site and public road access must provide two access options at all stages of development. As outlined in **Section 0**, the implementation of the Structure Plan will result in improved access across the site, through the removal of large cul-de-sacs and the amalgamation of lots.

5.4 Public education

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 Gosnells provides fire prevention advice to residents, available from their website http://www.gosnells.wa.gov.au/Your_property/Community_safety/Fire_prevention . Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses.

5.5 Assessment of bushfire management strategies

Vegetation which could pose a permanent bushfire hazard to future industrial land uses within the site in the post-development scenario are associated with Scrub vegetation west of the site, within the Roe Highway road reserve and Woodlupine Brook Reserve. This hazard does not incur a BAL rating exceeding BAL-29 within the site, given the separation of the site from the hazard provided by the 40 m wide freight railway reserve, which acts as an Asset Protection Zone.

By undertaking a bushfire hazard assessment for the site, this BMP determines the post-development bushfire prone areas for the site, based on the assessment of classified vegetation in accordance with AS 3959.

5.6 Implementing the Bushfire Management Plan

Table 2 outlines the future and/or ongoing responsibilities of the various stakeholders relating to bushfire risk mitigation. The future lot owners and tenants within the site are to maintain a reduced level of risk from bushfire within their properties (where applicable), 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. Additional bushfire mitigation responsibilities will be outlined as part of future updates to this BMP undertaken as further detail design is completed.

Table 2: Responsibilities for the implementation of the BMP

MANAGEMENT ACTION	TIMING
DEVELOPER/S	
Update BMP as development within the site progresses and detailed design on the proposed layout becomes available, if required.	As part of subdivision, amalgamation or development application.
Install the public roads to standards outlined in **Section 5.1.3.3** and ensure secondary access as outlined in this BMP are considered as part of development.	As part of subdivision, amalgamation or development application.
On all vacant land, comply with the CoG Annual Fire Hazard Reduction Notice.	Ongoing, where applicable.
Install reticulated water supply and hydrants to Water Corporation, DFES and the CoG standards during upgrades of roads.	As part of subdivision, amalgamation or development application.
Ensure appropriate in-lot APZs are established from industrial buildings foreach construction stage within the site to ensure any permanent or temporary hazard does not threaten any proposed development.	As part of subdivision, amalgamation or development application.
Provide detailed hydrant plans to the CoG and DFES local fire station for monitoring	As part of subdivision, amalgamation or development application.
PROPERTY OWNER/OCCUPIER	
Prepare a Bushfire/Evacuation Management Plan if required to support the application for a building licence.	Ongoing, where applicable.

MANAGEMENT ACTION	TIMING
Maintaining each property in good order to minimise bushfire fuels in accordance with the requirements outlined in this BMP.	Ongoing, where applicable.
Ensuring that all lots comply with the CoG Annual Fire Hazard Reduction Notice.	Ongoing, where applicable.
Ensuring that where the development's water supply is located, they are not obstructed and remain visible at all times	Ongoing, where applicable.
CITY OF GOSNELLS	
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 local fire control notice/s.	Ongoing, as requested.
Monitoring bush fuel loads in road reserves and liaising with relevant stakeholders to maintain fuel loads at safe levels	Ongoing.
Maintaining public roads to appropriate standards and ensuring compliance with the CoG Annual Fire Hazard Reduction Notice.	Ongoing.
PUBLIC TRANSPORT AUTHORITY	
Continue to maintain fuel loads through routine vegetation management within the freight railway reserve adjacent to the site.	Ongoing, when required.
WATER CORPORATION	
The Water Corporation is responsible for the repair and maintenance of hydrants.	Ongoing, when required.

6 Conclusions and Recommendations

6.1 Conclusion

The site is designated as bushfire prone within the state *Map of Bush Fire Prone Areas* (OBRM 2016). This BMP addresses the requirements of SPP 3.7 and the Guidelines (WAPC *et al.* 2015) and it has been demonstrated that the bushfire protection performance criteria outlined in the Guidelines (WAPC *et al.* 2015) can be achieved through:

- Permanent bushfire hazards are associated with classified Scrub and Grassland vegetation to the west and north of the site which result in BAL-29 being exceeded however only within areas located a maximum of 8 m within the site boundary. These areas are generally contained within the proposed PTA reserve and Parmelia gas pipeline easement which can readily accommodate an 8 m APZ if necessary.
- Temporary hazards which may be present at the time of construction will be considered and APZs provided between built form and classified vegetation where necessary to ensure that BAL-29 is not exceeded. The required APZ for any future buildings located adjacent to classified Grassland (Class G) and Woodland (Class B) vegetation is 8 m and 14 m respectively.
- An interconnected public road network, which facilitates vehicular movements to at least two egress points at all times.
- Providing a reticulated water supply and fire hydrants (to Water Corporation standards) to ensure emergency services are able to respond to a bushfire event.

This BMP provides mitigation strategies to respond to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the Guidelines (WAPC *et al*. 2015), specifically achieved through meeting the various acceptable solutions. On this basis, the proposed development will fall within the acceptable level of risk with regard to bushfire considerations. In addition, the proposed industrial development of the site, as set out in the Structure Plan, will facilitate the construction of industrial types buildings, which are not applicable to increased construction standards as set out in AS 3959. As such, the imposition of Bushfire Attack Levels on buildings within the site is not required and will not occur.

6.2 Recommendations

Based on the outcomes of the BMP, the following recommendations are provided:

- An 8 m separation is required to be provided between classified Grassland vegetation to the west and north of the site, and future buildings to ensure that that industrial buildings are not located within areas exposed to an unacceptable level of radiant heat flux (i.e. BAL-29 is not exceeded).
- Temporary APZs will need to be considered and accommodated throughout the different stages of development to ensure that industrial buildings are not located within areas exposed to an unacceptable level of radiant heat flux (i.e. BAL-29 is not exceeded). Given the large lot sizes proposed, internal APZs can be accommodated around buildings within industrial lots. Bushfire hazards should be assessed at future planning stages (i.e. subdivision/ amalgamation).
- The proposed industrial development of the site, as shown indicatively in **Appendix A**, will facilitate the construction of classes of buildings which are not subject to increased construction

standards as set out in AS 3959. As such increased construction standards in accordance with the BAL ratings are not required.

- This Bushfire Management Plan should be implemented in accordance with **Table 2**, which outlines the responsibilities of relevant stakeholders.
- This Bushfire Management Plan should be updated as required at future planning stages, as additional detailed design of the proposed industrial development is progressed.

7 References

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8 Glossary

AS	Australian Standard
AHD	Australian Height Datum
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BCA	Building Code of Australia
BMP	Bushfire Management Plan
BOM	Bureau of Meteorology
COG	City of Gosnells
DFES	Department of Fire and Emergency Services (was FESA)
ESL	Emergency Services Levy
FESA	Fire and Emergency Services (now DFES)
HSZ	Hazard Separation Zone
LPS	Local Planning Scheme
POS	Public Open Space
TPS	Town Planning Scheme
VBRC	Victorian Bushfires Royal Commission
WAPC	Western Australian Planning Commission

FIGURES

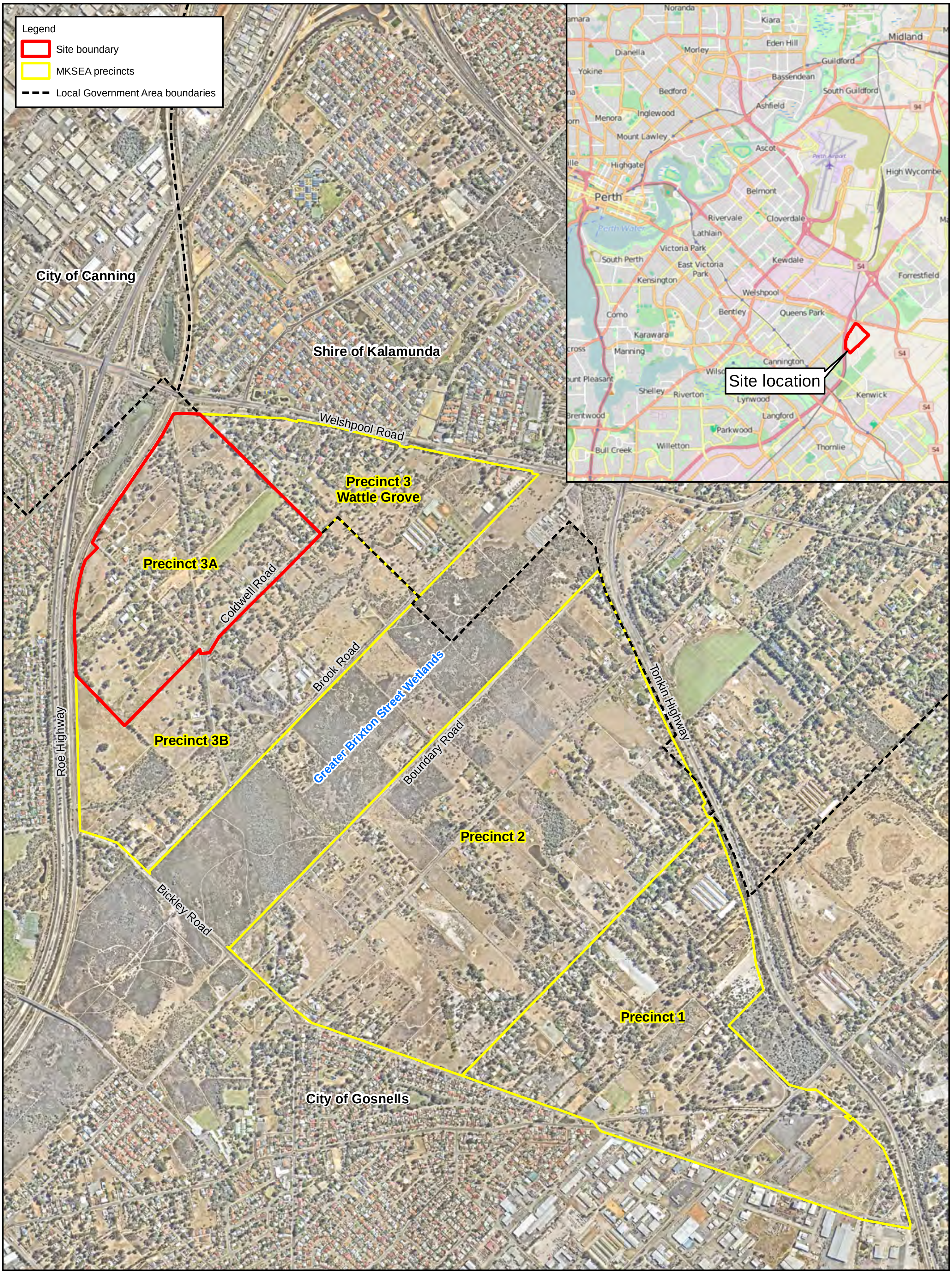

Figure 1:	**Location Plan**	**Plan Number: EP14-056(07)--F25a**	
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan	Drawn: ADB	Date: 23/03/2016
		Approved: JDH	Date: 23/03/2016
Client:	Linc Property Pty Ltd	Checked: ADB	Scale: 1:20,000@A4

0 200 400 800 Metres

emerge ASSOCIATES
Integrated Science & Design

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

Figure 2:	**Site Plan**		**Plan Number: EP14-056(07)--F26a**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan		Drawn: ADB Date: 23/03/2016 Approved: JDH Date: 23/03/2016 Checked: ADB Scale: 1:7,500@A4
Client:	Linc Property Pty Ltd		0 75 150 300 Metres

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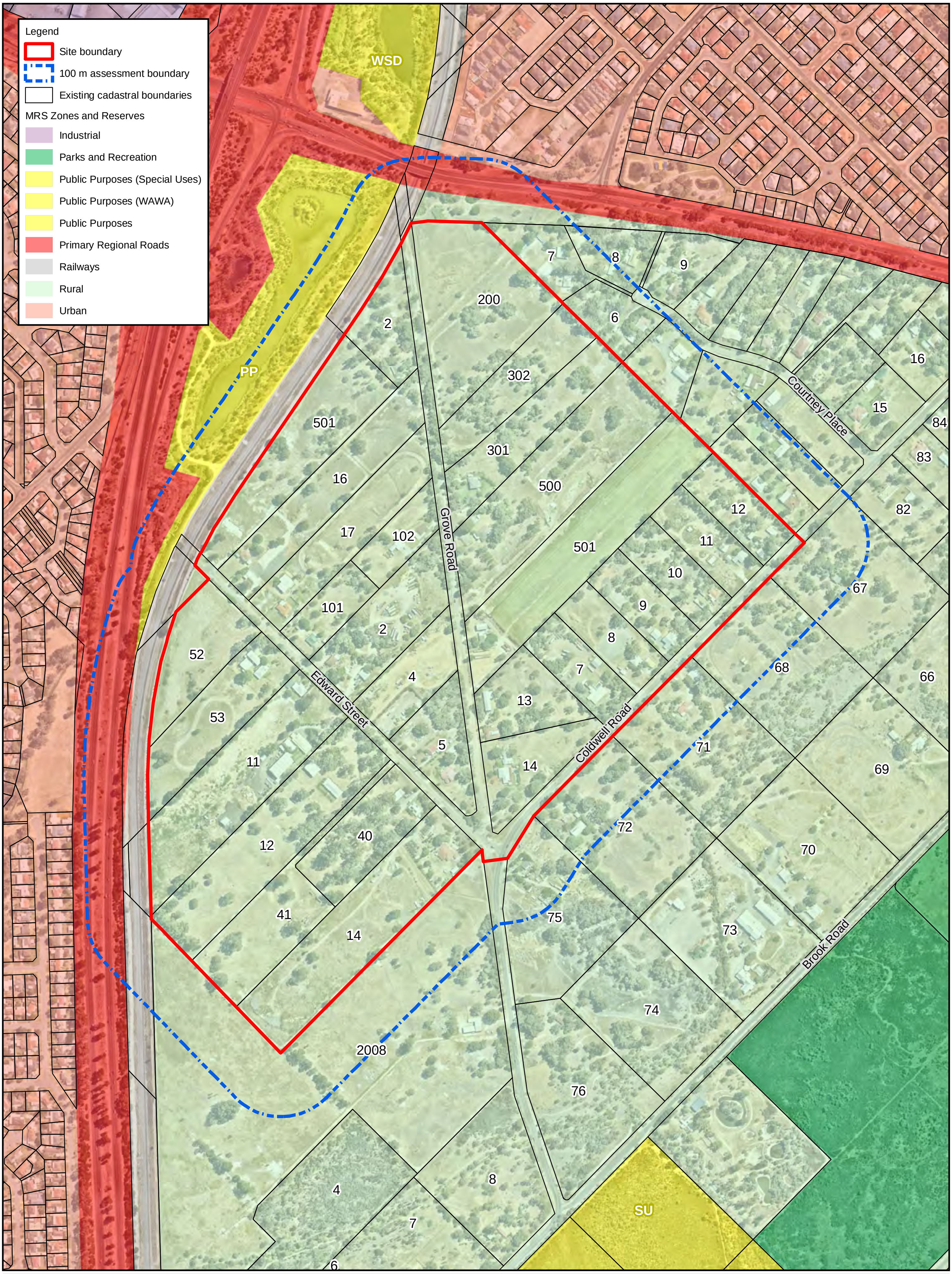

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Figure 3:	Existing Metropolitan Region Scheme
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(07)--F35a

Drawn:	ADB	Date:	23/03/2016
Approved:	JDH	Date:	23/03/2016
Checked:	ADB	Scale:	1:7,500@A4

0 75 150 300 Metres

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Figure 4:	Bushfire Prone Areas
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(07)--F36a			
Drawn:	ADB	Date:	23/03/2016
Approved:	JDH	Date:	23/03/2016
Checked:	ADB	Scale:	1:7,500@A4

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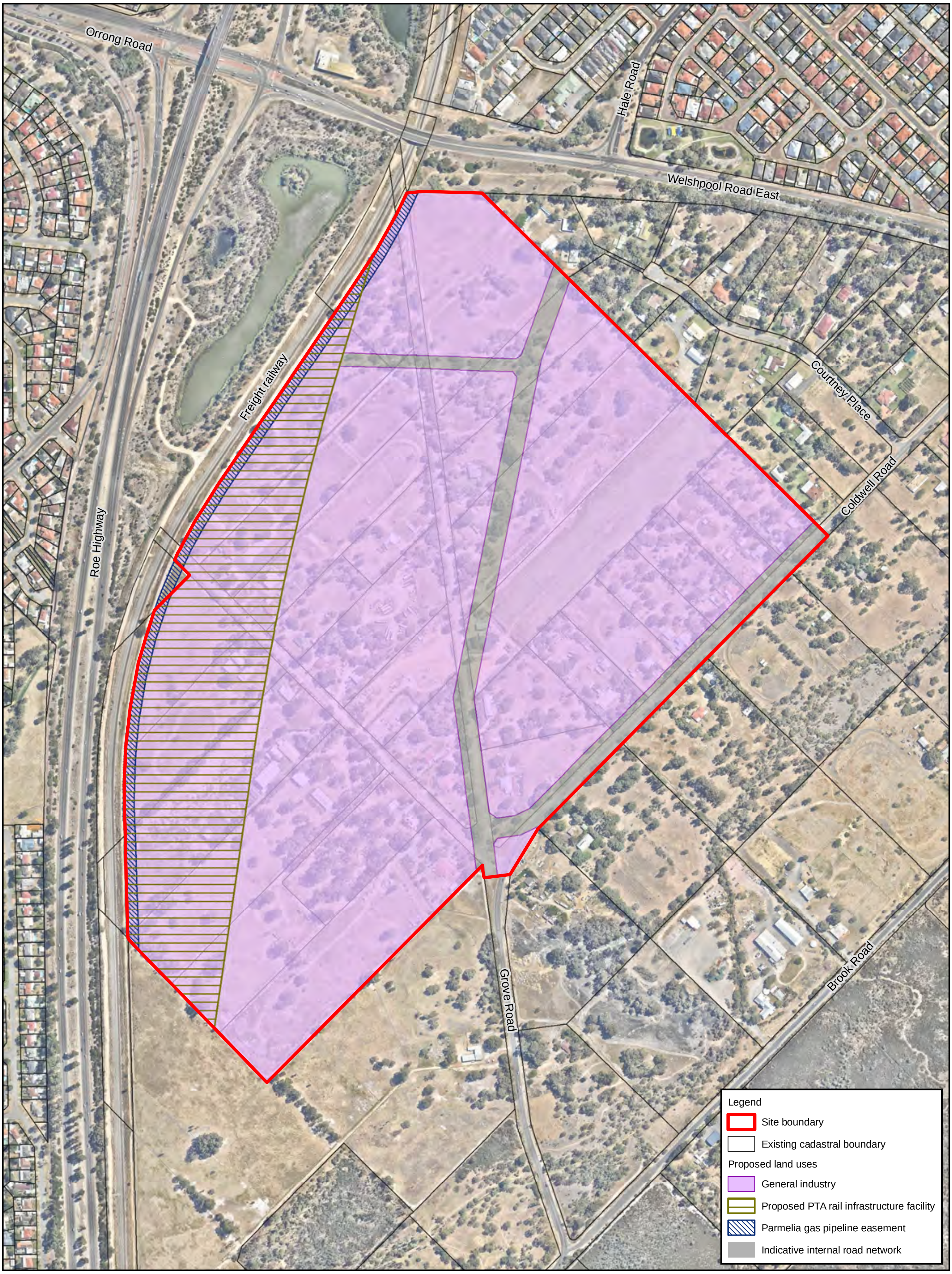

Figure 5:	**Proposed Structure Plan**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(07)--F37d

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Approved:	CKK	Date:	12/09/2016
Checked:	CKK	Scale:	1:7,000@A4

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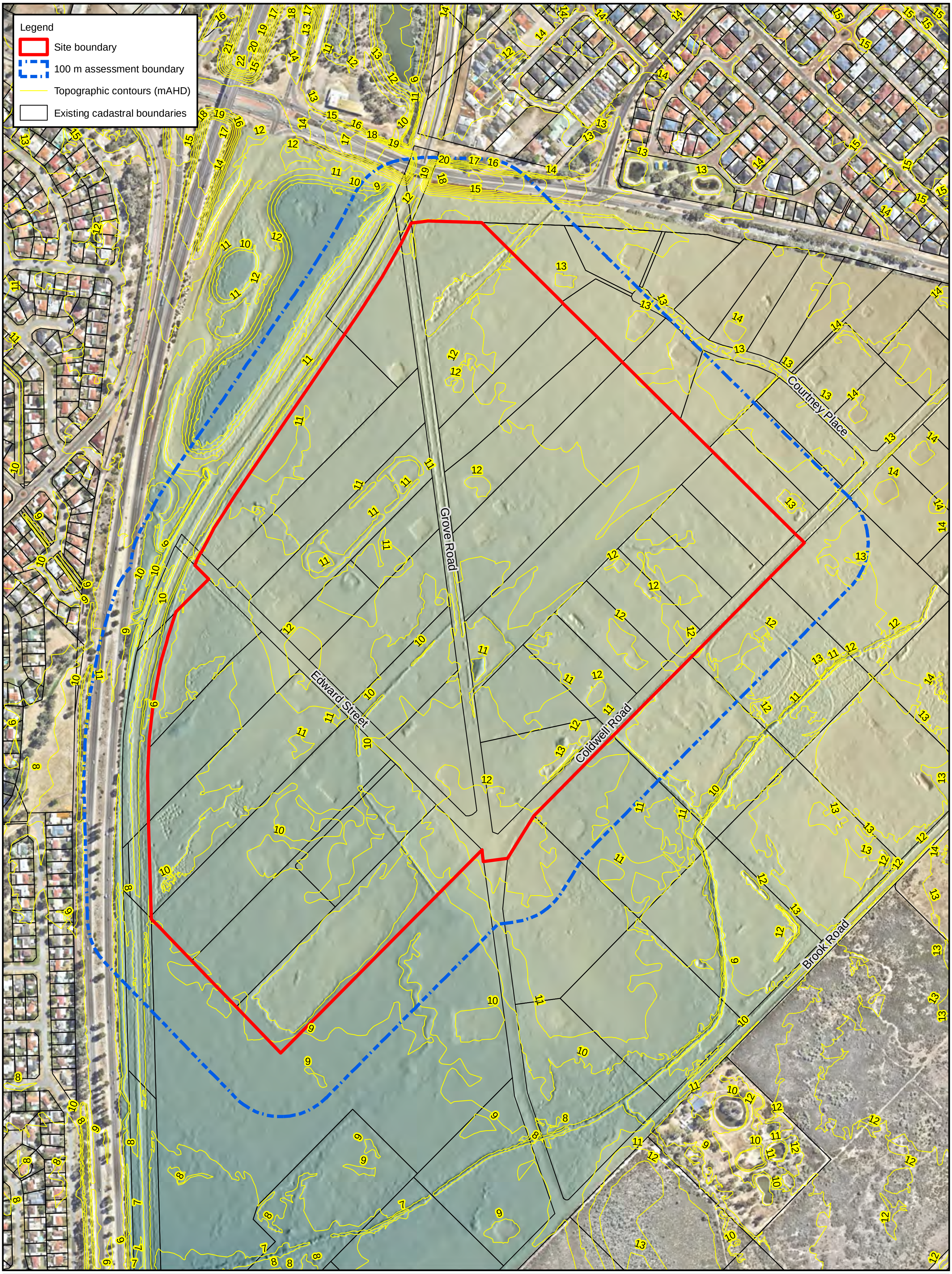

Figure 6: Site Topography

Project: Bushfire Management Plan
MKSEA Precinct 3A Structure Plan

Client: Linc Property Pty Ltd

Plan Number: EP14-056(07)--F38a			
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Approved:	JDH	Date:	23/03/2016
Checked:	ADB	Scale:	1:7,500@A4

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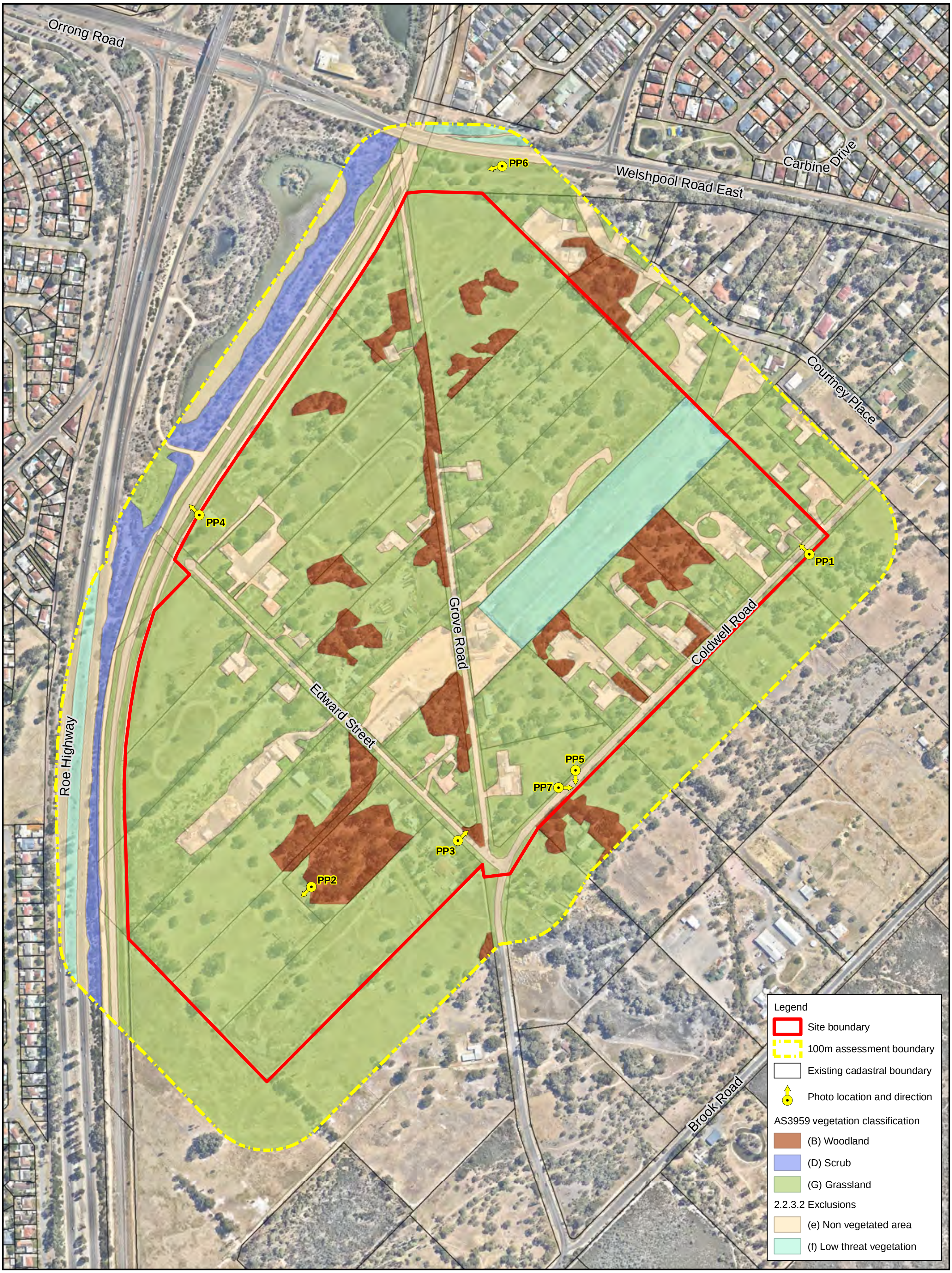

Figure 7:	**Pre-Development AS 1959 Vegetation Classifications**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(07)--F39d

Drawn:	KNM	Date:	16/09/2016
Approved:	JDH	Date:	16/09/2016
Checked:	CKK	Scale:	1:7,000@A4

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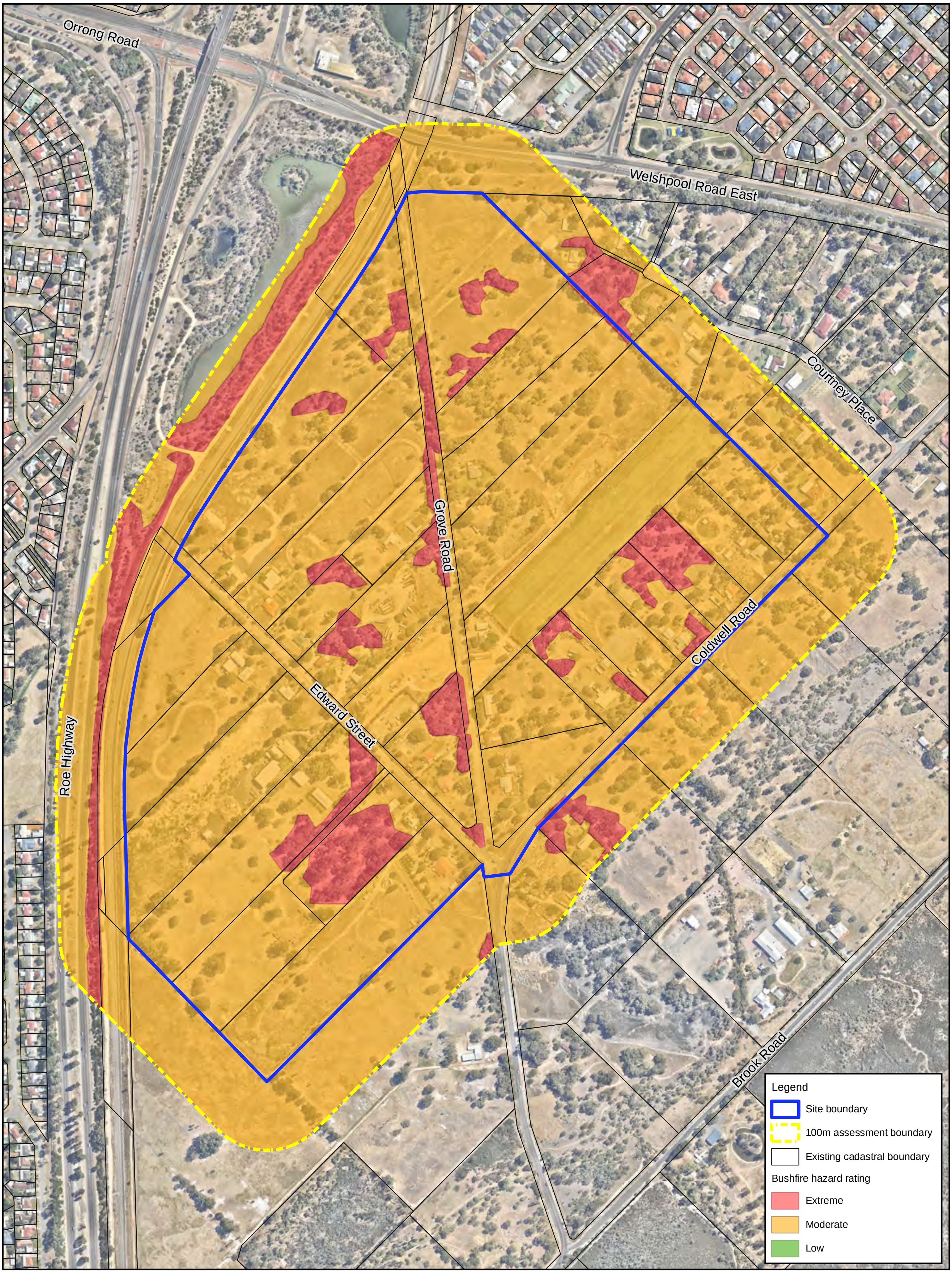

Figure 8:	**Pre-Development Bushfire Hazard Ratings**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

N

Plan Number: EP14-056(07)--F40c			
Drawn:	KNM	Date:	09/08/2016
Approved:	CKK	Date:	12/09/2016
Checked:	CJT	Scale:	1:7,000@A4

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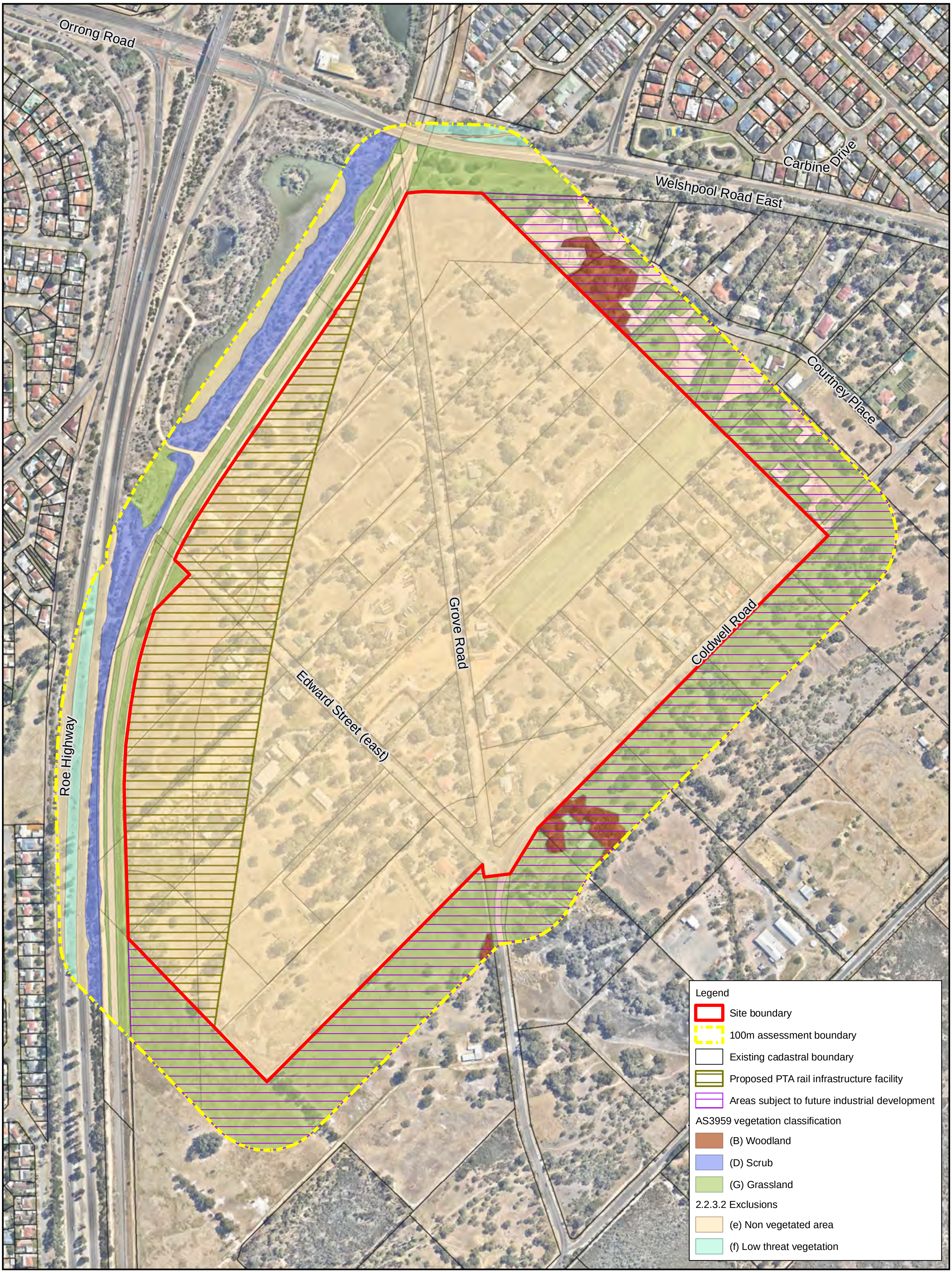

Figure 9:	**Post-Development AS 1959 Vegetation Classifications**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(07)--F41b

Drawn:	KNM	Date:	09/08/2016
Approved:	CKK	Date:	12/09/2016
Checked:	CJT	Scale:	1:7,000@A4

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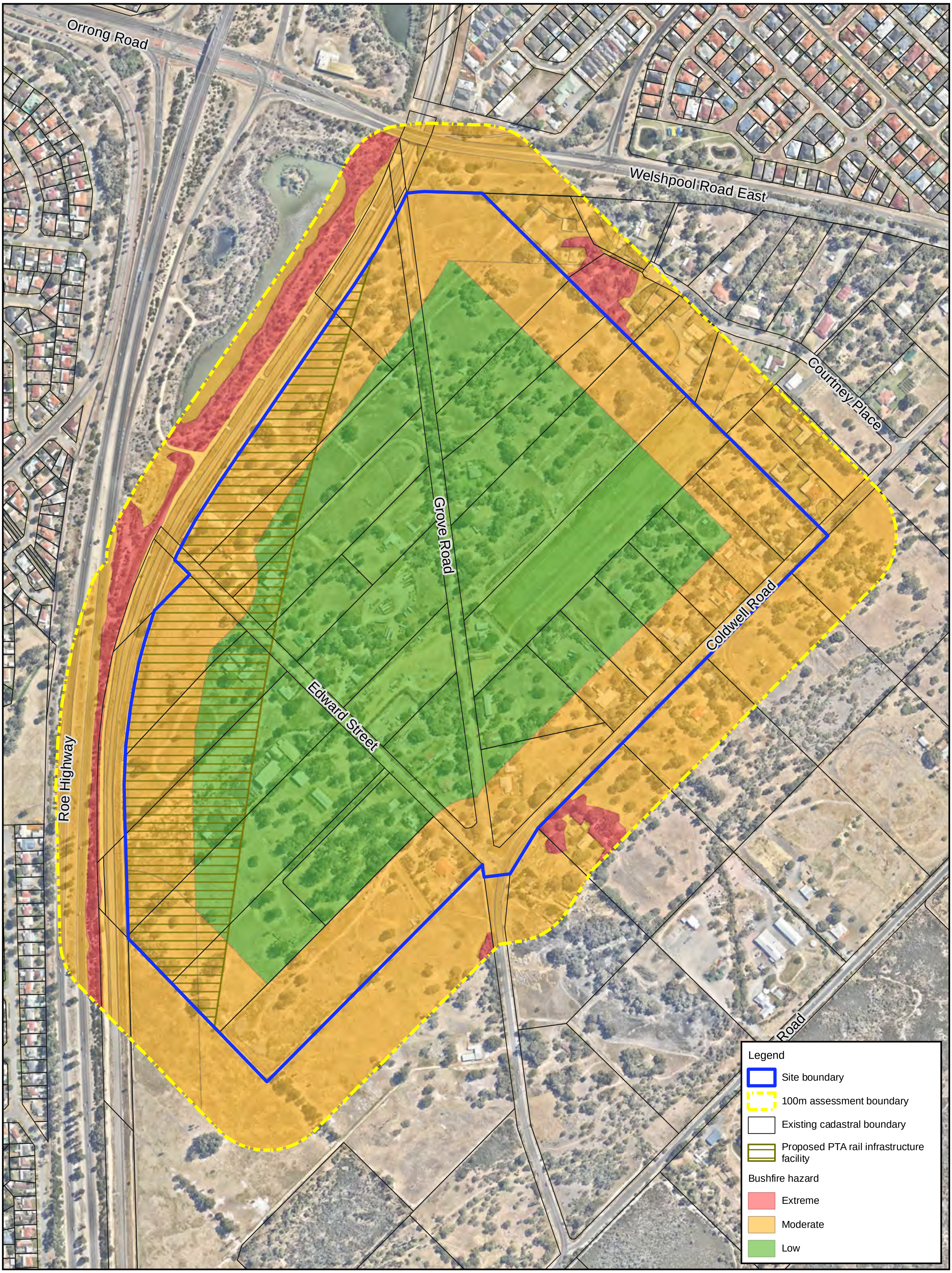

Figure 10:	**Post-Development Bushfire Hazard Ratings**		
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan		
Client:	Linc Property Pty Ltd.		

Plan Number: EP14-056(07)--F42d

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Approved:	CKK	Date:	12/09/2016
Checked:	CJT	Scale:	1:7,000@A4

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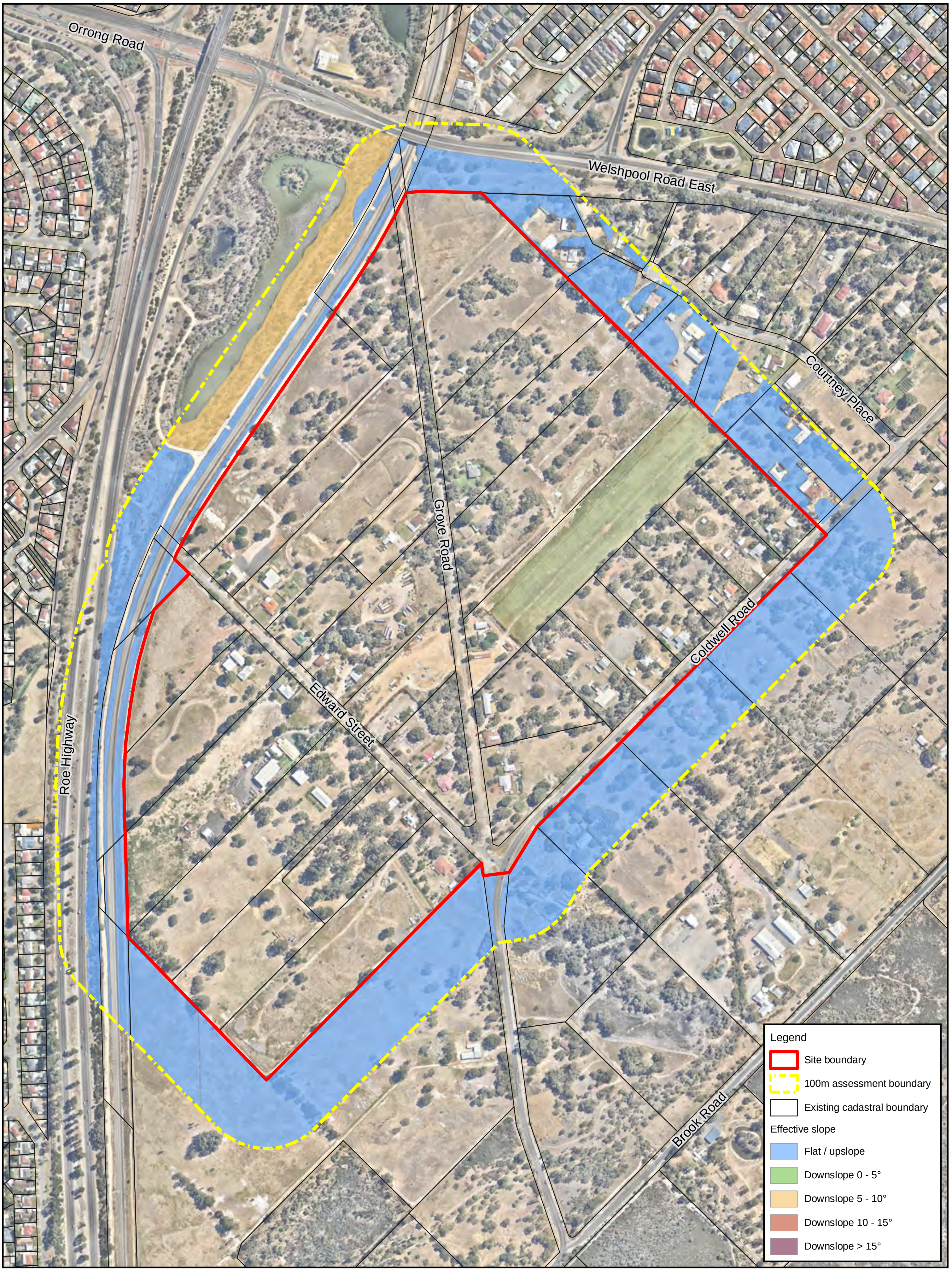

Figure 11:	**Post-Development Effective Slope**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(07)--F61a

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Approved:	CKK	Date:	12/09/2016
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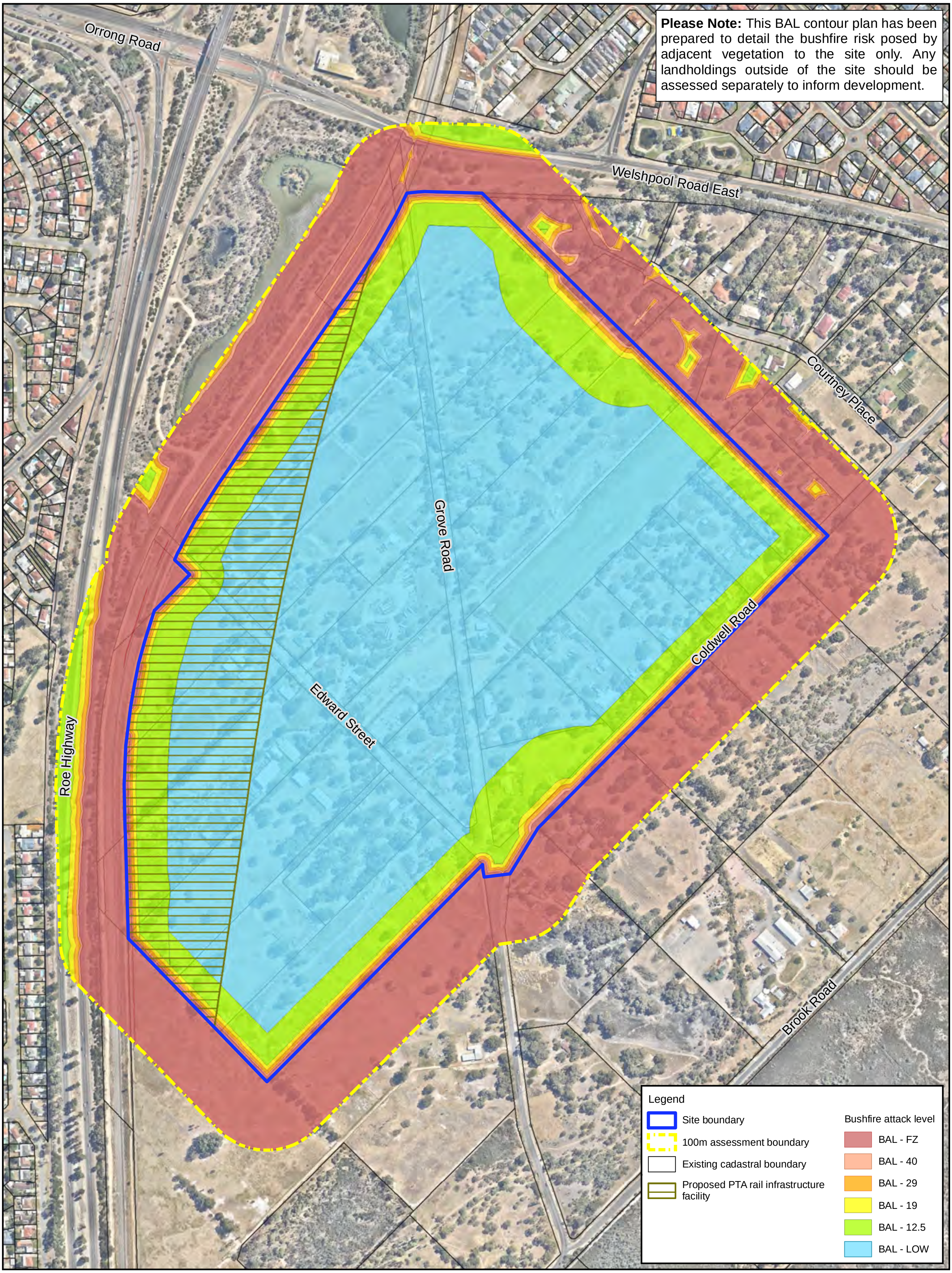

Figure 12:	**Post-Development Bushfire Attack Level Contour Map**
Project:	Bushfire Management Plan MKSEA Precinct 3A Structure Plan
Client:	Linc Property Pty Ltd.

Plan Number: EP14-056(07)--F62b

Drawn:	KNM	Date:	09/08/2016
Approved:	CKK	Date:	12/09/2016
Checked:	CJT	Scale:	1:7,000@A4

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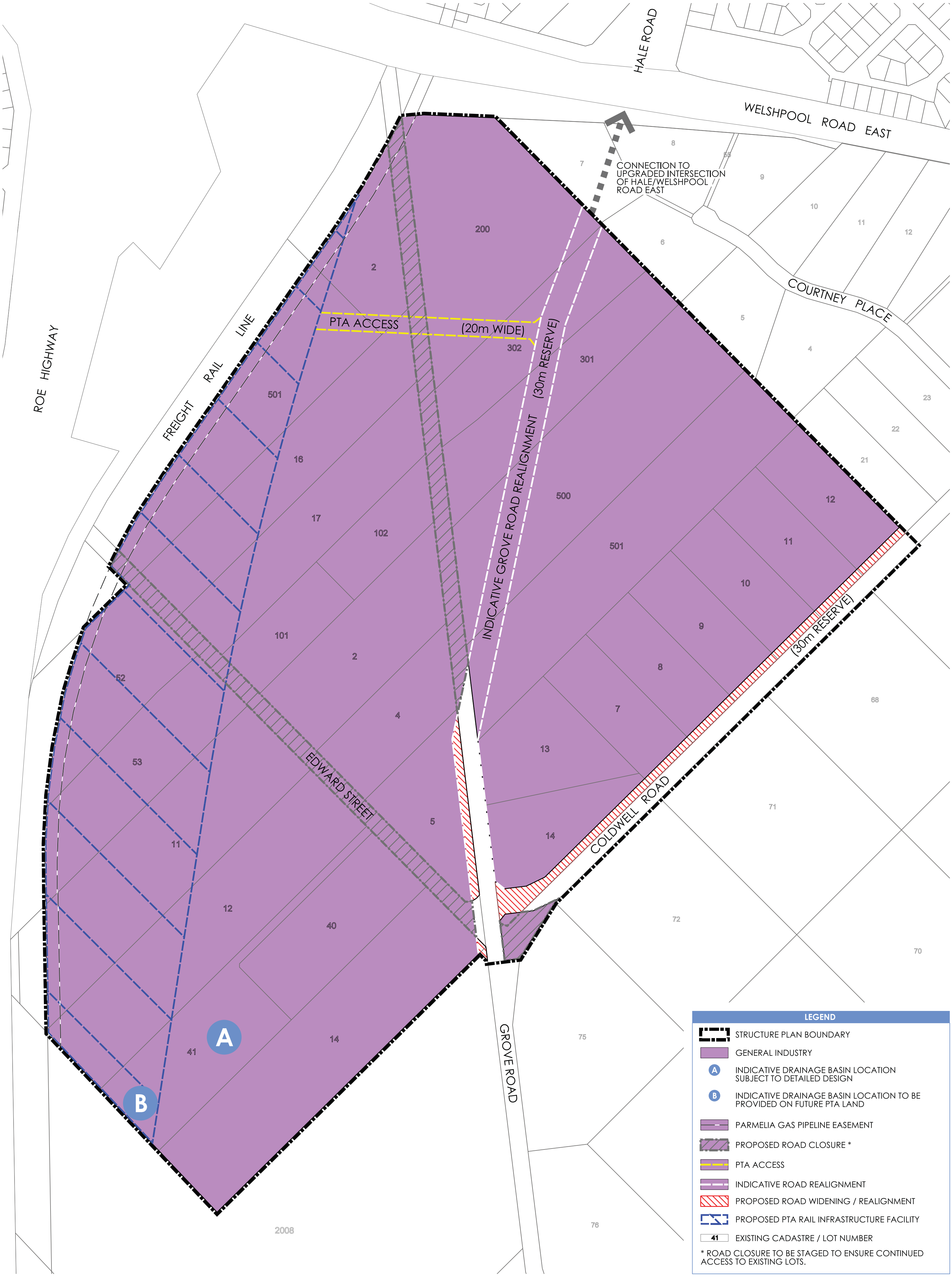
APPENDIX A

PRECINCT 3A STRUCTURE PLAN (TBB 2016)



PLAN 1 | STRUCTURE PLAN

Maddington - Kenwick Strategic Employment Area - Precinct 3A

A LINC PROPERTY PROJECT

0m 25 50 75m

s: 1:2,000@A1
d: 4 May 2016
p: 15/073/024L

Taylor Burrell Barnett Town Planning and Design
187 Roberts Road Subiaco Western Australia 6008
p: (08) 9382 2911 f: (08) 9382 4586
e: admin@tbbplanning.com.au

APPENDIX B

COMPLIANCE CHECKLIST

Appendix B: Compliance Checklist

ELEMENT/QUESTION	RESPONSE
1: Location	
Does the proposal comply with the performance criteria by applying acceptable solution A1.1?	Yes.
2: Siting and design of the Development	
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?	Not applicable. The performance criteria P2 is achieved through the provision of a compliant APZ.
3: Vehicular access	
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?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A3.3?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.4?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.5?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.6?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.7?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.8?	Not applicable.
4: Water	
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?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	Not applicable.

Applicant Declaration

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

Signature:

Name: Jason Hick

Date: 02/06/2016

APPENDIX C

CITY OF GOSNELLS ANNUAL FIRE HAZARD REDUCTION NOTICE

Annual Fire Hazard Reduction Notice
Bush Fires Act 1954 Section 33(1)

To prevent bush fires and to minimise the spread of a bush fire, all owners and occupiers of land within the City's district are required to comply with the requirements of this Annual Fire Hazard Reduction Notice.

For the purposes of this Notice, flammable matter includes, but is not limited to, vegetation (except for living trees, shrubs, plants and lawns under cultivation), prunings, cardboard, wood, paper, general rubbish and any other combustible material.

1. Owners or occupiers of land zoned 'General Rural' or 'Special Rural'

On or before 30 November each year, all owners or occupiers of land zoned 'General Rural' or 'Special Rural' under the City of Gosnells Town Planning Scheme No. 6 are required to:

a. Clear and maintain the land free of all flammable matter to a height no greater than 10cm; or

b. Maintain a mineral earth firebreak immediately inside all external boundaries of each lot on the land and maintain a mineral earth firebreak within 20m of all haystacks and stockpiled flammable matter.

Mineral earth firebreaks must be continuous (no dead ends) and maintained to a minimum standard of 3m wide by 4m high (vertical clearance) so as to provide unimpeded access for emergency vehicles. Driveways must also be maintained to these standards.

Firebreaks are intended to provide safe access on your property for emergency vehicles and to ensure fire does not travel under the vehicles or underfoot.

Note: The firebreaks and requirements set out above must be maintained up to and including 30 April in the following year.

2. Owners or occupiers of all other land, which is not zoned 'General Rural' or 'Special Rural'

At all times throughout the year, all owners or occupiers of land zoned other than 'General Rural' or 'Special Rural' under the Scheme are required to clear and maintain the land free of all flammable matter to a height no greater than 10cm.

Permission needed to vary requirements

If, due to the topography or other constraints of your land, you are unable to adhere to the requirements set out in this Notice, you may apply in writing to the City for permission to provide firebreaks in alternative locations or take alternative measures.

Unless and until permission in writing is granted by the City, you shall comply with the requirements of this Notice.

All land owners

Further to the above minimum requirements, the landowner may receive a separate written notice, sent to the address shown on the City of Gosnells rates record, requiring additional works which may be considered necessary by Council or an Authorised Officer of the City.

Penalty for non-compliance

Failing to comply with the requirements of this Notice is an offence under the Bush Fires Act 1954 (Act), which carries a penalty of up to $5,000. In addition, where the owner or occupier of the land fails to comply with a Notice given pursuant to Section 33(1), the City may enter the land to carry out the work required to comply with the Notice and also recover any costs and expenses incurred in carrying out that work from the owner or occupier of the land.

Burning rubbish, refuse or other material

A person shall not on any land less than 2000 square metres in area, set fire to or cause to be set on fire, any rubbish, refuse or other material.

Restricted Burning	Prohibited Burning	Restricted Burning
Permits required from 1 October to 30 November	From 1 December to 31 March	Permits required from 1 April to 31 May

Restricted and prohibited burning periods may be modified due to un-seasonal weather patterns. Changes will be advertised.

Prohibited burning times

During the prohibited burning times it is unlawful to set fire to or cause to be set on fire, any rubbish, refuse or other material.

Restricted burning times

During the restricted burning times, it is unlawful to set fire to or cause to be set on fire, any rubbish, refuse or other material without a permit.

Other times

At all other times, burning is permitted subject to compliance with the requirements of *Clause 22, 31 and 32* of the *City of Gosnells Animal, Environment and Nuisance Local Law 2009*.

Note: At all times the Department of Fire and Emergency Services should be notified on 9395 9209 at least 15 minutes prior to commencing your burn.

To apply for a permit visit www.gosnells.wa.gov.au or attend the Civic Centre during office hours.

The issuing of a permit does not preclude any state government regulations or requirements, that may apply to burning of the material.

City of Gosnells
PO Box 662
Gosnells WA 6990

9397 3000

council@gosnells.wa.gov.au
www.gosnells.wa.gov.au

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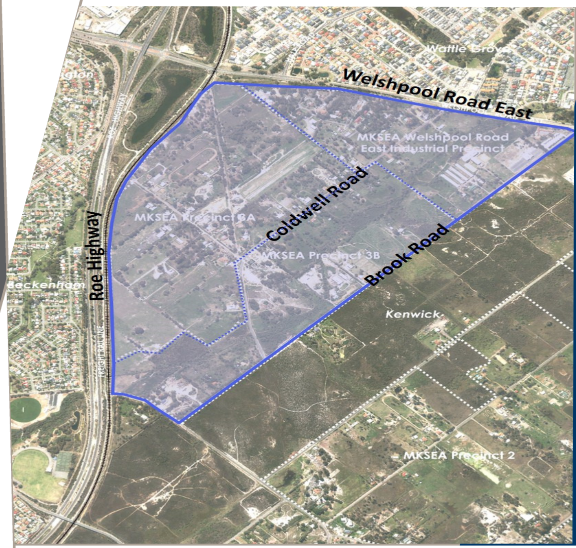
APPENDIX 3
TRAFFIC IMPACT ASSESSMENT

MKSEA Precinct 3

Transport Assessment

CW937700



Prepared for
Linc Property Pty. Ltd

July 2016

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Author(s):

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Approved By:

Ray Cook
Manager Traffic and Transport

Document Information

Prepared for	Linc Property Pty. Ltd
Project Name	Transport Assessment
Job Reference	CW937700
Date	4 July 2016
Revision Number	E
Effective Date	July 2016
Date Approved:	July 2016

Document History

Revision	Effective Date	Description of Revision	Prepared by:	Reviewed by:
A	18/12/15	Working Draft	Andreas Wang	Ray Cook
B	29/03/16	Draft	Andreas Wang	Ray Cook
C	02/05/16	Final Draft	Andreas Wang	Ray Cook
D	04/05/16	Final	Sneha Rapur	Ray Cook
E	04/07/16	Amended Final with AIMSUN Results	Andreas Wang	Ray Cook

Executive Summary

This Transport Assessment has been prepared in accordance with the Western Australia Planning Commission (WAPC) *Transport Assessment Guidelines for Developments: Volume 2 – Structure Plan (2006)* and outlines the transport aspects of Precinct 3 (incorporating Precincts 3A, 3B and Welshpool Road East Industrial Precinct) for the Maddington Kenwick Strategic Employment Area (MKSEA) and focuses on the traffic operations, access arrangements and road reservation widths within the area.

The following conclusions have been made in regard to the proposed Precinct 3 which includes the Precinct 3A Structure Plan:

- This Transport Assessment has been prepared based on the assumptions and data adopted for the entire MKSEA.
- Precinct 3 comprises a gross area of approximately 200ha of land, including 147ha of general industrial land use, 15ha for drainage and natural reserve (including Yule Brook) 17ha of road reservation and 20ha for Rail Infrastructure Facility to be utilised by the Public Transport Authority (PTA).
- Consistent with the Traffic Assessment undertaken for the entire MKSEA area, the land uses within the Precinct 3 will generate an estimated 603 trips during the AM peak hour period and 501 trips for the PM peak hour period upon full build-out of Precinct 3.
- Analysis of AIMSUN micro-simulation results for the scenarios evaluated suggest that the access options described in Scenarios 2 and 3 will result in acceptable LOS for all turning movements at the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road and are the most efficient operation of the entire model network.
    - Scenario 3 was found to have several advantages over Scenario 2 in terms of practical considerations and is therefore the preferred access configuration to the area.
- The proposed road cross-sections will allow for the provision of on-road cycle facilities and pedestrian facilities on the verge.
- In order to facilitate the development of the proposed industrial land uses within MKSEA, it is recommended to permit RAV4 vehicles (as a minimum) on all internal MKSEA roads.

Table of Contents

Figures

Appendices

1 Introduction

1.1 Background

Cardno was commissioned by Linc Property Pty Ltd to prepare a Transport Assessment for the proposed Maddington Kenwick Strategic Employment Area (MKSEA) Precinct 3 area which incorporates land contained in the City of Gosnells (Precincts 3A and 3B) and Shire of Kalamunda (Welshpool Road East Industrial Precinct).

This report has been prepared in accordance with the Western Australian Planning Commission (WAPC) *Transport Assessment Guidelines for Developments: Volume 2 – Structure Plan (2006)* and the checklist is included in **Appendix A**. Specifically, this report aims to assess the operations of the proposed development internally, its connections to the adjacent road network, with a focus on the traffic operations, access arrangements and road reservation widths within the area. This report will support the detailed structure planning for the locality.

This report also outlines the requirements and opportunities associated with traffic and transport within the development area, referencing relevant WAPC policies and guidelines as well as best-practice planning practice within Western Australia.

1.2 Site Location and Description

Precinct 3 is located at Kenwick, as indicated on **Figure 1-1** and covers a gross area of approximately 200 hectares (ha). Precinct 3 is likely to be developed as three sub areas as depicted at **Figure 1-2.**

Figure 1-1 Indicative Location of MKSEA Precinct 3

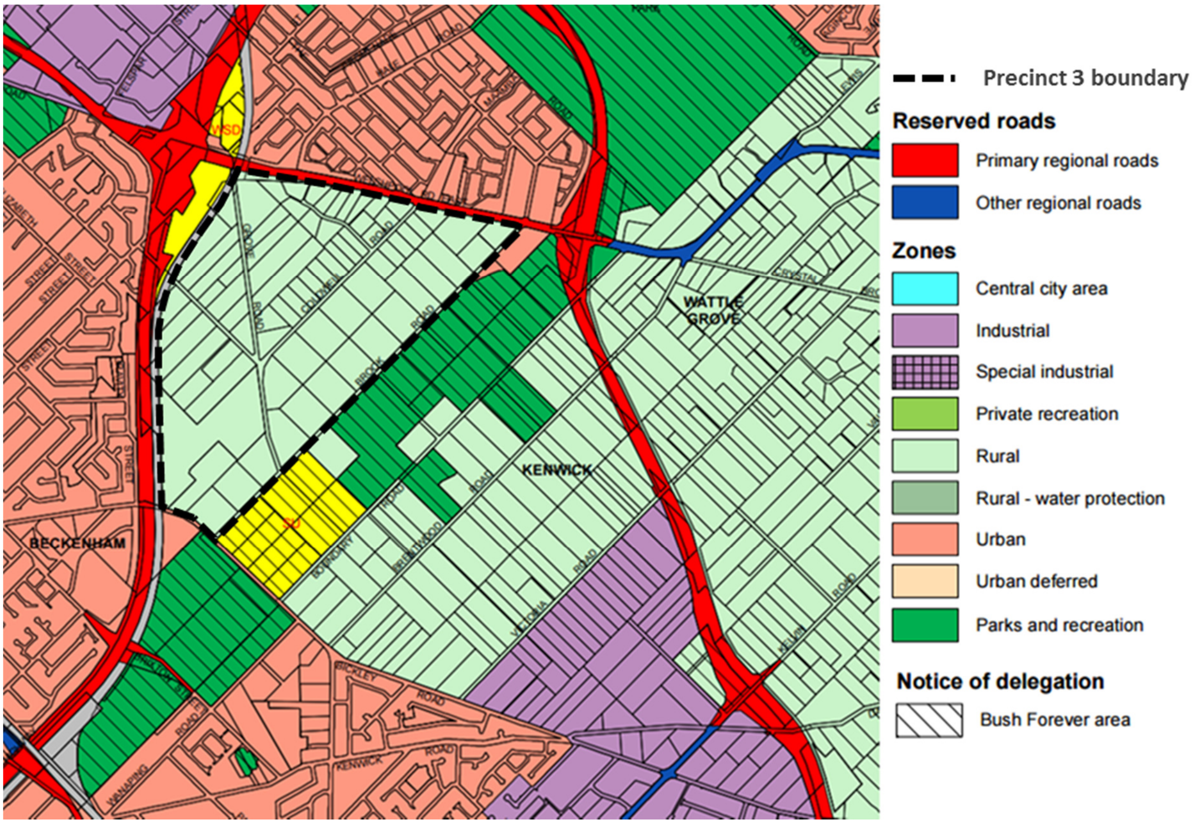
Figure 1-2 MKSEA Precinct 3 - Sub Areas

2 Existing Situation

2.1 Existing Land Uses within and Adjacent to Structure Plan Area

As shown in **Figure 2-1**, the land within the structure plan area is currently zoned as rural, with the area to the southeast zoned ‘Parks and Recreation’ and designated as a ‘Bush Forever area’. The WAPC has initiated MRS amendments to rezone the subject area to ‘Industrial’ and the City of Gosnells has initiated TPS amendments to rezone Precincts 3A and 3B to General Industry and Business Development respectively. The transport assessment is based on the ultimate land use of the area as Industrial.

Figure 2-1 Existing Zoning of Land within and Adjacent to Structure Plan Area

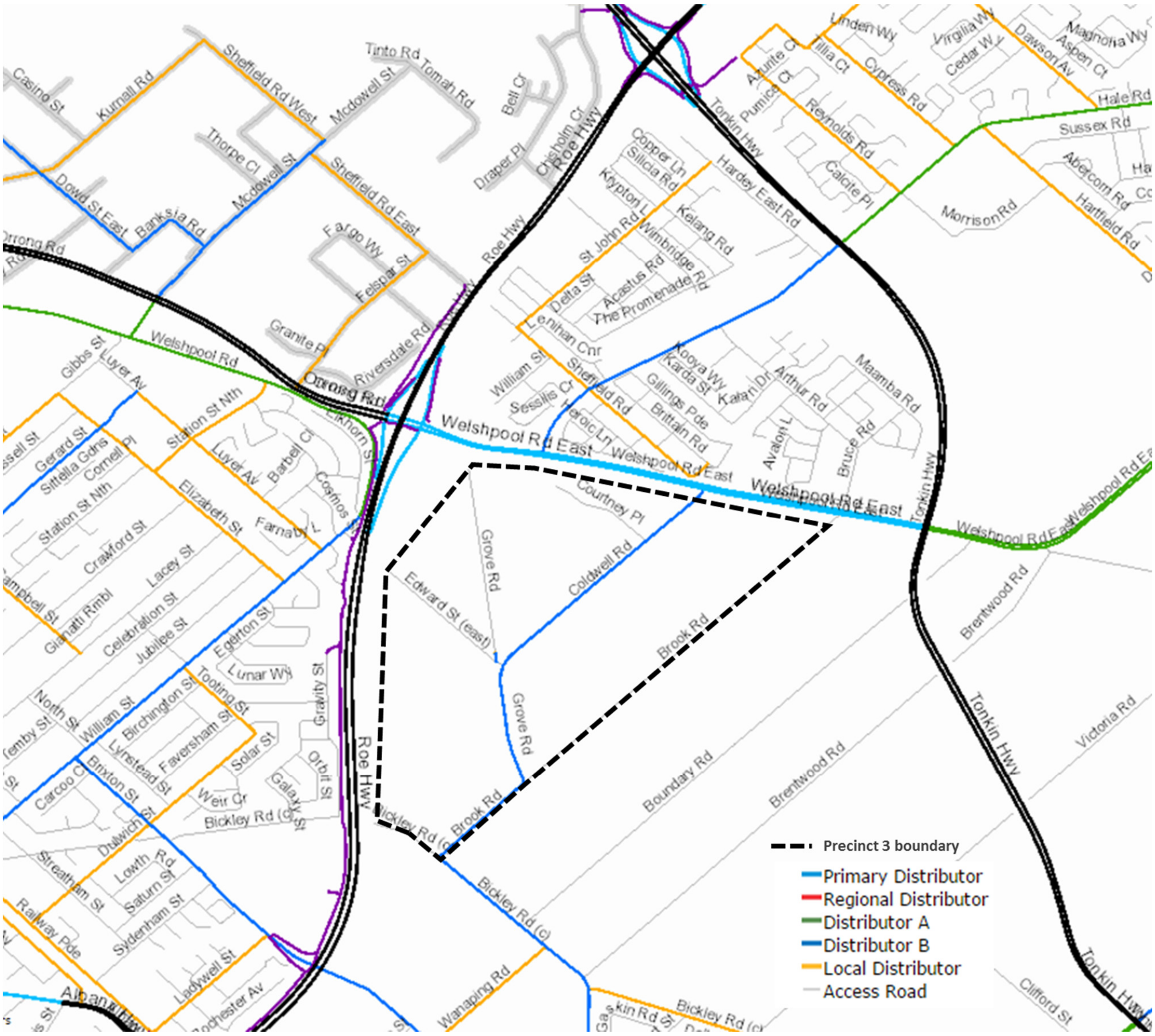


Source: Metropolitan Region Scheme (Map 20 – Langford), Department of Planning, 2015

2.2 Existing Road Network

The existing road network within and surrounding the structure plan area is shown in **Figure 2-2** below.

Figure 2-2 Existing Road Network Surrounding



The following discusses the characteristics of the surrounding road network:

- **Welshpool Road East** is classified as a *Primary Distributor* according to the MRWA *Metropolitan Functional Road Hierarchy* (MFRH) with a posted speed of 70 km/h.
- **Roe Highway** is classified as *Primary Distributor* with a posted speed of 100 km/h. It forms a part of the RAV 7 network.
- **Tonkin Highway** is classified as *Primary Distributor* with a posted speed of 100 km/h. It forms a part of the RAV 7 network (west of Roe Highway).
- **Coldwell Road** is classified as a Distributor B according to the MRWA MFRH with posted speed of 60 km/h. Coldwell Road currently serves as the primary point of access into and out of the area. Along with Grove Road and portions of Brook Road, it is designated MRWA RAV 2 and RAV 3 codes. Refer Section 5.4.1.

Road classifications are defined in the MFRH as follows:

Primary Distributors: provide for major regional and inter-regional traffic movements and carry large volumes of generally fast moving traffic. Some are strategic freight routes and are all State Roads. Primary Distributors are managed by MRWA.

Regional Distributors: Roads that are not Primary Distributors, but which link significant destinations and are designed for efficient movements of people and goods within and beyond regional areas. Regional Distributors are managed by local government.

Local Distributors: Roads that carry traffic within a cell and link District Distributors or Primary Distributors at the boundary, to access roads. The route of Local Distributors should discourage through traffic so that the cell formed by the grid of higher order distributor roads, only carries traffic belonging to, or serving the area.

Access Roads: Provide access to abutting properties with safety aspects having priority over the vehicle movement function. In urban area, these roads are bicycle and pedestrian friendly, with aesthetics and amenity also important. Access Roads are managed by local government.

2.3 Existing Traffic Volumes

Existing weekday traffic volumes were obtained from Main Roads WA for Welshpool Road and traffic counts were undertaken by Cardno for Coldwell Road. These traffic volumes are summarised in **Table 2-1Table 2-1**.

Table 2-1 Existing Weekday Traffic Volumes

Location	Year	Weekday Traffic Volumes (two-way)	
		AM Peak (7am-8am)	PM Peak (4pm-5pm)
Welshpool Road (MRWA)	2015	2,539	2,839
Coldwell Road (Cardno)	2015	327	391
Brook Road (Cardno)	2015	218	194
Roe Highway (MRWA)	2015	7,093	6,394

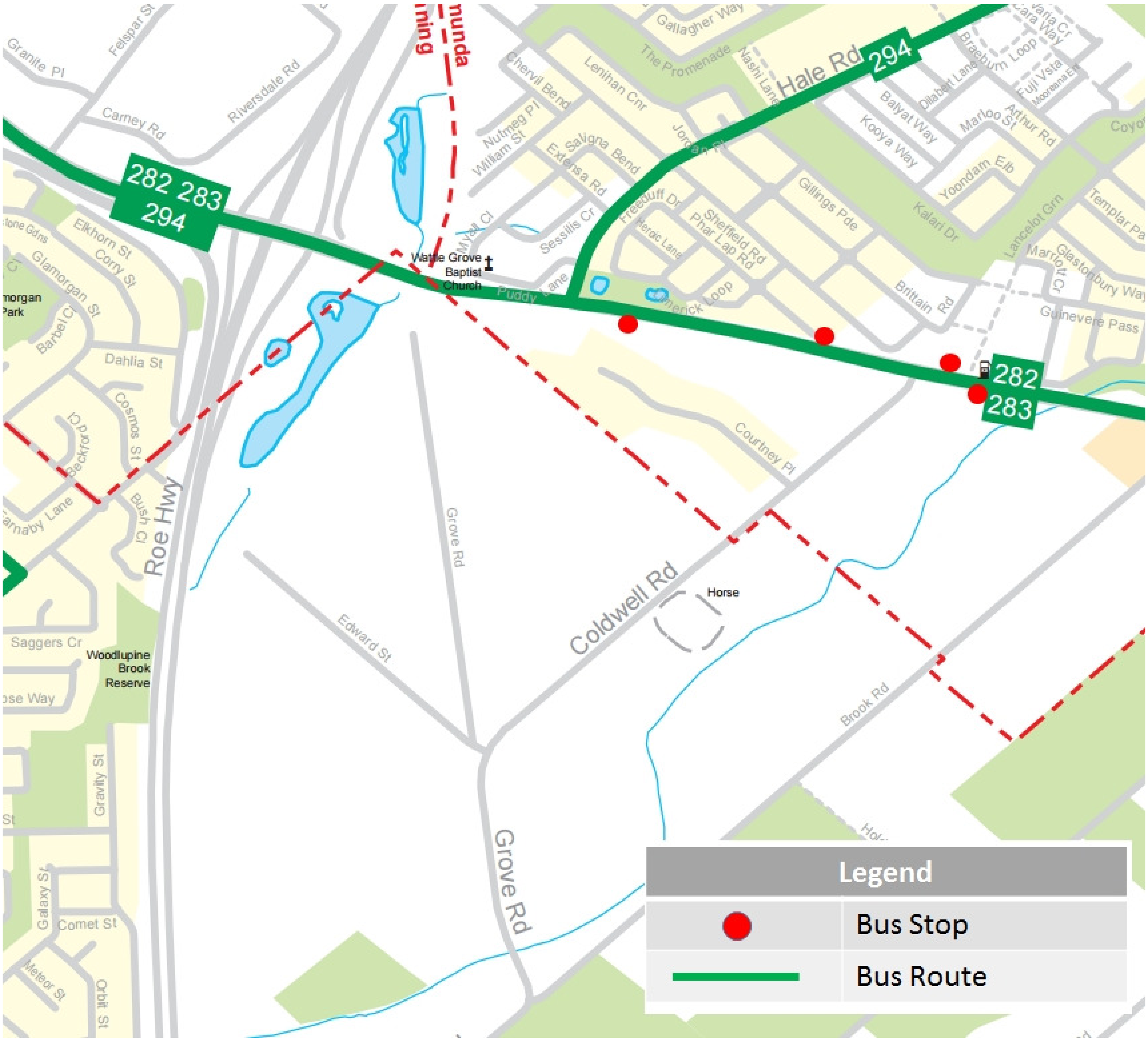
2.4 Existing Pedestrian/Cycle Networks

A 2.0m wide pedestrian footpath is currently provided on the northern side of Coldwell Road, between Welshpool Road and Courtney Place. No other pedestrian or cycle facilities are provided within the structure plan area.

2.5 Existing Public Transport Services

As shown in **Figure 2-3**, the structure plan area is not serviced by any existing Public Transport (PT) services. However, as shown in **Figure 2-3**, bus routes 282 and 283 run along Welshpool Road East, with bus stops located approximately 600m from the intersection of Welshpool Road East / Coldwell.

Figure 2-3 Existing PT Services and Bus Stops Adjacent to Structure Plan Area



(Source: TransPerth, 2015)

3 Changes to Surrounding Transport Networks

3.1 Proposed Changes to Surrounding Road Network

Cardno understands that by 2031, MRWA intend to upgrade both Tonkin Highway and Roe Highway to 3 lanes in each direction and diamond interchanges will be constructed at the intersections of Tonkin Highway / Welshpool Road and Tonkin Highway / Kelvin Road. As part of the Tonkin upgrade MRWA are contemplating severing access between Tonkin and Hale Road at the existing Tonkin/Hale intersection. The implications are discussed further in this report.

3.2 Changes to Pedestrian/Cycle Networks

There are no proposed changes to the pedestrian / cycle networks adjacent to MKSEA.

3.3 Public Transport

From consultation with the Public Transport Authority (PTA), is it understood that no changes to the existing public transport services along Welshpool Road are likely to occur within the foreseeable future. Advice from PTA suggest that due to the relatively low employment density associated with industrial land use, along with the lack of connectivity between the eastern and western precincts within MKSEA, it's highly unlikely that PTA would justify the provision of a public transport service to service the MKSEA.

3.4 Rail Infrastructure Facility

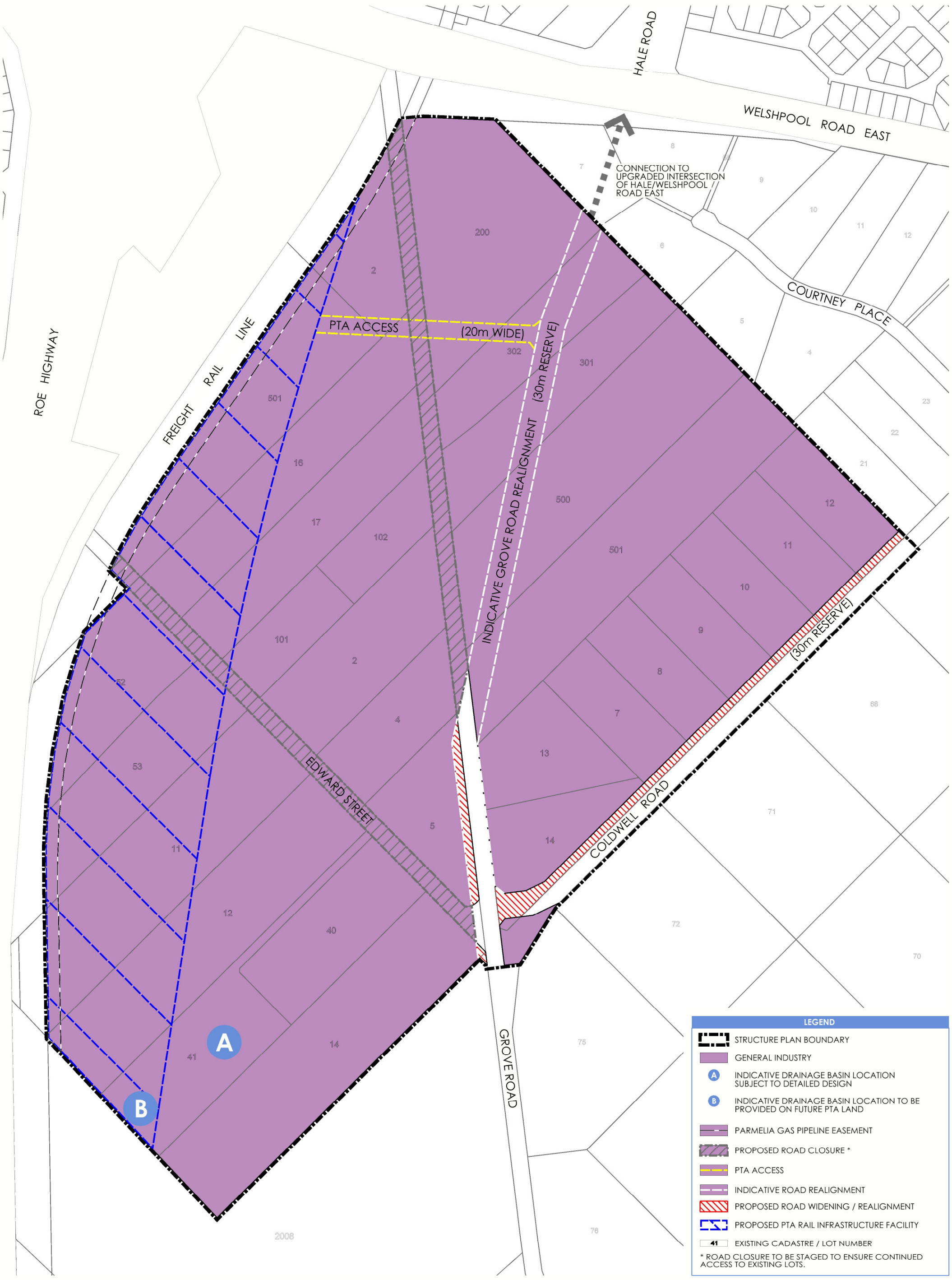
As shown in **Figure 4-1,** the western section of the structure plan area is proposed to be used by PTA as a Rail Infrastructure Facility to replace the current facility in Bellevue.

4 Proposed Development

4.1 Proposed Development Land Uses

Precinct 3 (including 3A, 3B and the Welshpool Road East Industrial Precinct) covers a total area of approximately 200ha. The Structure Plan area for precinct 3A is shown in **Figure 4-1** and covers a total area of approximately 125ha.

Figure 4-1 Proposed Structure Plan Layout for Precinct 3A



Source: Linc Property Pty Ltd

As shown in **Table 4-1**, the gross land area for industrial land use for the Precinct 3 areas is approximately 147ha.

Table 4-1 Proposed Development Area Land Use

Land Use	Gross Developable Area (ha)
General industry	147.3
Drainage and Natural Reserve (including Yule Brook)	15.4
Road Reserve	17.4
Rail Infrastructure Facility (PTA)	20.1
TOTAL	**200.2**

4.2 Precinct 3 Access arrangements

Access to Precinct 3 is proposed via the following intersections:

- Welshpool Road / Brook Road (priority controlled, left-in, left-out only)
- Brook Road / Bickley Road (priority controlled, full movements)
- Refer Section 5.3 for description of potential access options for the intersections of Welshpool Road / Hale Road / Grove Road (realigned) and Welshpool Road / Coldwell Road

4.3 Development Traffic Generation

As shown in **Table 4-1**, the Precinct 3 area is proposed to comprise of a total of **147.3 ha** of general industrial land use (167.4ha including the land required for the PTA Rail Infrastructure Facility).

Cardno previously prepared a Transport Assessment for the entire MKSEA area (refer MKSEA Transport Study Report dated February 2016) which was commissioned by the City of Gosnells and had been previously referred to relevant agencies.

Consistent with the Transport Assessment undertaken, the traffic generation for Precinct 3 is summarised in **Table 4-2**.

Table 4-2 Traffic Generation for the Proposed Land Uses within Structure Plan Area

	AM Peak Hour		PM Peak Hour	
Land Use	**Incoming**	**Outgoing**	**Incoming**	**Outgoing**
General Industrial/Industrial Development	497	106	133	368
TOTAL	**497**	**106**	**133**	**368**

4.4 Internal Road Layout

The proposed internal road layout for the Precinct 3A structure plan area is shown in **Figure 4-1**, while the proposed road cross-sections for the internal road network are described in **Section 5.2**

5 Analysis of Transport Network

5.1 Assessment Years and Time Periods

As stated in the Section 8.9.2 of the WAPC Transport Assessment Guidelines for Developments: Volume 2 – Structure Plans "*the analysis of the transport networks should therefore be undertaken for the (assumed) year of full development*". Assessment of MKSEA Precinct 3 is therefore undertaken for the 2031 horizon year, for the peak hour periods identified in **Section 2.3**.

In accordance with Section 8.9.3 of the WAPC *Transport Assessment Guidelines for Developments: Volume 2 – Structure Plans*, no analysis has been undertaken for daily traffic volumes.

5.2 Network Changes to Intersection of Tonkin Highway / Hale Road

Cardno understands that as part of Main Roads WA network planning for the area, the connectivity for Hale Road at the intersection of Hale Road / Tonkin Highway may be severed. Due to the unavailability of forecast data available for this intersection, it has conservatively been assumed that where reasonable, the affected turning movements currently undertaken at this intersection will instead utilise the intersection of Welshpool Road / Hale Road as shown in **Figure 5-1 - Figure 5-8**.

It is noted that the existing turning volumes at the intersection of Tonkin Highway / Hale Road have been estimated from SCATS data provided by Main Roads WA for this intersection.

Figure 5-1 Assumed Redirection of Northbound Left-Turning Traffic from Tonkin Highway

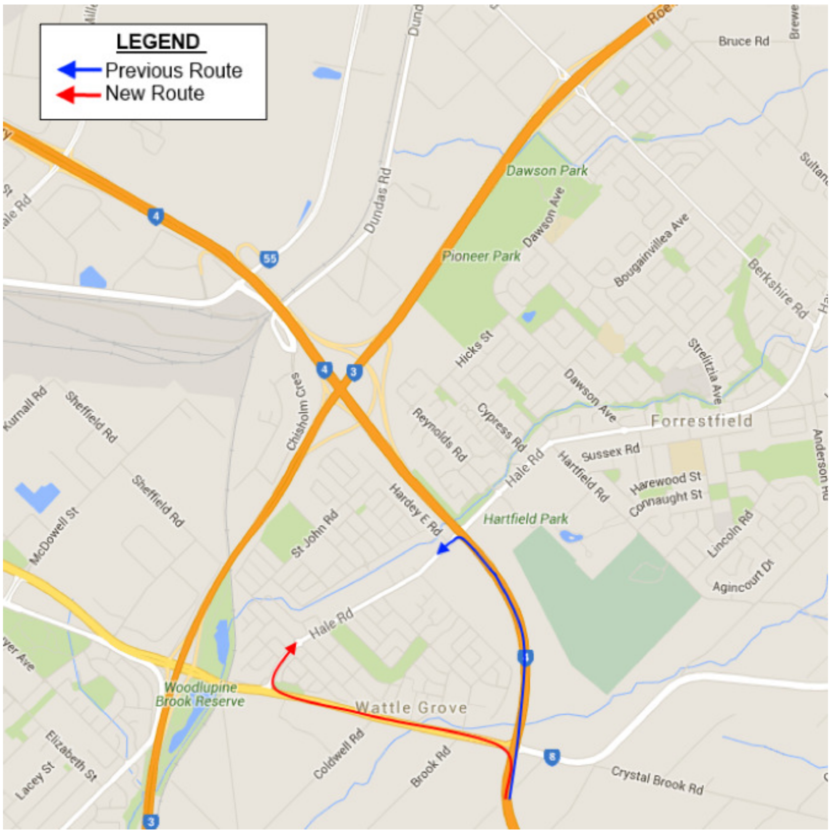


Figure 5-2 Assumed Redirection of Northbound Left-Turning Traffic from Hale Road to Tonkin Highway

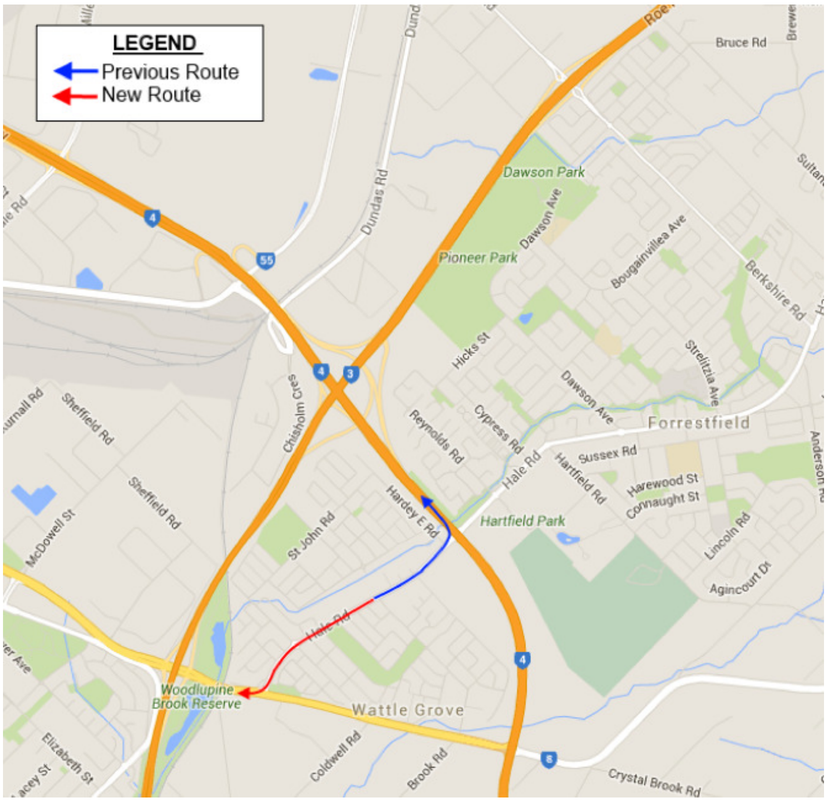


Figure 5-3 Assumed Redirection of Southbound Left-Turning Traffic from Tonkin Highway to Hale Road

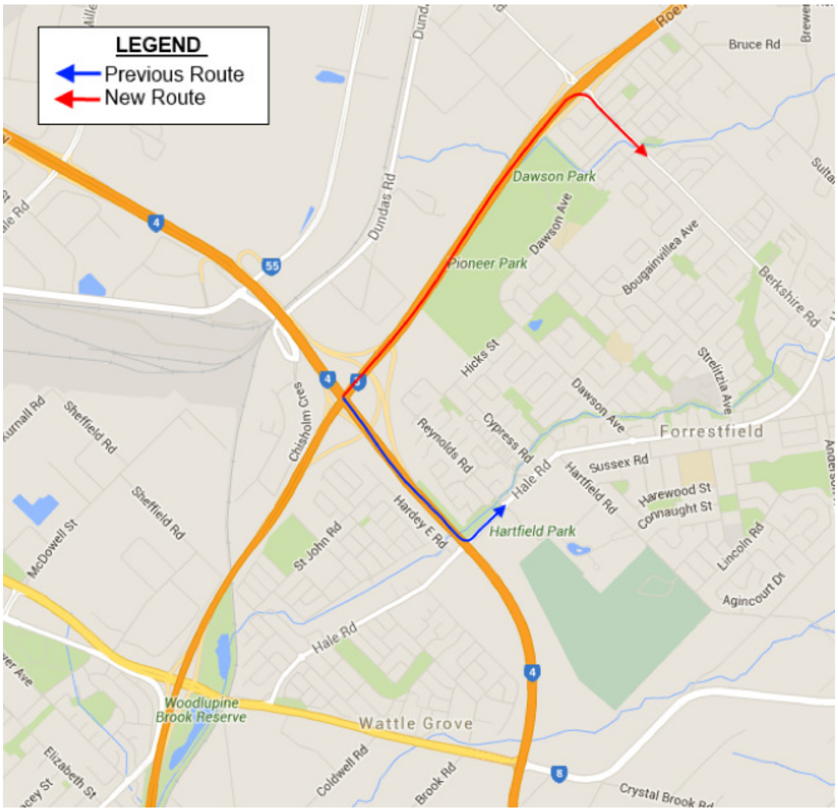


Figure 5-4 Assumed Redirection of Southbound Left-Turning Traffic from Hale Road to Tonkin Highway

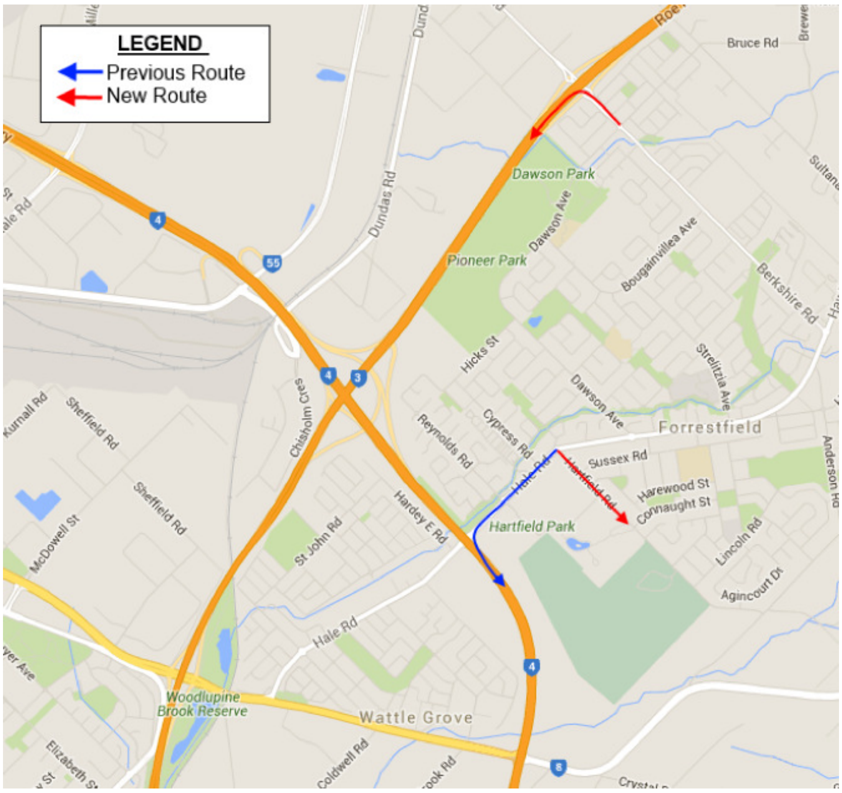


Figure 5-5 Assumed Redirection of Southbound Right-Turning Traffic from Tonkin Highway to Hale Road

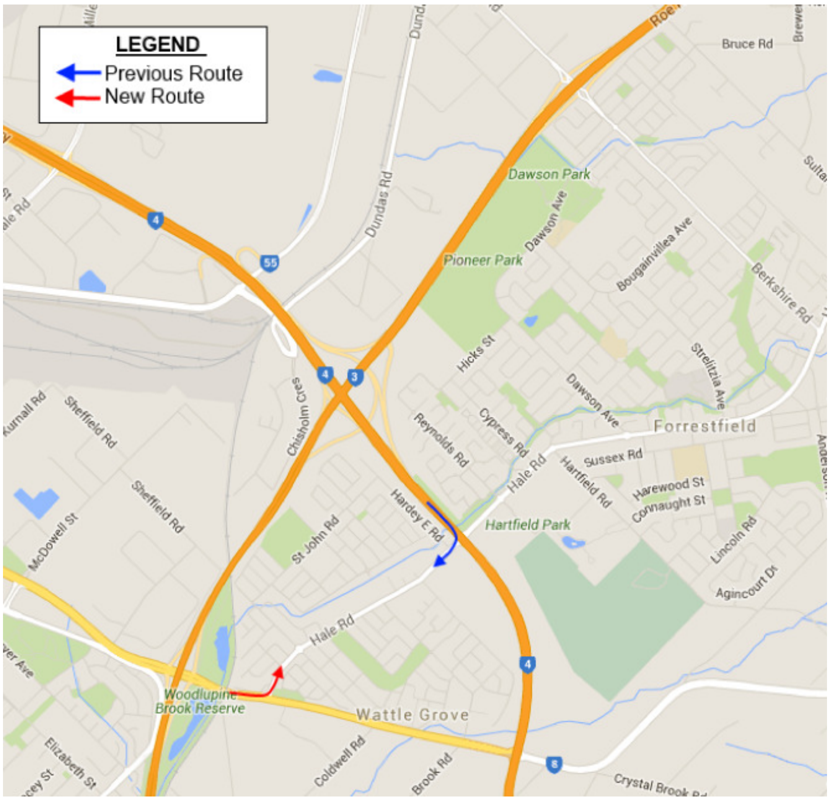


Figure 5-6 Assumed Redirection of Southbound Right-Turning Traffic from Hale Road to Tonkin Highway

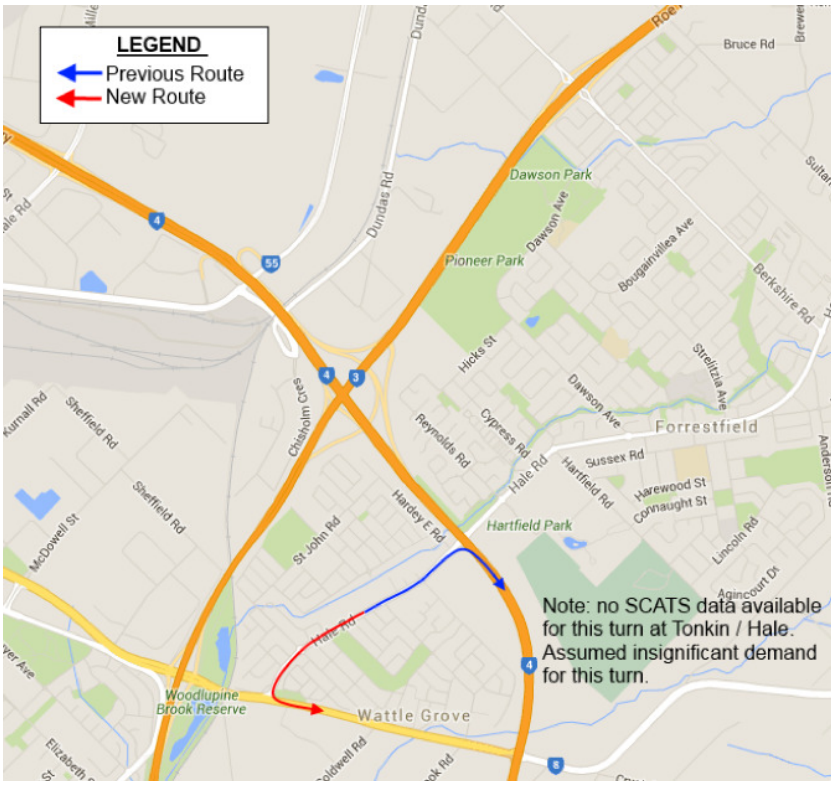


Figure 5-7 Assumed Redirection of Northbound Right-Turning Traffic from Tonkin Highway to Hale Road

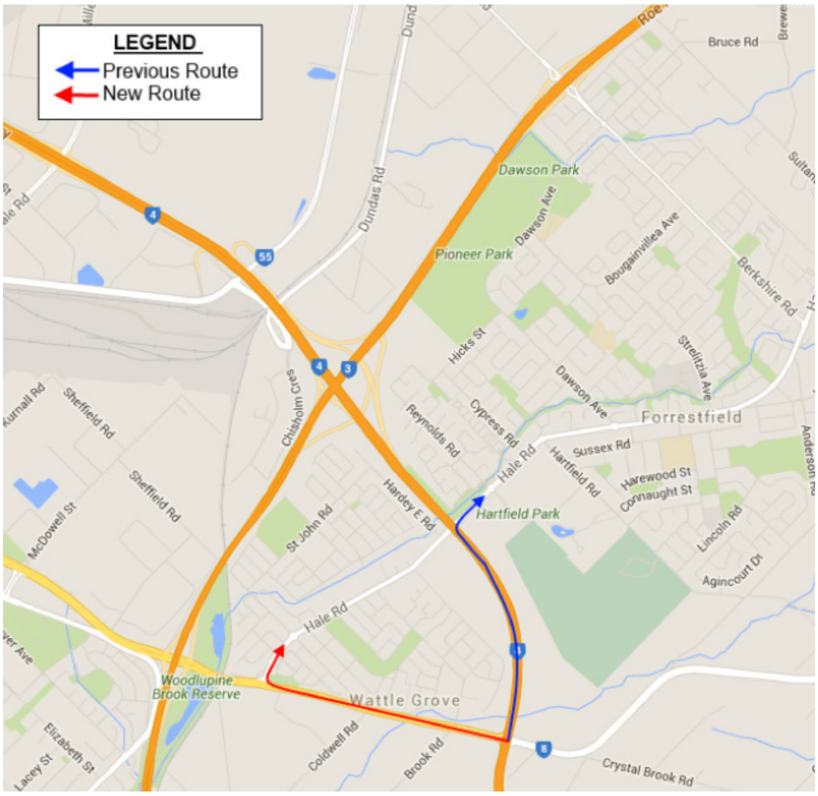
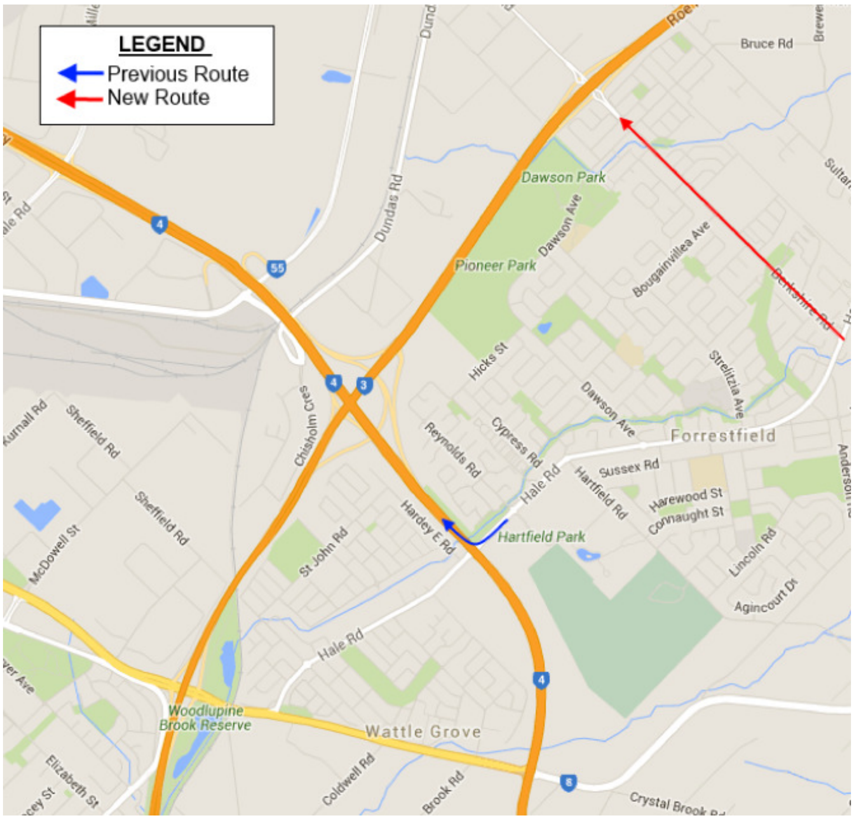


Figure 5-8 Assumed Redirection of Northbound Right-Turning Traffic from Hale Road to Tonkin Highway



5.3 AIMSUN Analysis

The following potential 2031 access scenarios have been modelled as part of this assessment:

- **Scenario 1** - Signalised intersection with all movements at Welshpool Road East/ Coldwell Road (LILO under priority) with intersection of Welshpool Road East/ Hale Road retaining its existing form;
- **Scenario 2** - Signalised intersection with all movements at Welshpool Road East/ Coldwell Road (LILO under priority) and access to MKSEA Precinct 3 also provided at the intersection of Welshpool Road East/ Hale Road / realigned Grove Road (in the form of signalised left-in, left-out and right-in) with an Auxiliary Through Lane (ATL) provided in westbound direction for intersection of Welshpool Road East / Hale Road;
- **Scenario 3** - Intersection of Welshpool Road East / Coldwell Road to remain a priority intersection (as existing) but without right-out movement. Access to MKSEA Precinct 3 also provided at intersection of Welshpool Road East/ Hale Road / realigned Grove Road (in the form of signalised left-in, left-out, right-in and right-out)with an Auxiliary Through Lane (ATL) provided in westbound direction for intersection of Welshpool Road East/ Hale Road;
- **Scenario 4 (at MRWA request)** - Signalised intersection all movements at Welshpool Road East/ Coldwell Road (LILO under priority) and access to MKSEA Precinct 3 also provided at intersection of Welshpool Road East/ Hale Road / Grove Road in the form of un-signalised LILO at realigned Grove (ie priority LILO).

For each of the modelled scenarios, the following key metrics have been extracted and based on an average of 5 simulation runs:

- Average intersection delays (for Welshpool Road / Hale Road and Welshpool Road / Coldwell Road)
- Vehicle Kilometres Travelled (VKT)
- Vehicle Hours Travelled (VHT)
- Unreleased vehicle statistics
- Link Volume Plots (included in **Appendix B**)

It is noted that due to the forecast severance of connectivity at the intersection of Tonkin Highway / Hale Road, it has been assumed that the right turn lane on Hale Road (southbound) at the intersection of Welshpool Road / Hale Road is extended by approximately 60m (to a total length of approximately 105m) to provide sufficient capacity for the right turning vehicles during the AM peak hours, as well as a left-turn slip lane on this intersection approach.

5.3.1 Scenario 1

The assumed intersection form for the intersection of Welshpool Road / Hale Road for Scenario 1 is shown in **Figure 5-9**, with the associated intersection delays summarised in **Table 5-1**.
The assumed intersection form for the intersection of Welshpool Road / Coldwell Road for Scenario 1 is shown in **Figure 5-10**, with the associated intersection delays summarised in **Table 5-2**.

Figure 5-9 Assumed Welshpool Road / Hale Road Intersection Form for Scenario 1

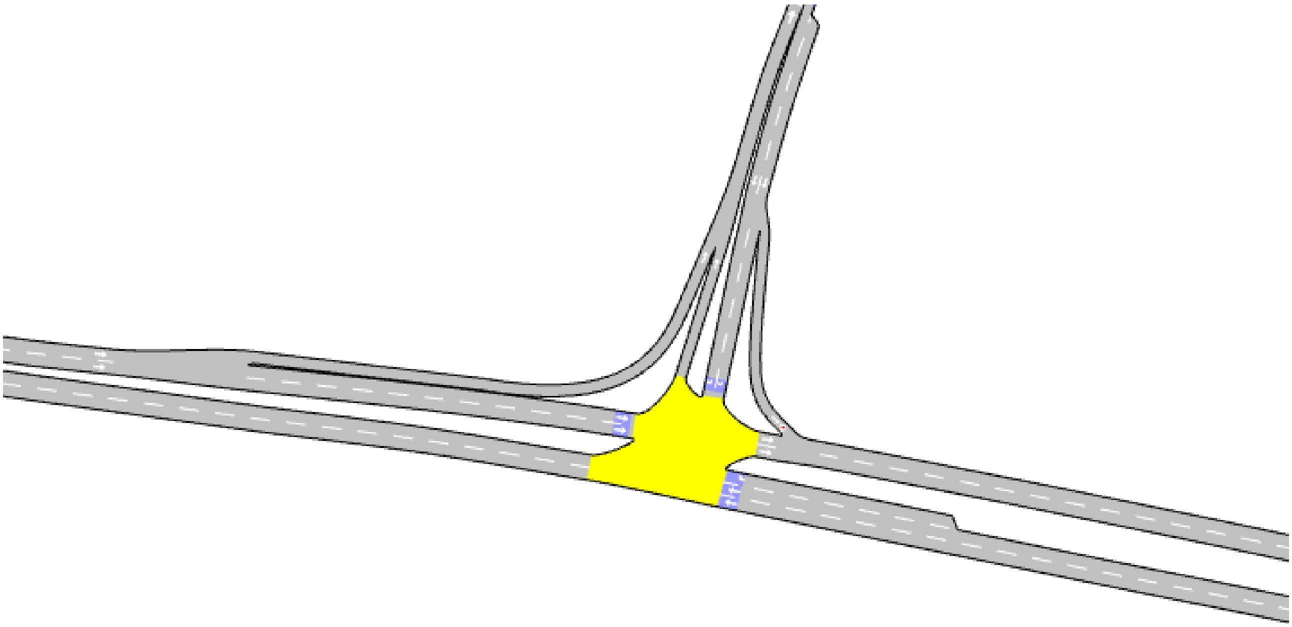


Figure 5-10 Assumed Welshpool Road / Coldwell Road Intersection Form for Scenario 1

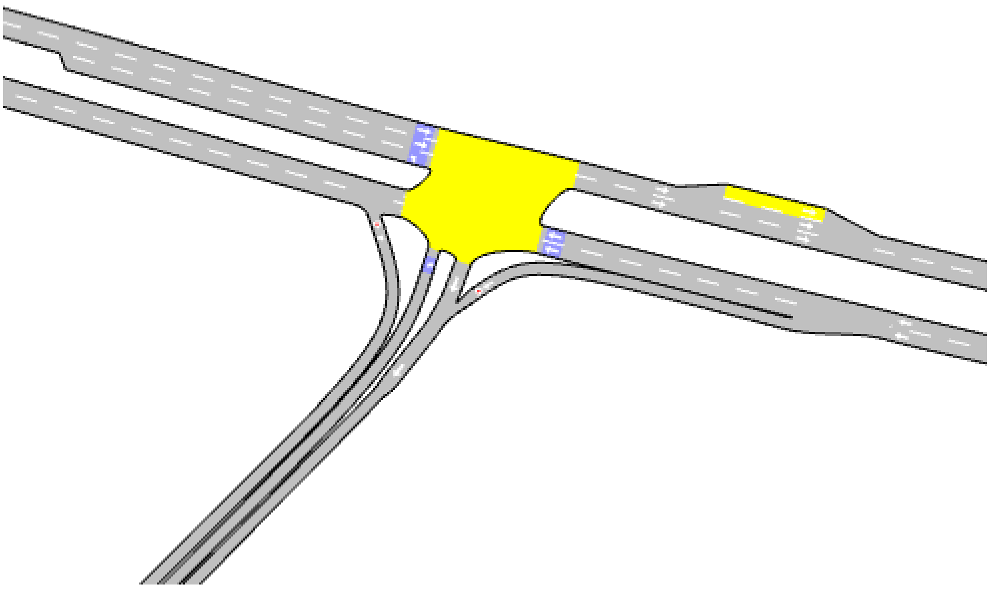


Table 5-1 Average Intersection Approach Delays for Intersection of Welshpool Road / Hale Road - Scenario 1

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Left	0	3
	Through	24	23
	Right	-	-
East	Left	-	-
	Through	27	9
	Right	100	83
North	Left	12	8
	Through	-	-
	Right	42	56
South	Left	-	-
	Through	-	-
	Right	-	-

Table 5-2 Average Intersection Approach Delays for Intersection of Welshpool Road / Coldwell Road - Scenario 1

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Through	7	7
	Right	42	52
East	Left	5	1
	Through	35	15
South	Left	9	5
	Right	50	44

5.3.2 Scenario 2

The assumed intersection form for the intersection of Welshpool Road / Hale Road for Scenario 2 is shown in **Figure 5-11**, with the associated intersection delays summarised in **Table 5-3.**
The assumed intersection form for the intersection of Welshpool Road / Coldwell Road for Scenario 2 is shown in **Figure 5-12**, with the associated intersection delays summarised in **Table 5-4**.

Figure 5-11 Assumed Welshpool Road / Hale Road Intersection Form for Scenario 2

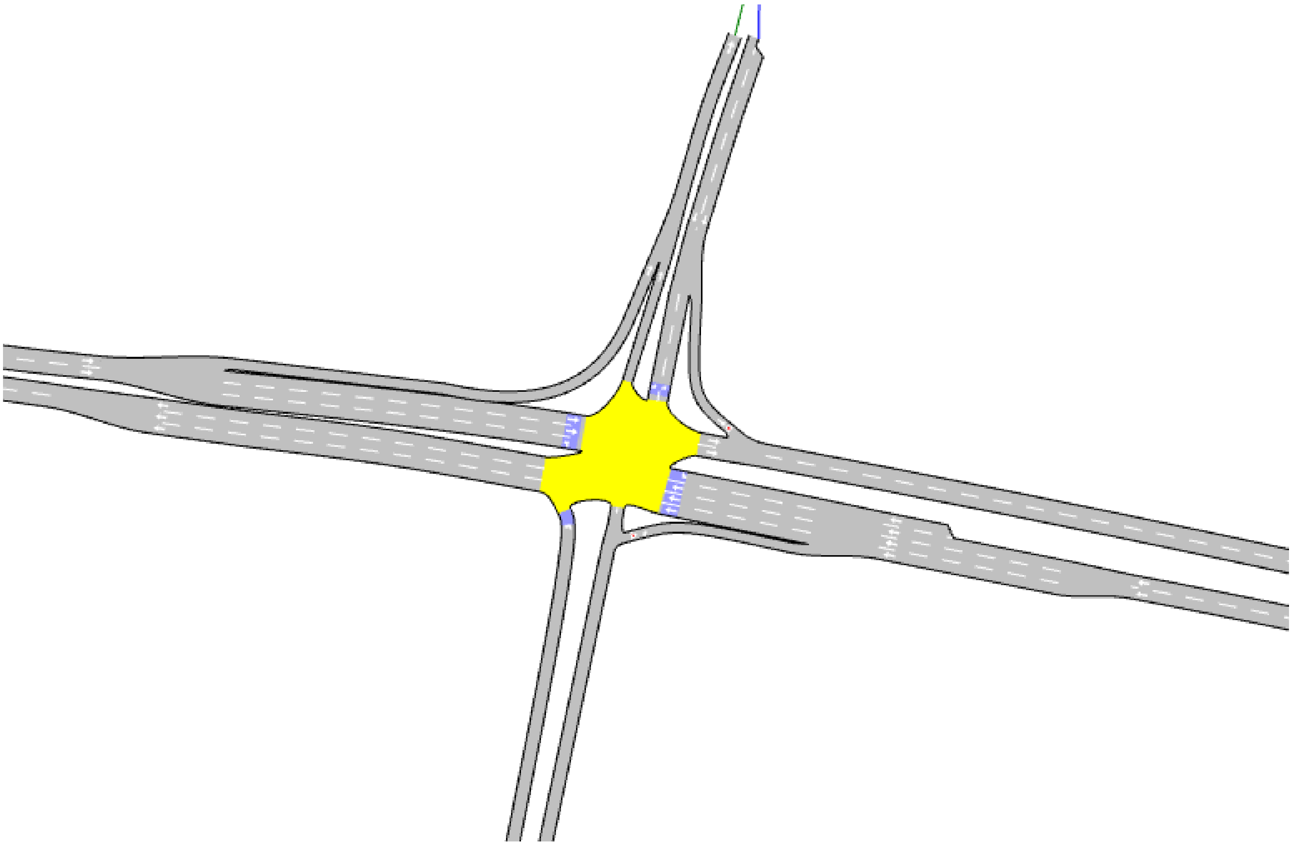


Figure 5-12 Assumed Welshpool Road / Coldwell Road Intersection Form for Scenario 2

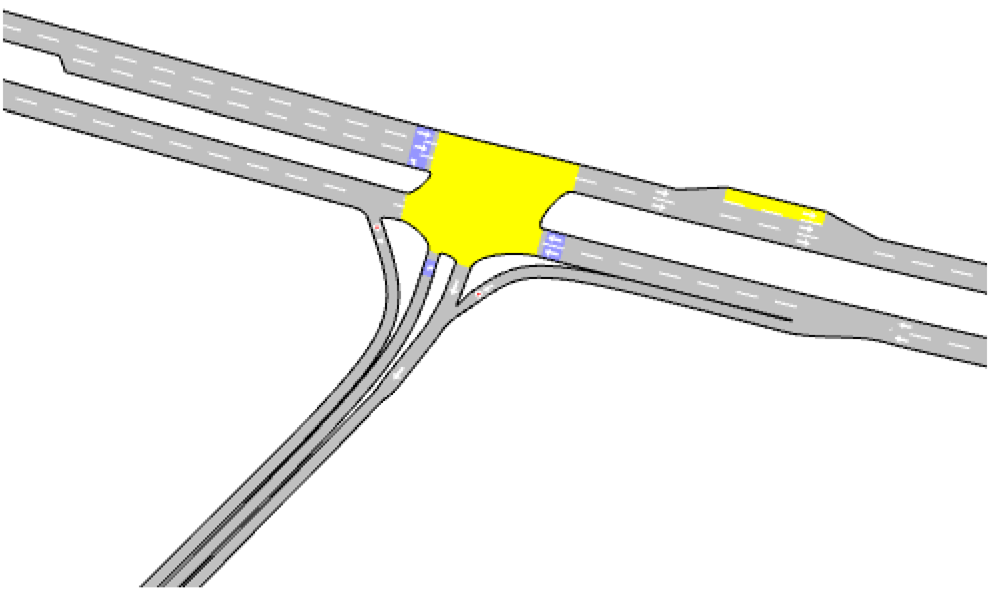


Table 5-3 Average Intersection Approach Delays for Intersection of Welshpool Road / Hale Road - Scenario 2

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Left	0	3
	Through	40	24
	Right	65	63
East	Left	9*	3*
	Through	36	16
	Right	43	56
North	Left	24	9
	Through	-	-
	Right	49	64
South	Left	52	64
	Through	-	-
	Right	-	-

* includes delay time for left-turning vehicles queued beyond extent of left-turn slip lane

Table 5-4 Average Intersection Approach Delays for Intersection of Welshpool Road / Coldwell Road - Scenario 2

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Through	4	8
	Right	52	46
East	Left	1	0
	Through	15	10
South	Left	5	4
	Right	44	44

5.3.3 Scenario 3

The assumed intersection form for the intersection of Welshpool Road / Hale Road for Scenario 3 is shown in **Figure 5-13**, with the associated intersection delays summarised in **Table 5-5.**
The assumed intersection form for the intersection of Welshpool Road / Coldwell Road for Scenario 3 is shown in **Figure 5-14**, with the associated intersection delays summarised in **Table 5-6**.

Figure 5-13 Assumed Welshpool Road / Hale Road Intersection Form for Scenario 3

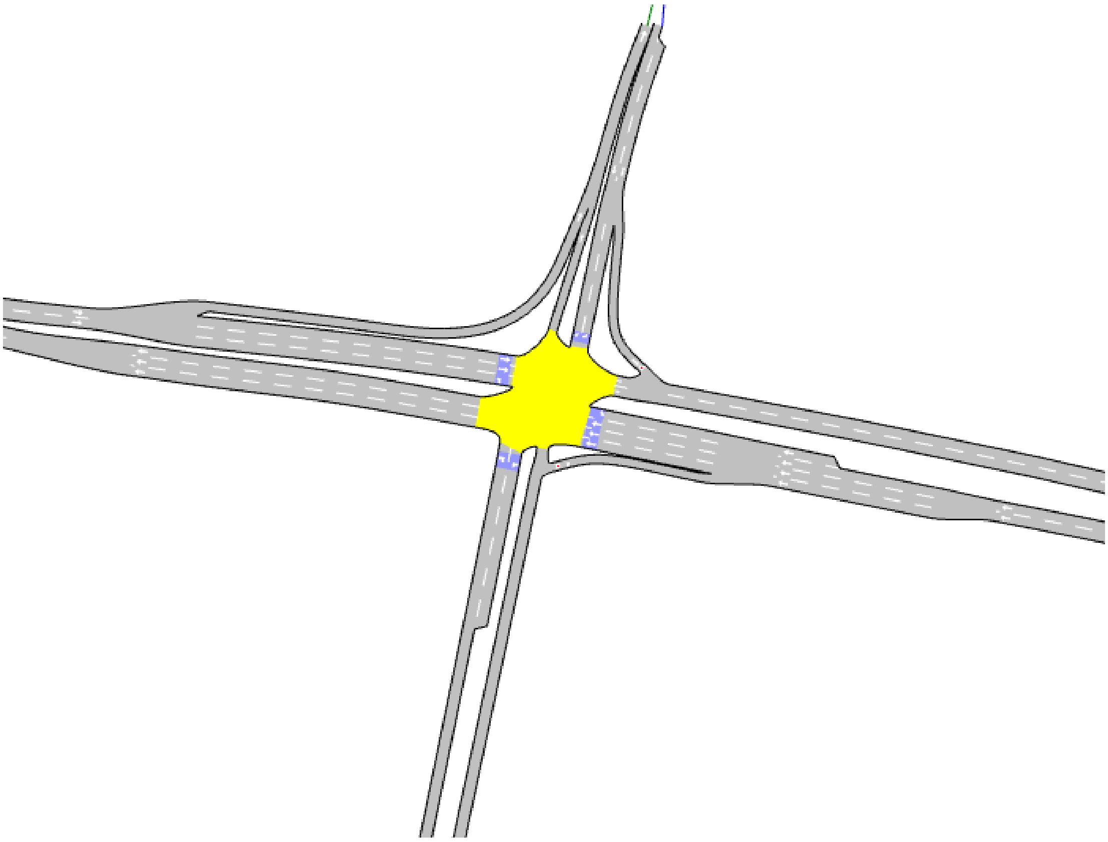


Figure 5-14 Assumed Welshpool Road / Coldwell Road Intersection Form for Scenario 3

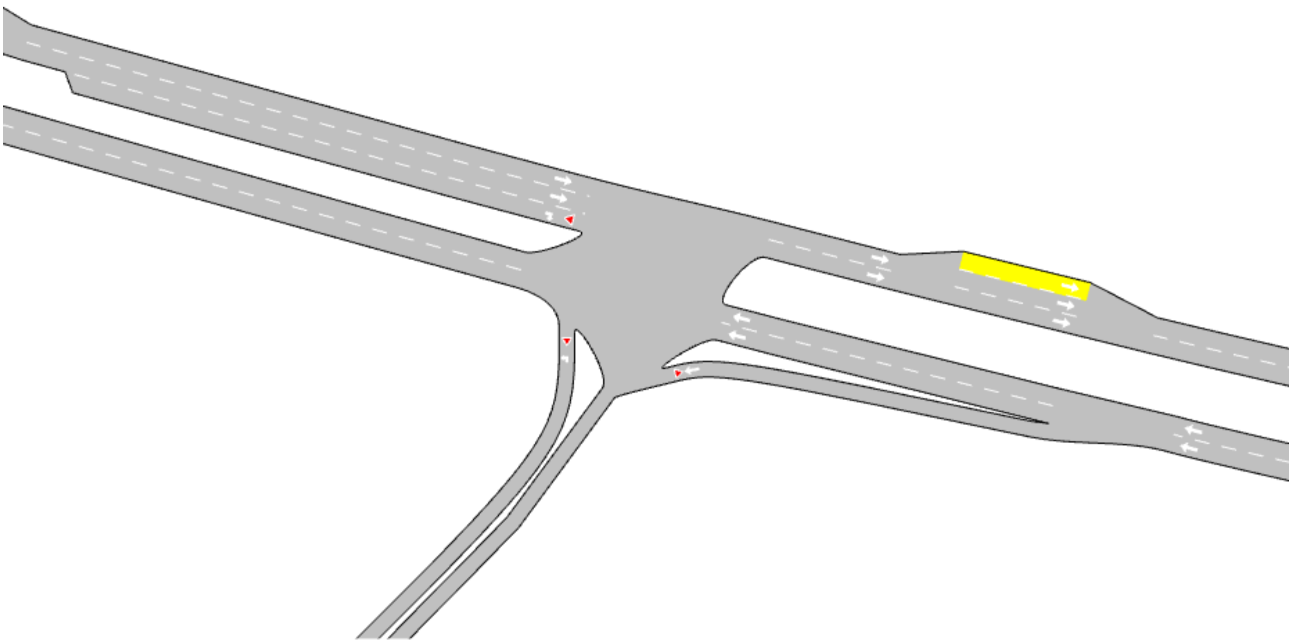


Table 5-5 Average Intersection Approach Delays for Intersection of Welshpool Road / Hale Road - Scenario 3

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Left	1	5
	Through	37	39
	Right	71	54
East	Left	6*	1*
	Through	34	29
	Right	52	51
North	Left	21	0
	Through	-	-
	Right	55	57
South	Left	55	69
	Through	-	-
	Right	48	60

* includes delay time for left-turning vehicles queued beyond extent of left-turn slip lane

Table 5-6 Average Intersection Approach Delays for Intersection of Welshpool Road / Coldwell Road - Scenario 3

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Through	0	0
	Right	11	4
East	Left	0	0
	Through	0	0
South	Left	0	0
	Right	-	-

5.3.4 Scenario 4

The assumed intersection form for the intersection of Welshpool Road / Hale Road for Scenario 4 is shown in **Figure 5-15**, with the associated intersection delays summarised in **Table 5-7**.
The assumed intersection form for the intersection of Welshpool Road / Coldwell Road for Scenario 4 is shown in **Figure 5-16**, with the associated intersection delays summarised in **Table 5-8**.

Figure 5-15 Assumed Welshpool Road / Hale Road Intersection Form for Scenario 4

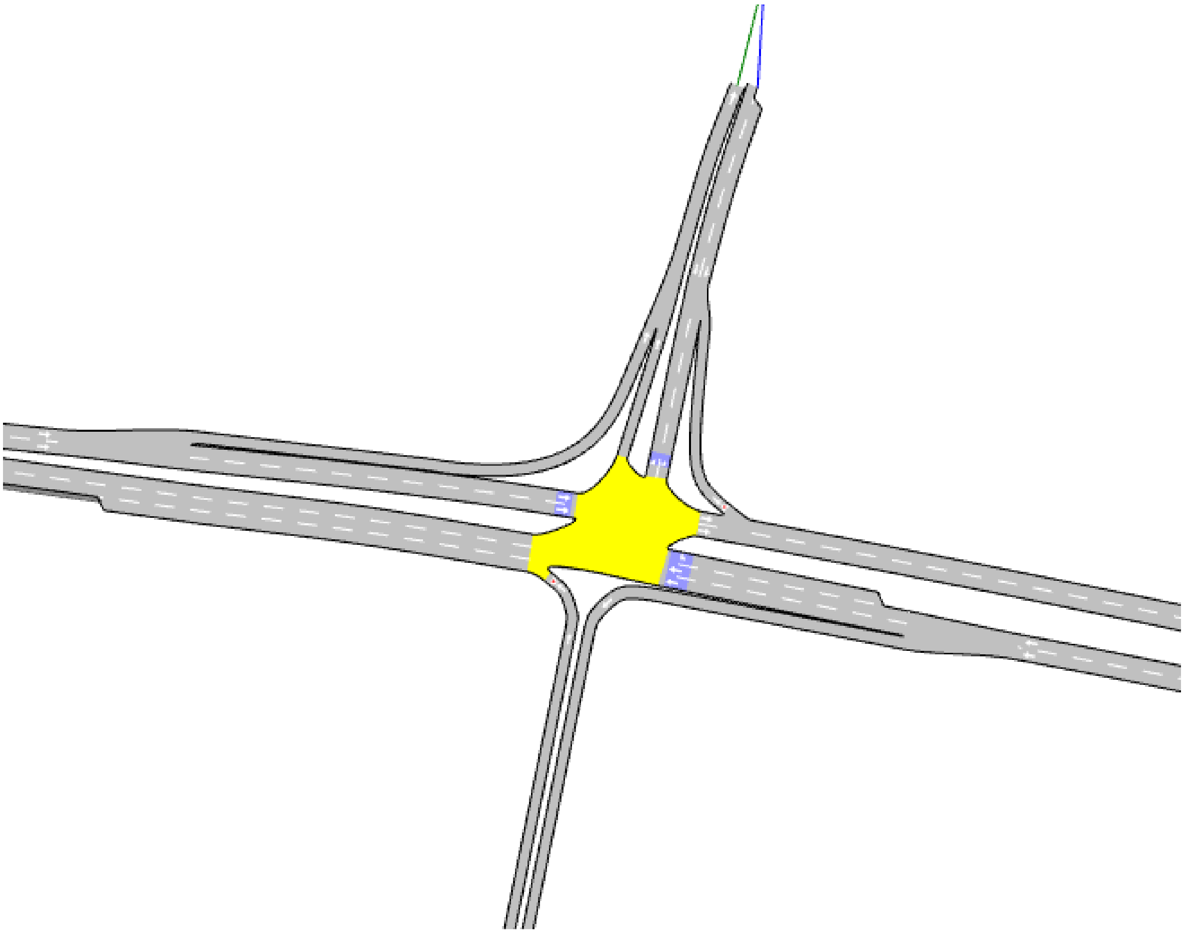


Figure 5-16 Assumed Welshpool Road / Coldwell Road Intersection Form for Scenario 4

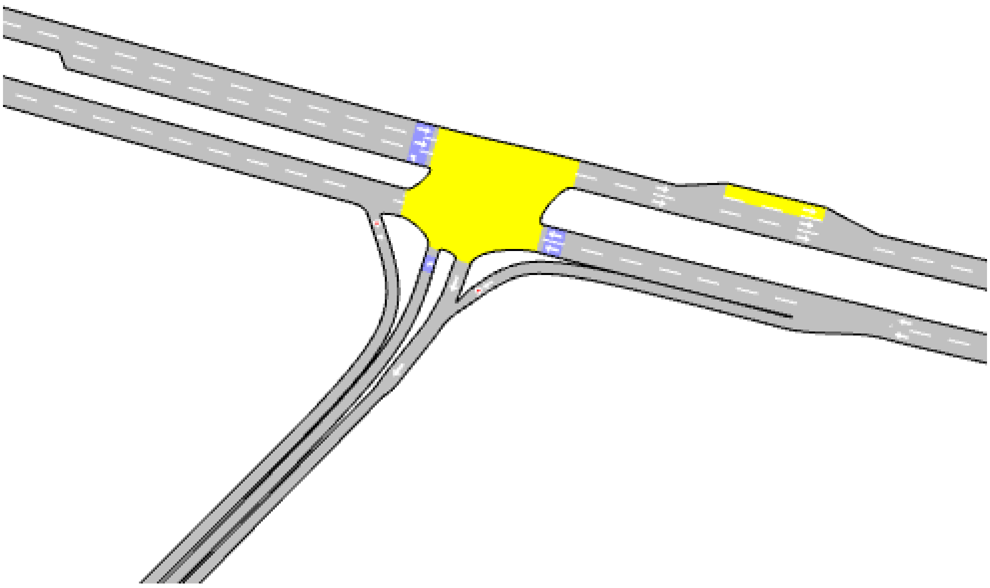


Table 5-7 Average Intersection Approach Delays for Intersection of Welshpool Road / Hale Road - Scenario 4

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Left	0	3
	Through	25	23
	Right	-	-
East	Left	0*	2*
	Through	13	10
	Right	98	76
North	Left	24	6
	Through	-	-
	Right	60	67
South	Left	1	1
	Through	-	-
	Right	-	-

* includes delay time for left-turning vehicles queued beyond extent of left-turn slip lane

Table 5-8 Average Intersection Approach Delays for Intersection of Welshpool Road / Coldwell Road - Scenario 4

Intersection Approach	Turning Movement	2031 AM	2031 PM
West	Through	5	7
	Right	20	52
East	Left	11*	2*
	Through	38	16
South	Left	5	4
	Right	50	43

* includes delay time for left-turning vehicles queued beyond extent of left-turn slip lane

5.3.5 Key Model Output Metrics

The following key model metrics have been output from the models to evaluate the network-wide impacts of the different access scenarios:

- Vehicle Kilometres Travelled (VKT) for all model vehicles – refer **Table 5-9**
- VKT for regional (non-MKSEA) vehicles only – refer **Table 5-10**
- Vehicle Hours Travelled (VHT) – refer **Table 5-11**
- VHT for regional (non-MKSEA) vehicles only – refer **Table 5-12**
- Unreleased vehicle statistics – refer **Table 5-13**

Table 5-9 VKT Statistics for each Scenario (All Vehicles)

Scenario	2031 AM	2031 PM
1	5797	6457
2	5261	6012
3	5311	6064
4	5599	6143

Table 5-10 VKT Statistics for each Scenario (Non-MKSEA Vehicles Only)

Scenario	2031 AM	2031 PM
1	4394	5377
2	4325	5230
3	4373	5177
4	4338	5285

Table 5-11 VHT Statistics for each Scenario (All Vehicles)

Scenario	2031 AM	2031 PM
1	161	131
2	138	128
3	128	130
4	142	125

Table 5-12 VHT Statistics for each Scenario (Non-MKSEA Vehicles Only)

Scenario	2031 AM	2031 PM
1	131	109
2	113	110
3	105	112
4	113	107

Table 5-13 Unreleased Vehicle Statistics for each Scenario (All Vehicles)

Scenario	2031 AM	2031 PM
1	3	1
2	3	1
3	4	1
4	17	1

5.4 Discussion of Model Results

The only turning movement found to have LOS F (average delay greater than 80 seconds) is the right turn from Welshpool Road to Hale Road for Scenarios 1 and 4. This is primarily due to the amount of green time required for the east-west movements.

The auxiliary westbound through lane for the intersection of Welshpool Road / Hale Road (assumed in Scenarios 2 and 3) is found to substantially reduce the average delays associated with the right turn from Welshpool Road to Hale Road as the through movements require less green time (which can be allocated to other phases, or reduce the overall cycle time).

The Unreleased Vehicle summary suggest that the assumed intersection forms will have sufficient capacity to release all vehicles within the model, while the VHT and VKT statistics generally suggest that Scenarios 2 and 3 will result in the most efficient network performance for MKSEA generated traffic.

For regional (non-MKSEA) vehicles, the model results for Scenario 1 suggest that the delays introduced for the westbound movement at the intersection of Welshpool Road / Coldwell Road as a result of the green time required to accommodate the right-in movement from Welshpool Road to Coldwell Road, will result in a significant increase in terms of VKT. Scenario 3 is found to result in the lowest VHT statistics for the AM scenarios as the intersection of Welshpool Road / Coldwell Road is assumed to remain in a priority form and for this scenario and therefore does not require the east-west through traffic on Welshpool Road to stop at this intersection. The VKT statistics for the other scenarios are largely similar.

In terms of VKT for the regional (non-MKSEA) vehicles, the results suggest that none of the scenarios will result in significantly improved (or deteriorated) network performance.

5.4.1 Network Considerations

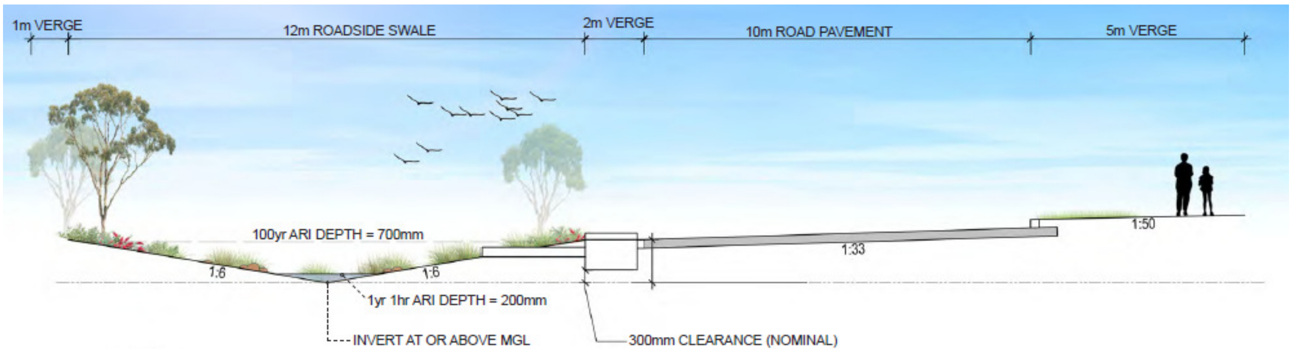
As described above, Scenarios 2 and 3 were found to result in acceptable LOS for all turning movements at both of the intersections analysed. However, Scenario 3 is considered the overall best network configuration due to the following:

- As the critical turning movements to/from MKSEA Precinct 3 can be undertaken at the intersection of Welshpool Road / Hale Road / Grove Road in Scenario 3, this will negate the requirement to upgrade the intersection of Welshpool Road / Coldwell Road to a signalised form, which would be consistent with the potential plans by Main Roads WA to upgrade Welshpool Road to an express-way form.
- As the developer of MKSEA Precinct 3 holds control over the relevant land parcels required to provide the connection from Grove Road to Welshpool Road, this connection can be practically achieved in the short-term.
- As the developer of MKSEA Precinct 3 does not hold control of the relevant land parcels required to upgrade the intersection of Welshpool Road / Coldwell Road to the required signalised form, this access configuration may not be achievable in the short-to-medium time frames.
- The connection from Grove Road to Welshpool Road would minimise the travel times for heavy vehicles travelling on Welshpool Road.
- As scenario 4 provides a signalised left-out from Grove Road to Welshpool Road, this would minimise the need for heavy vehicles to merge and change lanes.

5.5 Road Reservation Widths and Cross Sections

As shown in **Figure 4-1**, both Coldwell Street and Grove Road are proposed to have 30m wide road reservations. The cross-section for these roads are shown in **Figure 5-17** and include a 10m road pavement which provides 5m traffic lanes in each direction. The 5m lane widths make adequate provision for on-road cycling. The 5m verge width is adequate to contain a footpath if required.

Figure 5-17 Nominal 30m Road Cross-Section for Coldwell Road and Grove Road



5.6 Specific Issues

5.6.1 Existing Restricted Access Vehicle (RAV) Network

The existing RAV2, RAV3, RAV4 and RAV7 network within and surrounding the MKSEA are shown in **Figure 5-18** to **Figure 5-21** and show that currently only RAV2 and RAV3 vehicles have access to the internal MKSEA roads of Coldwell Road, Brook Road, Kelvin Road and Boundary Road.

While RAV4 vehicles are permitted on Welshpool Road, these vehicles are currently not permitted on roads within MKSEA, which is probably reflective of the area's current land uses.

It is noted that RAV7 vehicles are currently only permitted on Roe Highway and therefore do not have access to MKSEA.

In order to facilitate the development of the proposed industrial land uses within MKSEA, it is recommended to permit vehicles up to RAV4 on all internal MKSEA roads.

Figure 5-18 Existing RAV2 Network

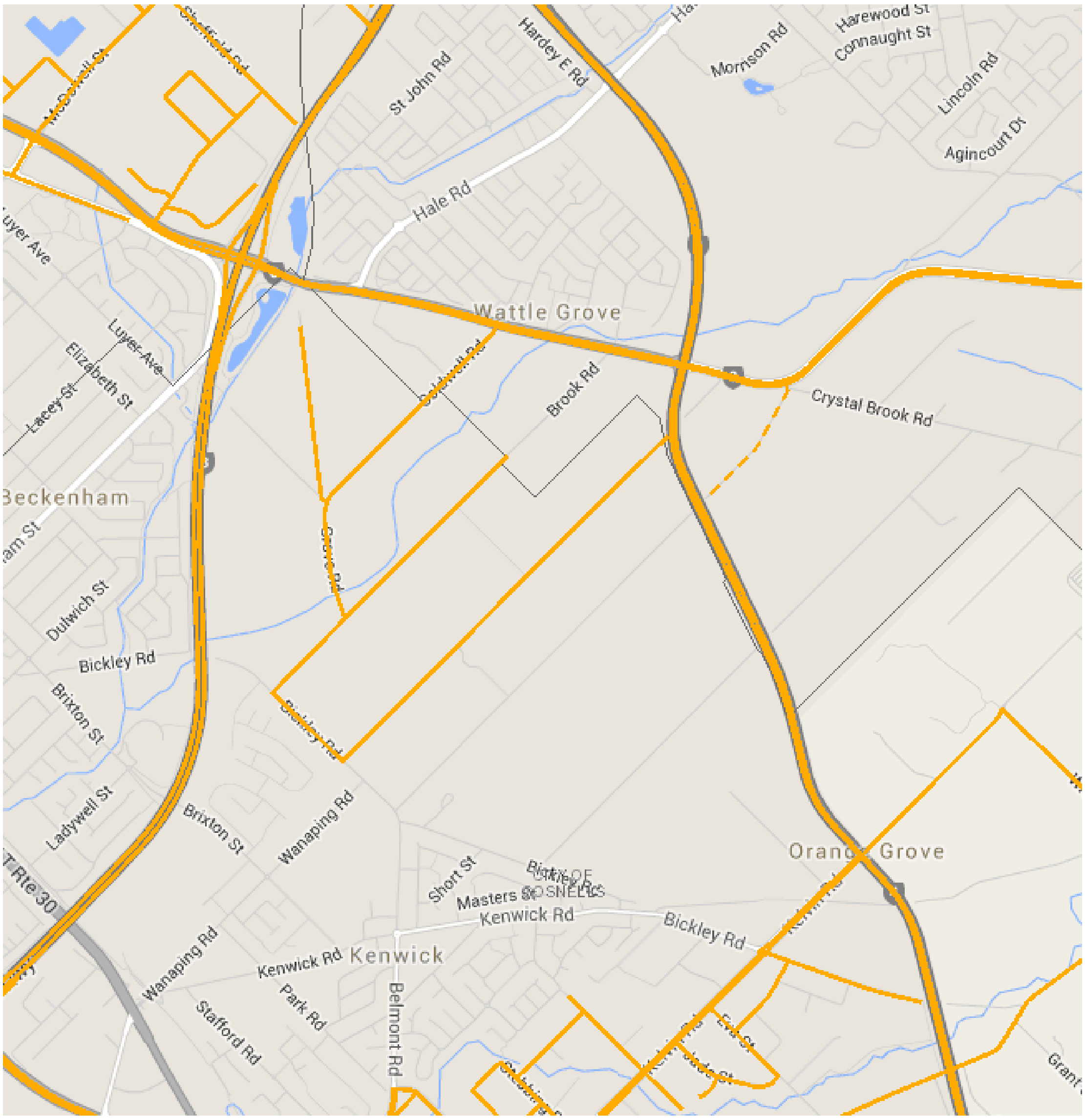


Figure 5-19 Existing RAV3 Network

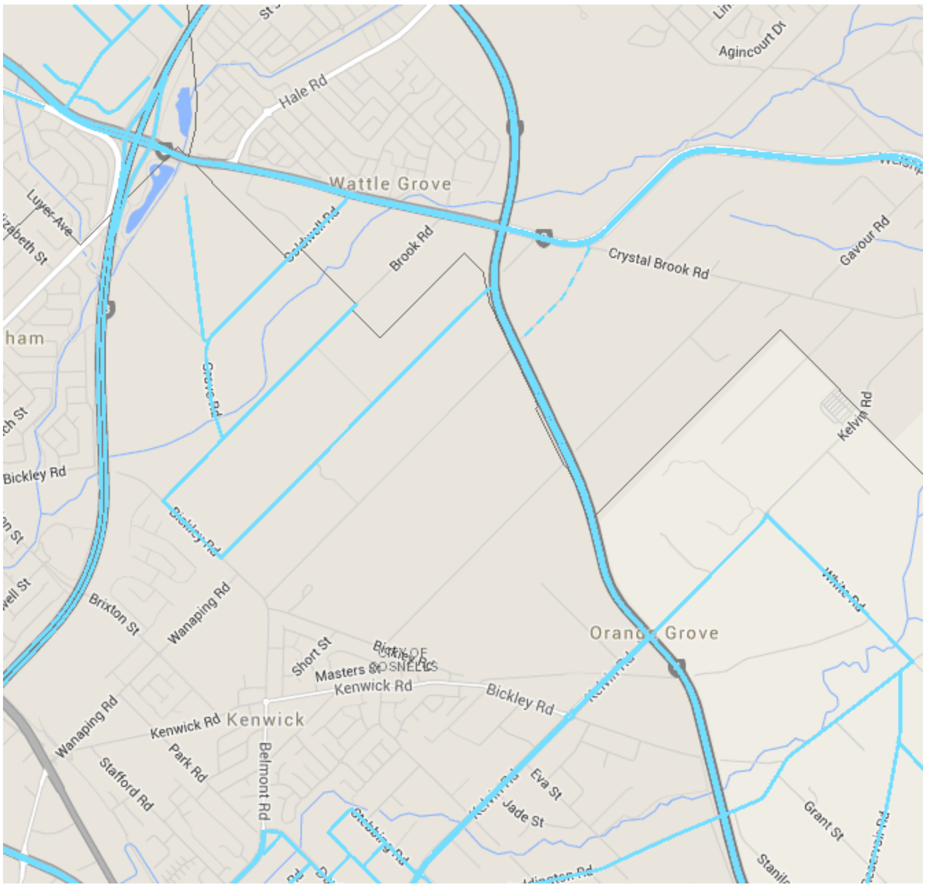


Figure 5-20 Existing RAV4 Network

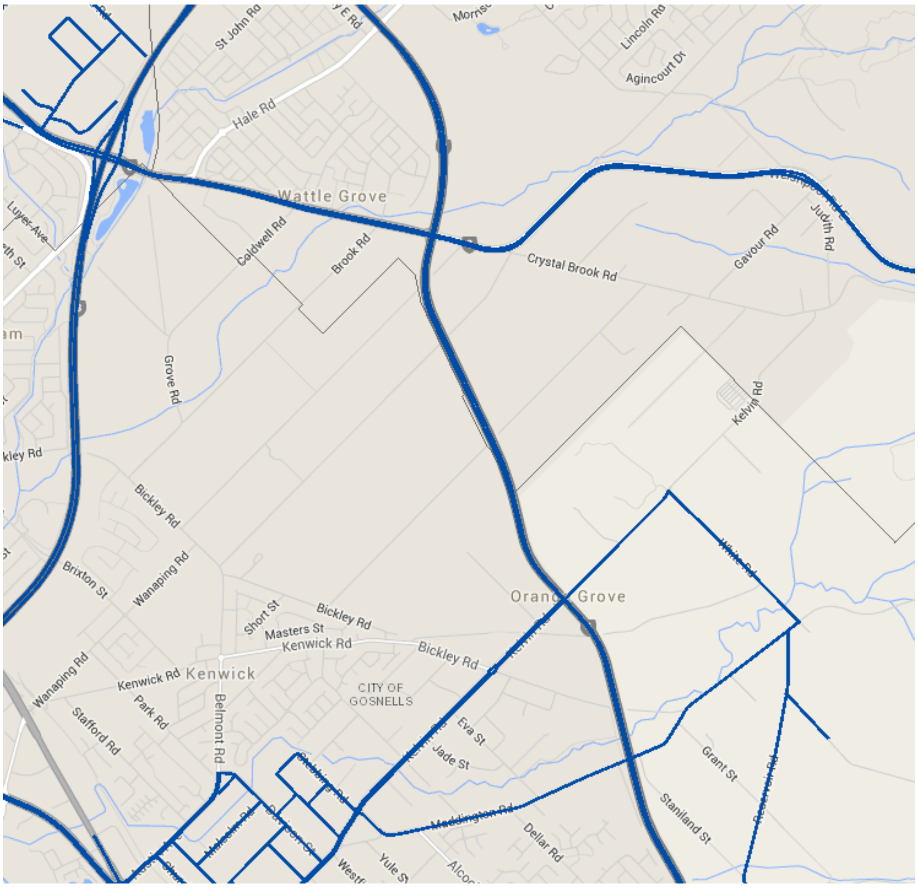
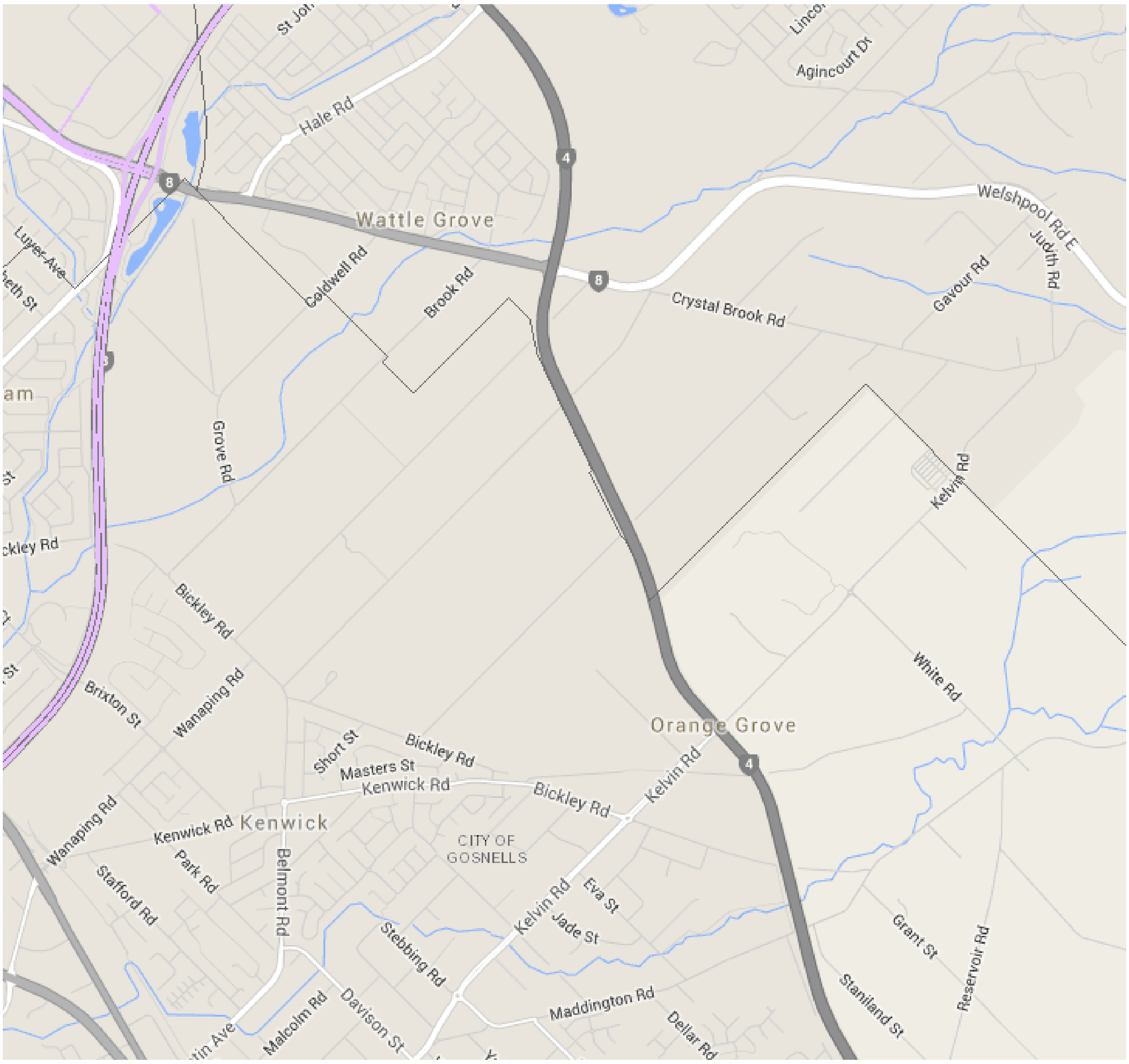


Figure 5-21 Existing RAV7 Network



(Source: MRWA RAV GIS Mapping 2012)

6 Conclusions

This Transport Assessment has been prepared in accordance with the Western Australia Planning Commission (WAPC) *Transport Assessment Guidelines for Developments: Volume 2 – Structure Plan (2006)* and outlines the transport aspects of Precinct 3 (incorporating Precincts 3A, 3B and Welshpool Road East Industrial Precinct) for the Maddington Kenwick Strategic Employment Area (MKSEA) and focuses on the traffic operations, access arrangements and road reservation widths within the area.

The following conclusions have been made in regard to the proposed Precinct 3 which includes the Precinct 3A Structure Plan:

- This Transport Assessment has been prepared based on the assumptions and data adopted for the entire MKSEA.
- Precinct 3 comprises a gross area of approximately 200ha of land, including 147ha of general industrial land use, 15ha for drainage and natural reserve (including Yule Brook) 17ha of road reservation and 20ha for Rail Infrastructure Facility to be utilised by the Public Transport Authority (PTA).
- Consistent with the Traffic Assessment undertaken for the entire MKSEA area, the land uses within the Precinct 3 will generate an estimated 603 trips during the AM peak hour period and 501 trips for the PM peak hour period upon full build-out of Precinct 3.
- Analysis of AIMSUN micro-simulation results for the scenarios evaluated suggest that the access options described in Scenarios 2 and 3 will result in acceptable LOS for all turning movements at the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road and are the most efficient operation of the entire model network.
    - Scenario 3 was found to have several advantages over Scenario 2 in terms of practical considerations and is therefore the preferred access configuration to the area.
- The proposed road cross-sections will allow for the provision of on-road cycle facilities and pedestrian facilities on the verge.
- In order to facilitate the development of the proposed industrial land uses within MKSEA, it is recommended to permit RAV4 vehicles (as a minimum) on all internal MKSEA roads.

APPENDIX A

STRUCTURE PLAN TRANSPORT ASSESSMENT CHECKLIST

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Item	**Status**	**Comments/Proposals**
Summary		
Introduction/Background	Complete	**Included in section 1.1**
Structure Plan Proposal	Complete	**Included in section 4.1**
Regional context	Complete	**Included in section 2.1**
Proposed land uses	Complete	**Included in section 4.1**
Table of land uses and quantities	Complete	**Included in section 4.1**
Major attractors / generators	--	N/A
Specific Issues	Complete	**Included in section 5.6**
Existing Situation		
Existing land uses within structure plan	Complete	**Included in section 2.1**
Existing land uses within 800m of structure plan area	Complete	**Included in section 2.1**
Existing road network within structure plan area	Complete	**Included in section 2.2**
Existing pedestrian/cycle networks within structure plan area	Complete	**Included in section 2.4**
Existing public transport services within structure plan area	Complete	**Included in section 2.5**
Existing road network within 2 (or 5) km of structure plan area	Complete	**Included in section 2.2**
Traffic flows on roads within structure plan area (AM and/or PM peak hours)	Complete	**Included in section 2.3**
Traffic flows on roads within 2 (or 5) km of structure plan area (AM and/or PM peak hours)	Complete	**Included in section 2.3**
Existing pedestrian/cycle networks within 800m of structure plan area	Complete	**Included in section 2.4**
Existing public transport services within 800m of structure plan area	Complete	**Included in section 2.5**
Proposed Internal Transport Networks		
Changes/additions to existing road network or proposed new road network	Complete	**Included in section 4.4**
Road reservation widths	Complete	**Included in section 5.2**
Road cross-sections and speed limits	Complete	**Included in section 5.2**
Intersection controls	Complete	**Included in section 4.1**
Pedestrian / cycle networks and crossing facilities		
Public transport routes	Complete	**Included in section 3.3**
Changes to External Transport Networks		
Road network	Complete	**Included in section 3.1**
Intersection controls	Complete	**Included in section 3.1**
Pedestrian/cycle networks and crossing facilities	Complete	**Included in section 3.2**

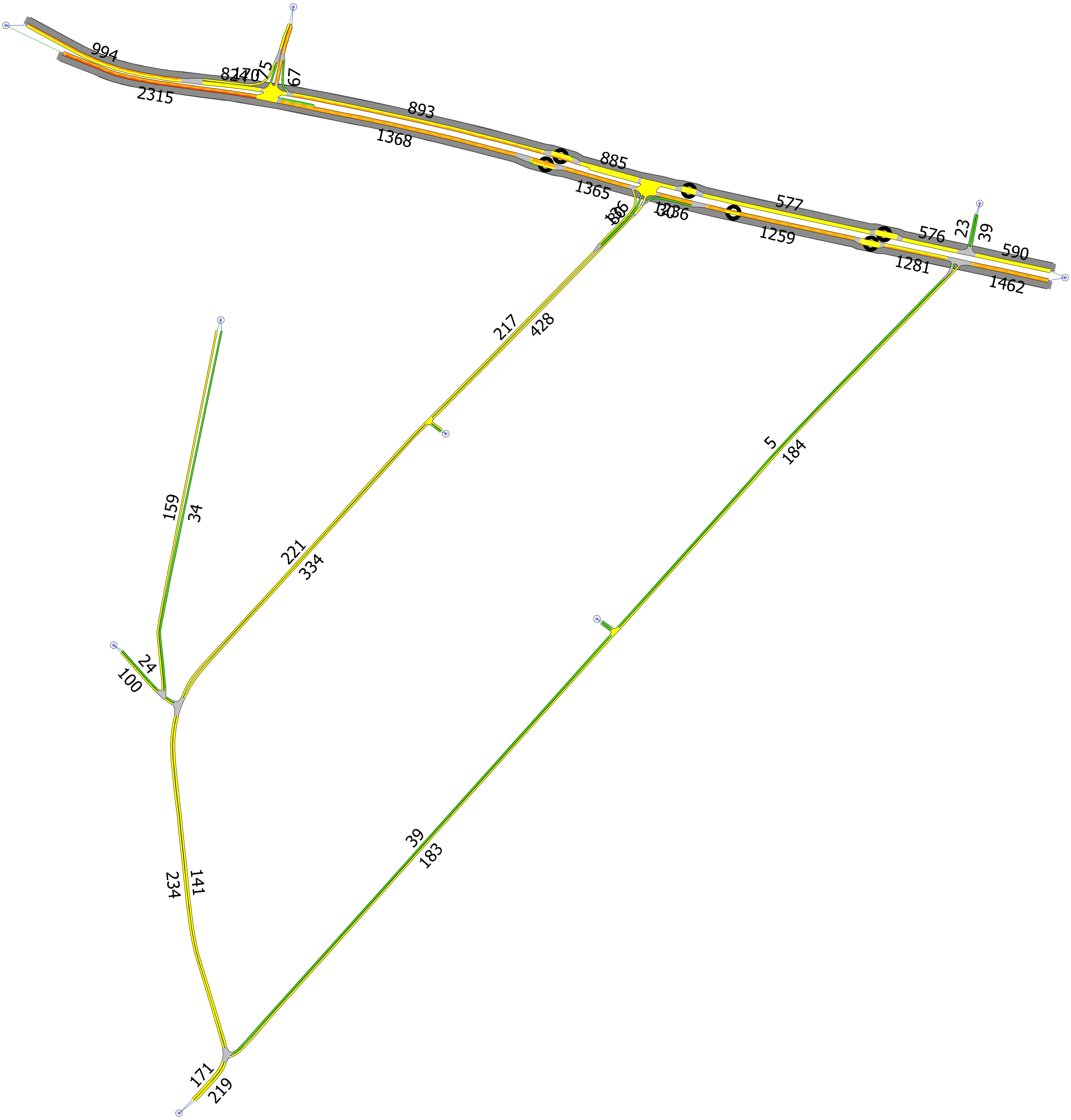
Public transport services	Complete	**Included in section 3.3**
Analysis of Internal Transport Networks		
Assessment year(s) and time period(s)	Complete	**Included in section 5.1**
Structure plan generated traffic	Complete	**Included in section 4.3**
Extraneous (through) traffic	Complete	**Included in section 5.1**
Design traffic flows (ie. Total traffic)	Complete	**Included in SIDRA analysis**
Road cross-sections	Complete	**Included in section 5.2**
Intersection controls	Complete	**Included in section 4.2**
Access strategy	Complete	**Included in section 4.2**
Pedestrian / cycle networks	Complete	**Included in section 3.2**
Safe routes to schools	--	N/A
Pedestrian permeability and efficiency	--	N/A
Access to public transport	Complete	**Included in section 3.3**
Conclusions	Complete	**Included in section** 6

Transport Assessment

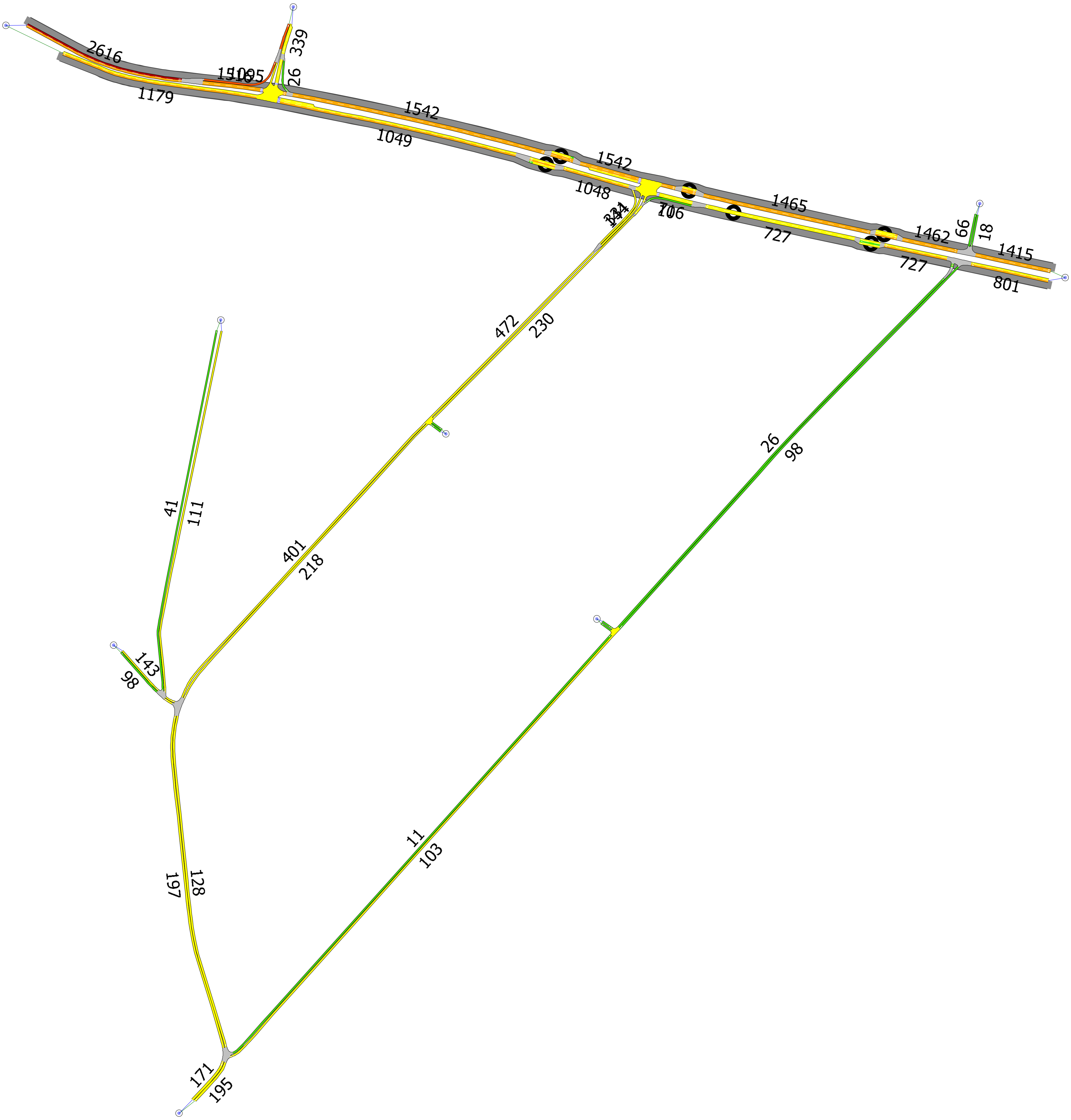
APPENDIX B
AIMSUN LINK VOLUME PLOTS

Shaping the Future

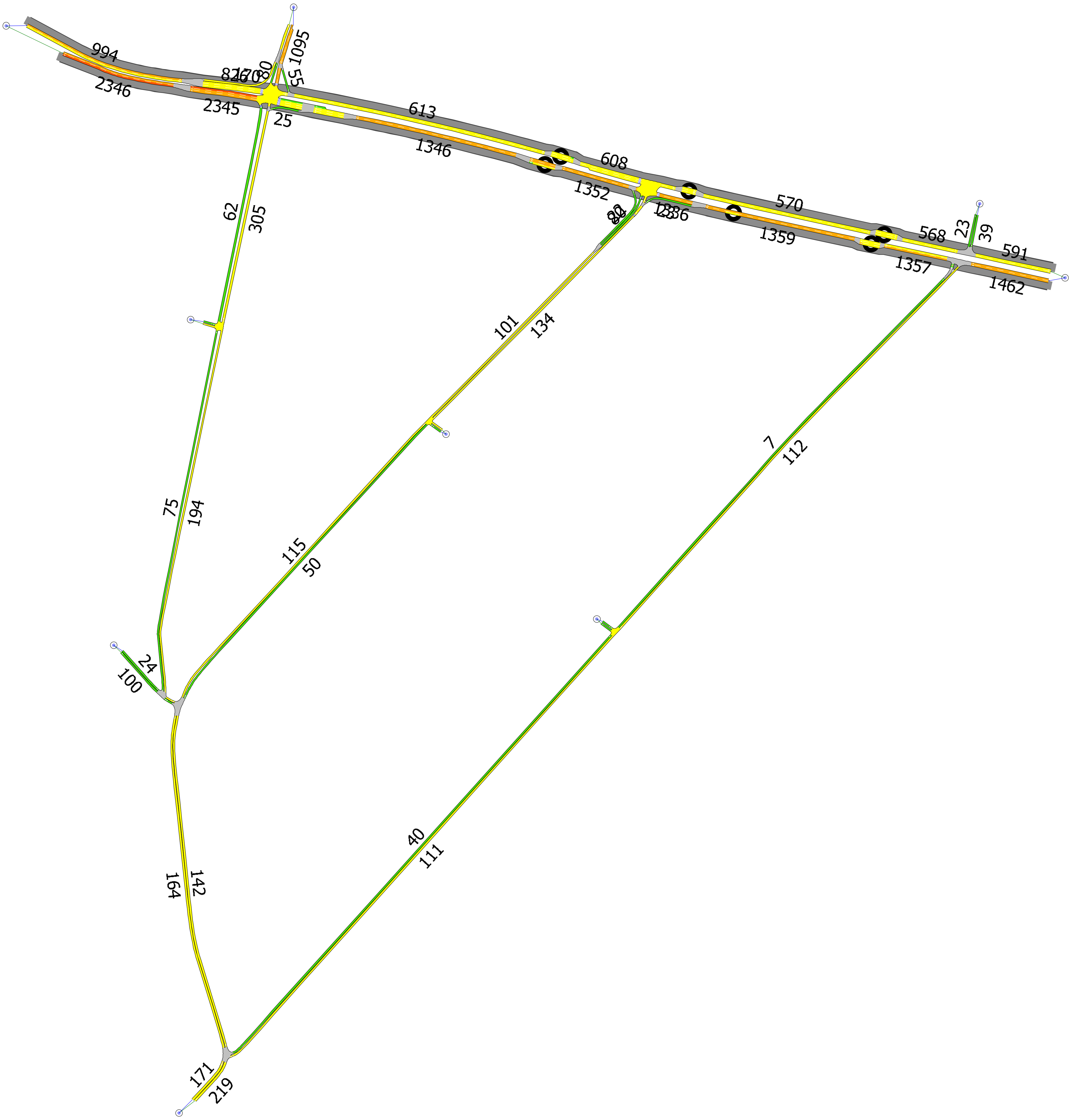
2031 AM - Scenario 1



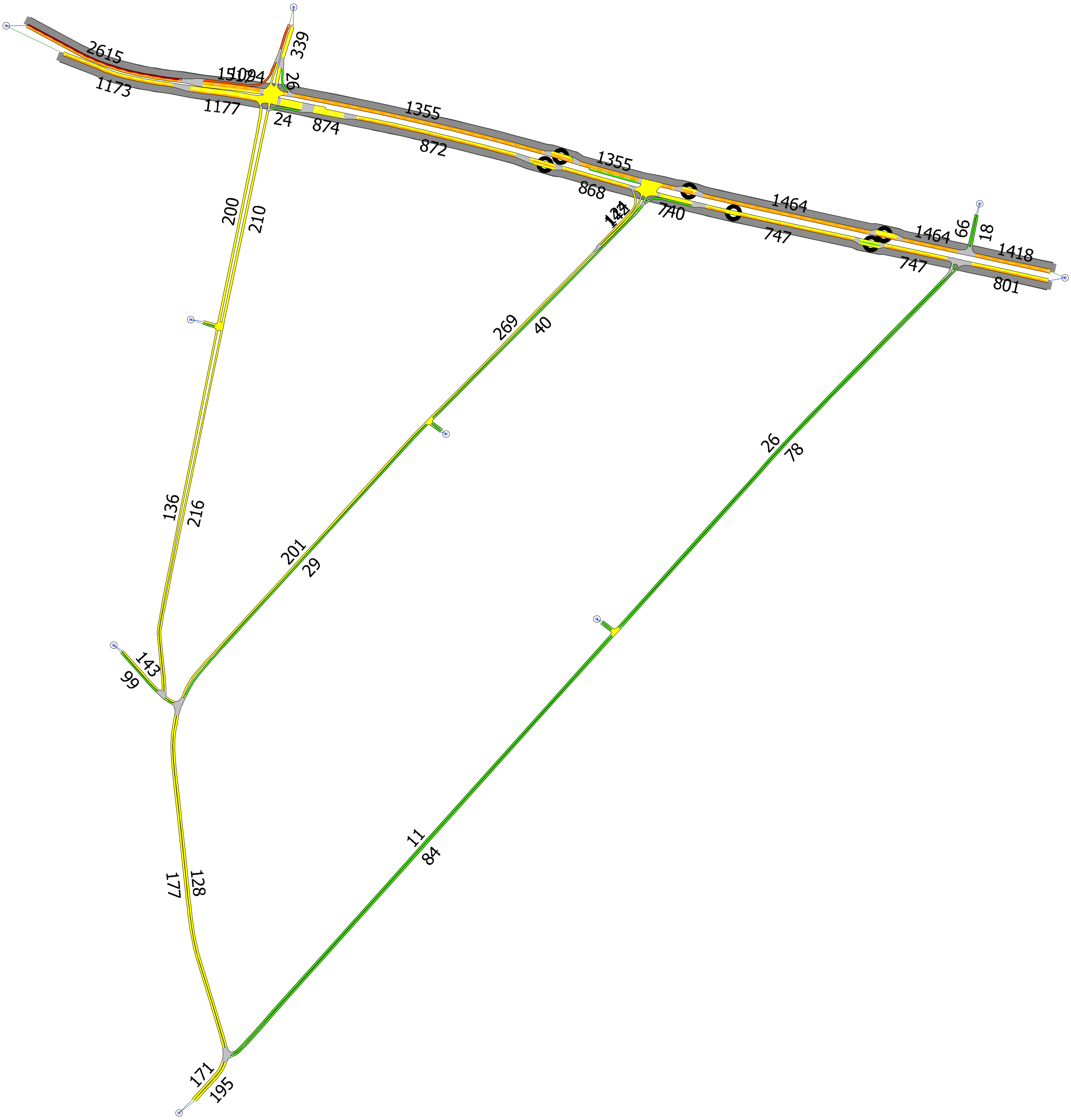
2031 PM - Scenario 1



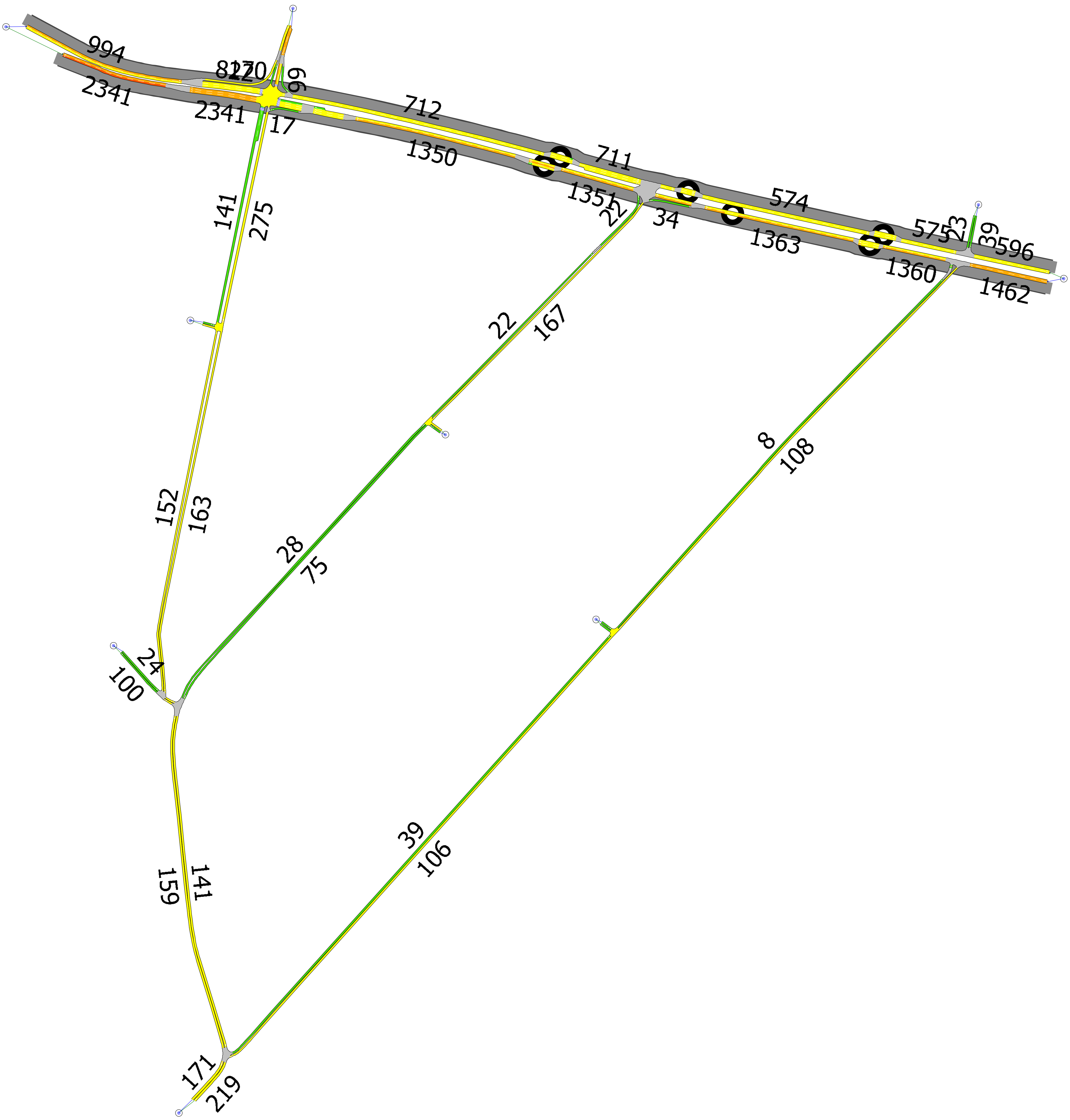
2031 AM - Scenario 2



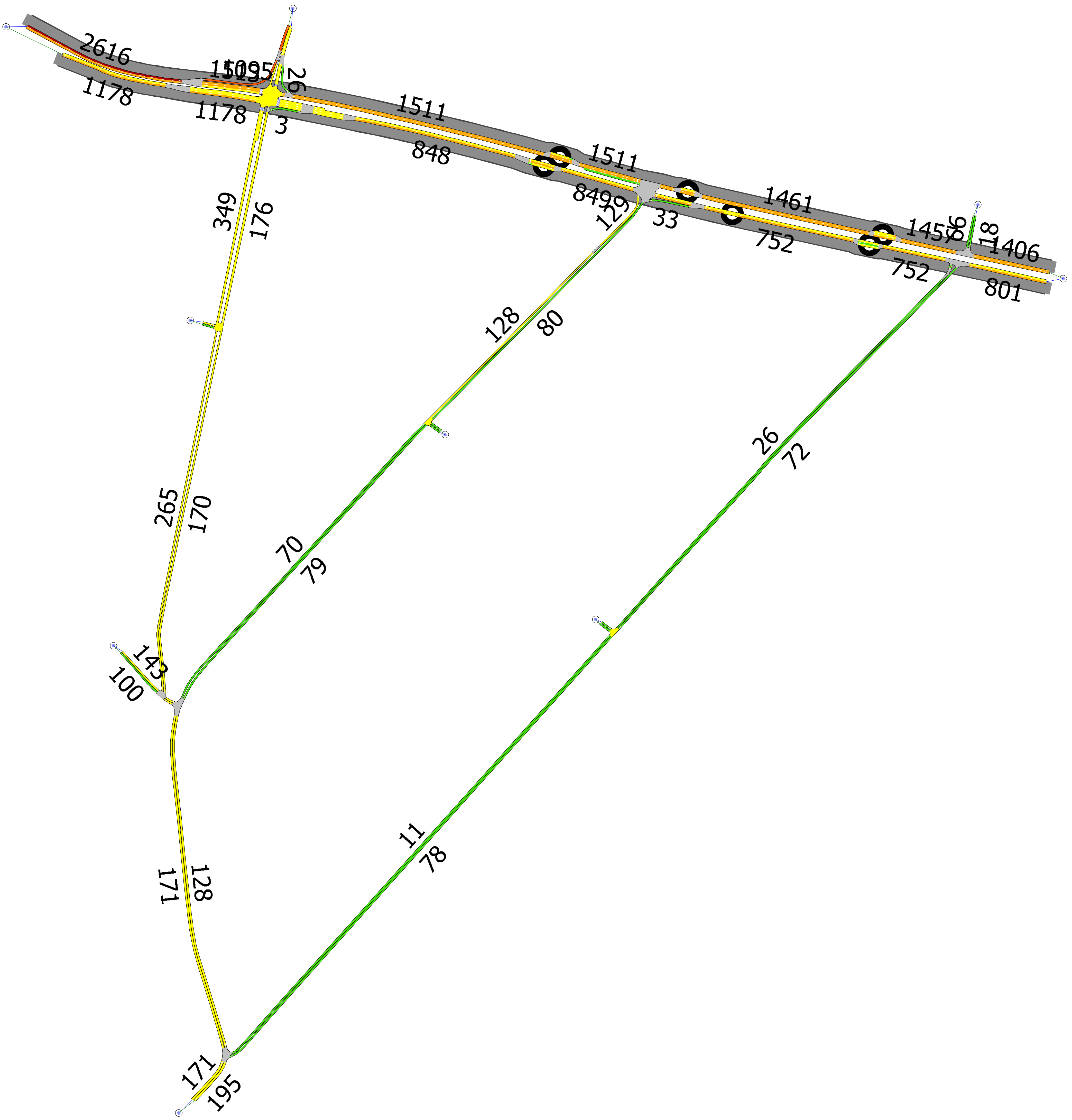
2031 PM - Scenario 2



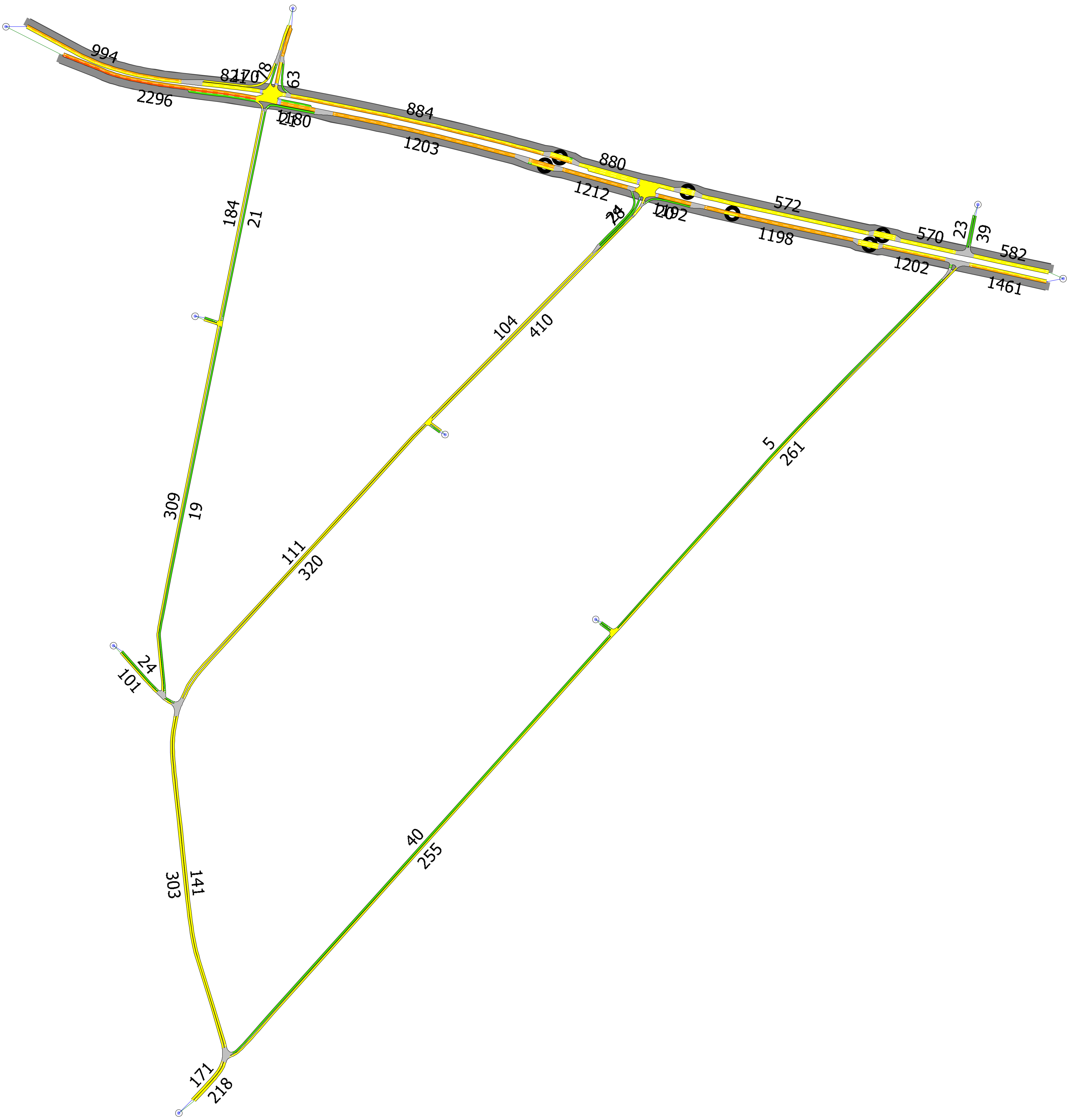
2031 AM - Scenario 3



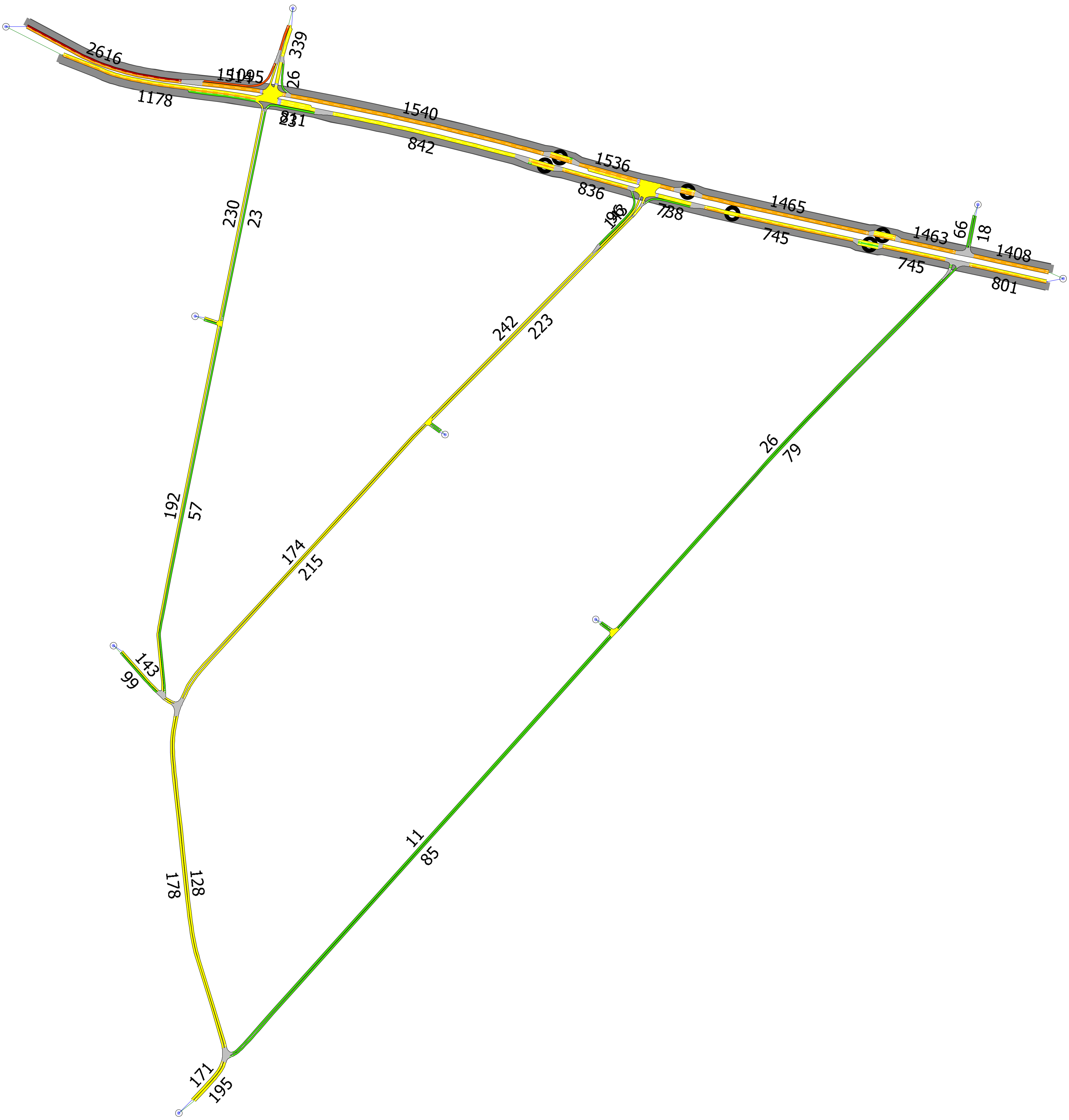
2031 PM - Scenario 3



2031 AM - Scenario 4

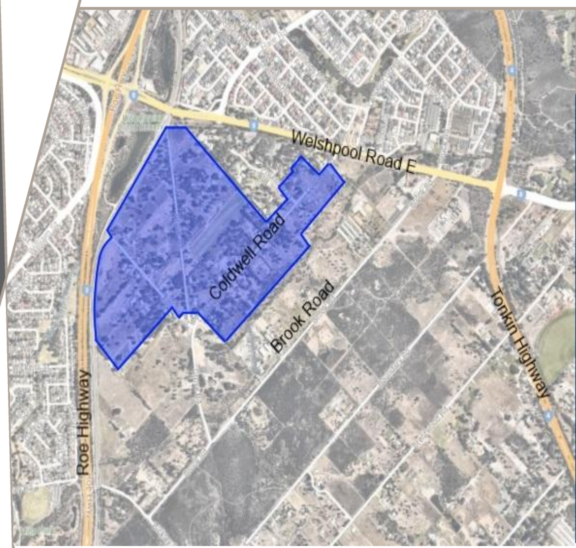


2031 PM - Scenario 4



Addendum to MKSEA Precinct 3

Transport Assessment



Prepared for
Linc Property Pty. Ltd.

16 January 2017

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Revision	Date	Description of Revision	Prepared by:	Reviewed by:
A	13/01/2017	Technical Memorandum	Andreas Wang	Ray Cook
B	16/01/2017	Final Report	Andreas Wang	Ray Cook

Table of Contents

Appendices

Figures

1 Background

Cardno have been commissioned by Linc Property Pty Ltd (Linc) to prepare an addendum to the '*MKSEA Precinct 3 Transport Assessment*' (Cardno July 2016).

The Cardno *MKSEA Precinct 3 Transport Assessment* was initially prepared to support the City of Gosnell's Precinct 3A Structure Plan. It considered a range of potential access scenarios for the area. Feedback from the referral authorities including the Shire of Kalamunda, submissions from surrounding landowners during the Structure Plan advertising and further discussions with Main Road Western Australia (MRWA) resulted in a new access strategy.

Importantly, the new access strategy ensures that there is no possible straight-through movements (between Grove Road and Hale Road) or right-turn-out vehicle movements from the industrial estate (particularly traffic from the industrial estate directly accessing Hale Road).

This addendum summarises the new access strategy and the further work that has been undertaken. It demonstrates that there is negligible impact on the performance of the existing and future road network and safety. The addendum has been prepared to support the rezoning of the MKSEA Kalamunda Wedge Precinct 3A.

2 Introduction

The new access strategy proposes intersection upgrades to two existing intersections on Welshpool Road, as follows:

1. Modification of the intersection of Welshpool Road / Hale Road / Grove Road (realigned) to allow for Left-In, Left-Out and signalised Right-In (LILO-RI) turning movements to/from Grove Road (southern intersection approach). The intersection will include and Auxillary Through Lane (ATL) in the westbound direction to provide additional capacity for the westbound through movement during the critical AM Peak hour period.

   A preliminary intersection plan has been prepared by Cossill and Webbley Engineers and is attached as **Figure 2-2**. This is a concept plan only and is subject to detailed design and approval by the relevant authorities. It serves to demonstrate that there will be no vehicular movement directly from Grove Road to Hale Road, with exiting vehicles being required to turn left only.

2. The upgrade of the Welshpool Road / Coldwell Road to provide a signalised intersection.

The existing form of the Welshpool Road East / Hale Road intersection is a 3-way signalised intersection as shown in **Figure 2-1**, while the proposed intersection modifications to allow right-in access to MKSEA Precinct 3 is shown in **Figure 2-2**. It is noted that, while not shown in **Figure 2-2**, for the purpose of this assessment it has been assumed that the left-turn from Hale Road is modified to an unsignalised left-turn priority slip lane to reduce the future queue lengths for the Hale Road approach. **Figure 2-3,** shows an example of a similar left-turn slip lane that is proposed for Hale Road to improve egress from Hale Road.

As the right-in movement will require modifications to the traffic signal phasing, the proposed intersection form will include a westbound “Auxiliary Through Lane” (ATL) through the intersection to increase the capacity of the intersection and ensure that the intersection will operate satisfactorily for the 2031 design horizon.

2.1 2031 Traffic Volumes

To ensure that the assumptions for the modelled 2031 traffic volumes were consistent with Main Roads WA modelling and planning assumptions, the MKSEA traffic data (in terms of how much traffic is generated by MKSEA and where it’s going) was sourced from the Main Roads WA strategic transport model (ROM24). This methodology also ensured that road network changes outside of the study area were accounted for. This includes, for example, severance of connectivity at the intersection of Tonkin Highway / Hale Road, and the Roe Highway / Tonkin Highway interchange upgrade.

Figure 2-1 Existing Form of Welshpool Road East / Hale Road Intersection

Figure 2-2 Conceptual Sketch of Proposed Intersection Modification

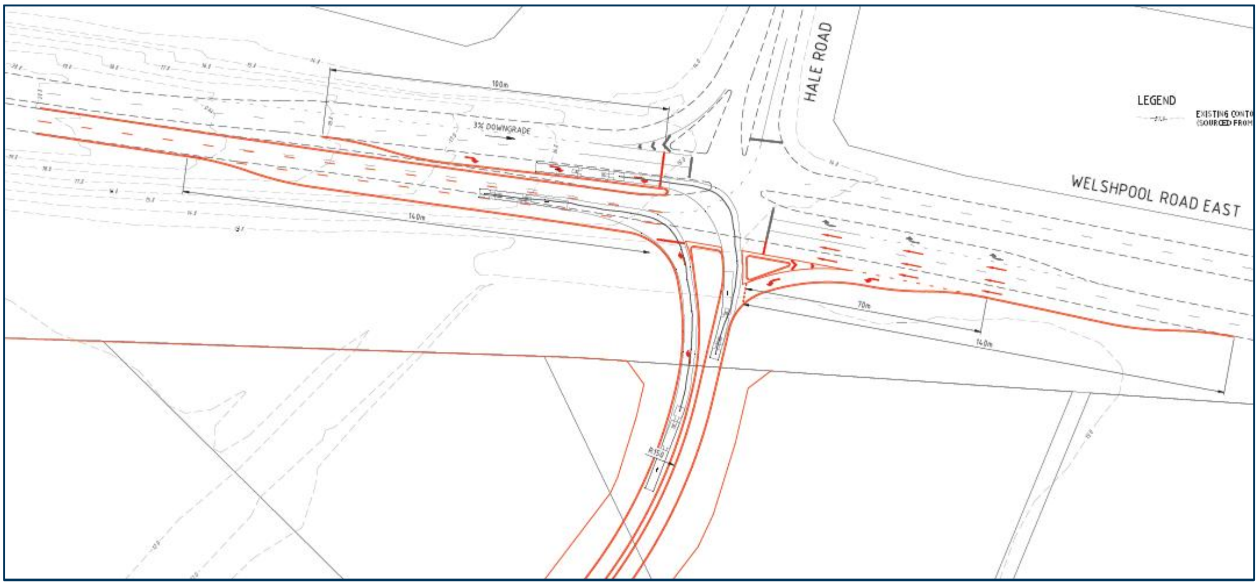
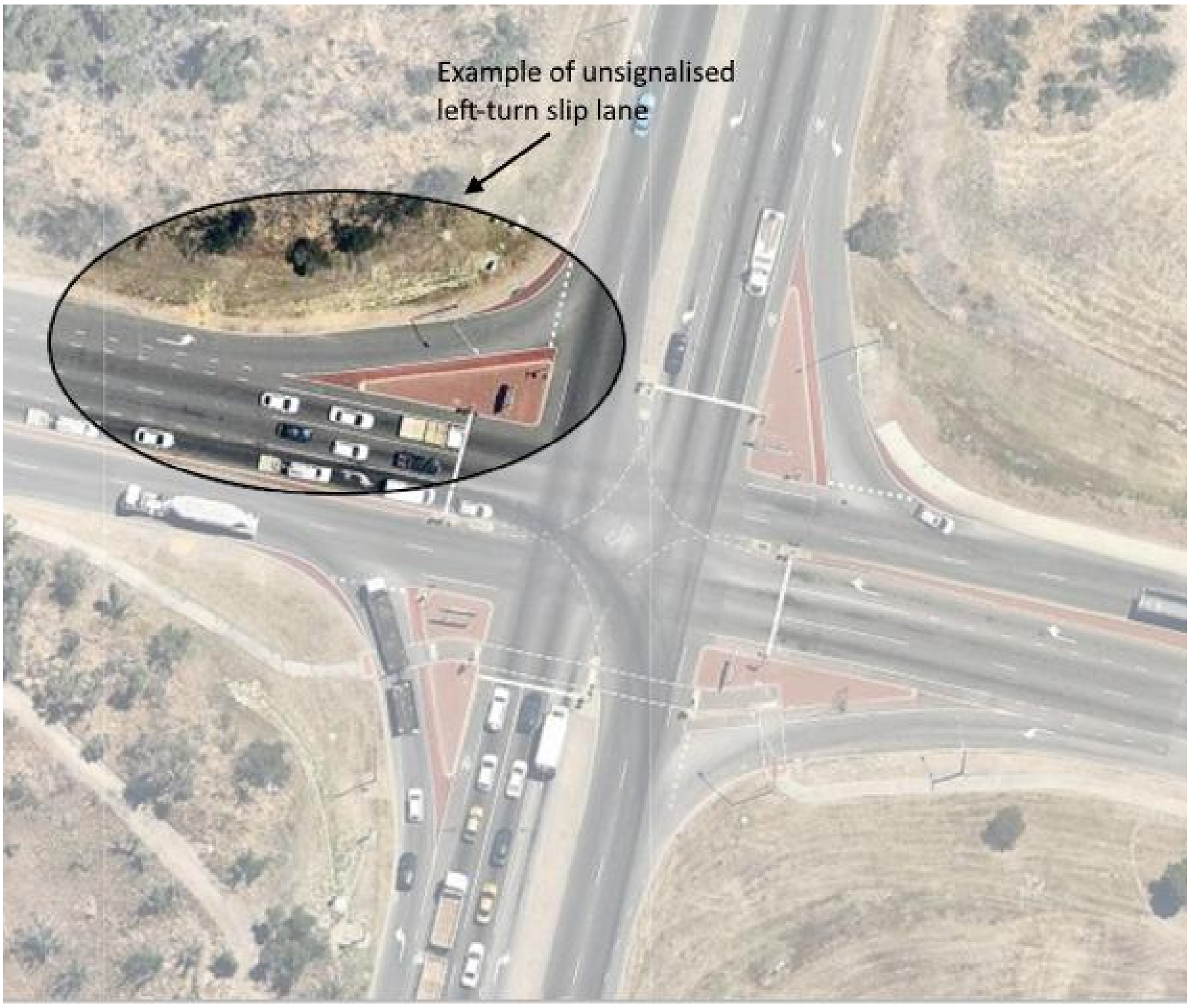


Figure 2-3 Examples of Left-Turn Slip Lanes (Intersection of Welshpool Road East / Tonkin Highway)



3 Summary of Welshpool Road / Hale Road / Grove Road Intersection Performance

A summary of the intersection operation for the 2031 horizon year, in terms of average delays and Level Of Service (LOS), is shown in **Figure 3-1** for a 2031 “Do Nothing” scenario (i.e. without any development within MKSEA or associated road network upgrades) and in **Figure 3-2** for a 2031 “With MKSEA” scenario.

For comparison purposes, the WAPC Transport Impact Assessment Guidelines (dated August 2016) consider LOS E the threshold for acceptable performance for individual turning movements.

The model results suggest that the average delays will increase slightly for vehicles turning right from Hale Road to Welshpool Road East (by approximately 2-4 seconds), while the average delays for the right-in movement from Welshpool Road East to Hale Road is shown to decrease in the AM peak hour and decrease in the PM peak hour.

It is noted that the proposed left-in, left-out and right-in modifications to the intersection are only proposed as an interim intersection form in the short-to-medium term, and the ultimate (long-term) intersection form may include partial grade-separation of this intersection. Previous modelling undertaken for the potential ultimate intersection form was shown to result in LoS A / B for all turning movements.

The realigned Grove Road access at the Hale Road/Welshpool Road East intersection offers the most logical entry and exit point to the estate, with the majority of the heavy vehicle traffic seeking to enter and exit from and to the west (particularly to/from Roe Highway as this forms part of the Perth Freight Link). It is therefore more efficient from a freight transport perspective and consistent with the Shire of Kalamunda’s desire to route heavy vehicles into the estate as soon as possible to avoid amenity impacts on residences abutting Welshpool Road East further east. The arrangements also minimise new access infrastructure (the addition of one leg to an existing signalised intersection is in real terms a relatively minor modification).

Figure 3-1 Summary of Average Turning Movement Delay (in Seconds) and Level of Service for 2031 Do-Nothing Scenario

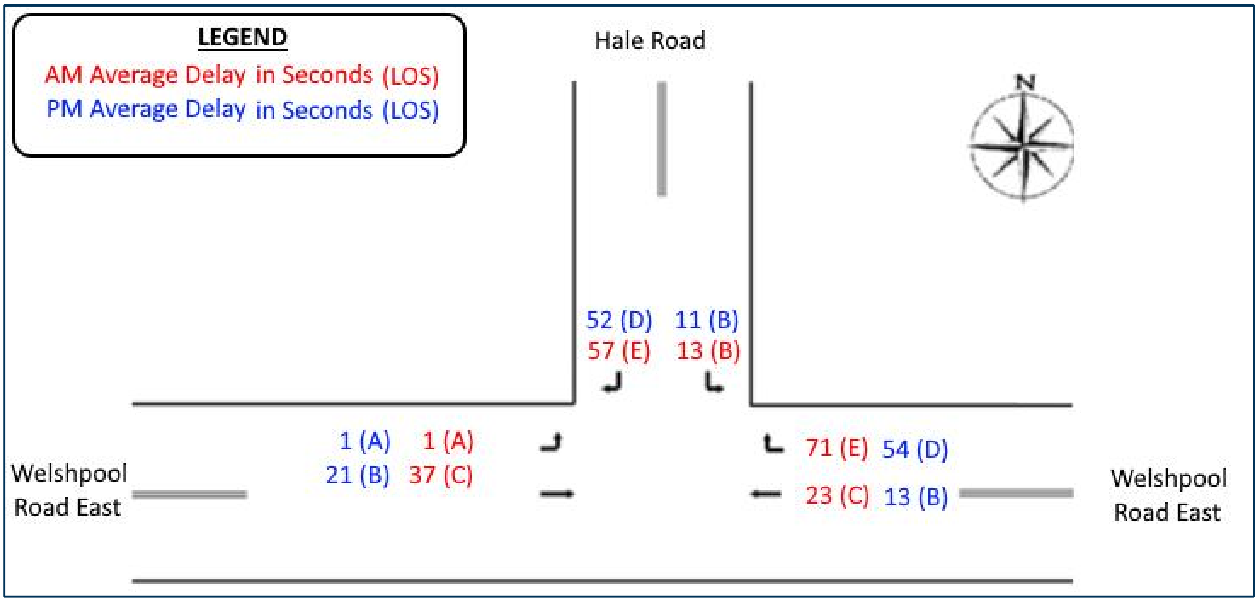
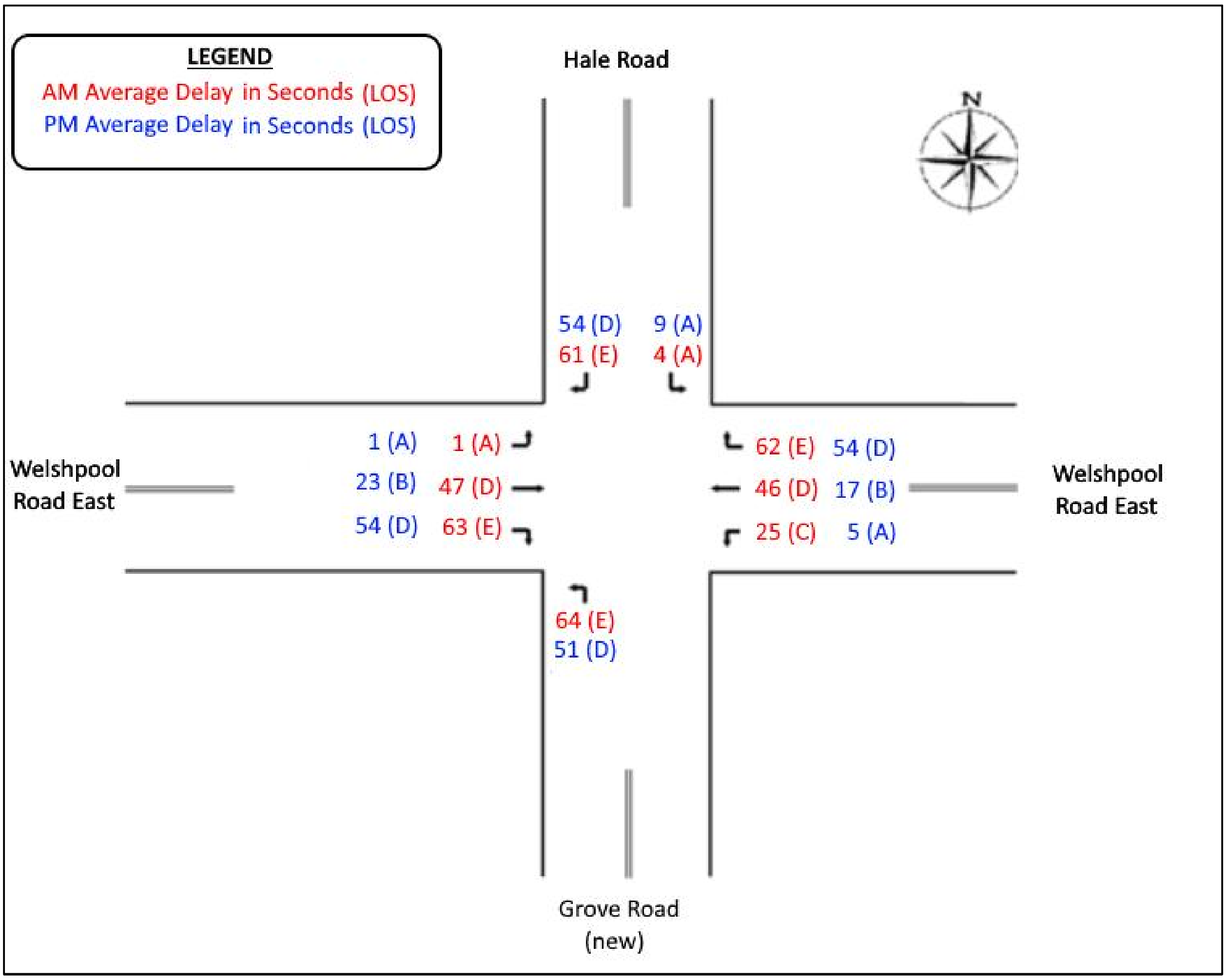


Figure 3-2 Summary of Average Turning Movement Delay (in Seconds) and Level of Service for 2031 MKSEA Development Scenario



3.1 Network Performance

Various traffic modelling and simulations undertaken indicates a right-in from Welshpool Road East to Grove Road at the Hale Road/Welshpool Road East intersection will improve traffic distribution to and from Welshpool Road East to MKSEA P3 and, with upgrades to the Hale Road/Welshpool Road East/Grove Road intersection have no significant effect on traffic operations for Welshpool Road East or Hale Road due to the additional capacity provided by the proposed westbound ATL through the intersection.

The traffic modelling undertaken indicates that a right-in at the intersection of Welshpool Road East/Hale Road will improve the forecast traffic operational issues at the Coldwell Road/ Welshpool Road East intersection as the right-in demand is split over 2 intersections, thus reducing the amount of green time required for the right-in phase to ensure that the queues are cleared during most cycles.

The model results suggest that allowing right-in movements to be undertaken at 2 intersections will reduce travel time statics (Vehicle Hours Travelled) on Welshpool Road East by between 10-15% (depending on the comparison scenarios) compared to a single intersection, thereby indicating that the proposed access arrangements will have a net benefit to all network users.

The model results also indicate that the traffic turning right from Hale Road to Welshpool Road East will not be adversely impacted by the provision of the right-in movement as this movement will retain the proportional amount of green time required to ensure that the queue lengths on this intersection approach are cleared during most cycles.

Additional information and data relating to technical aspects of this study are included in **Appendix 1** – Cardno Technical Memorandum '*MKSEA Precinct 3 – SIDRA and AIMSUN Intersection Analysis*' (Rev D - January 2017)

3.2 Intersection Safety

The additional right-in movement at the intersection of Hale Road/Welshpool Road East does not create additional mixing of residential traffic with industrial traffic as the same industrial traffic must pass through the Hale Road intersection if no right-in at Hale Road was in place and turn right at Coldwell Road. The proposed right-in at Hale Road/Welshpool Road East will remove heavy vehicles sooner from Welshpool Road East.

Cardno conducted a safety assessment of the proposed intersection modification which has been subject to an independent review by an accredited road safety auditor. The safety assessment confirms that the addition of a right-in at Hale Road/Welshpool Road East can be designed to satisfy relevant safety design criteria and will deliver a number of improved safety outcomes, including the following:

- It will reduce the queue of traffic that will otherwise head straight through this intersection, and therefore decrease the risk of rear-end crashes;
- It will reduce the probability of vehicles from the west running a red light at speed (via a through movement) by providing a lower speed right-in turn;
- The provision of an additional alternative right-in movement into the estate will reduce the likelihood of red light running and the over-reliance on a single green phase at a single intersection (or limited gaps in a high volume traffic flow associated with a roundabout). This will in turn improve the safety of the Coldwell Road/Welshpool Road East intersection; and
- It will improve the safe egress of heavy vehicles leaving the estate (left-out) by providing a period during each cycle (right-in cycle) with no conflict movements.

Right-in traffic will be slower moving than straight through traffic (having slowed into a deceleration/slip lane) and hence is more controlled. Significantly, the right-in at Hale Road improves the safety (and performance) of the Coldwell Road/Welshpool Road East intersection by distributing right-in traffic into MKSEA P3 over two intersections.

Appendix 2 – Cardno Technical Memorandum '*Maddington Kenwick Strategic Employment Area Precinct 3 – Summary Note of Traffic and Safety Issues Related to Potential Access Forms*' (Rev D - December 2016) contains a detailed assessment of the preferred against alternative access arrangements and includes the Intersection Safety Review.

APPENDIX

A

SIDRA AND AIMSUN INTERSECTION ANALYSIS

Technical Memorandum

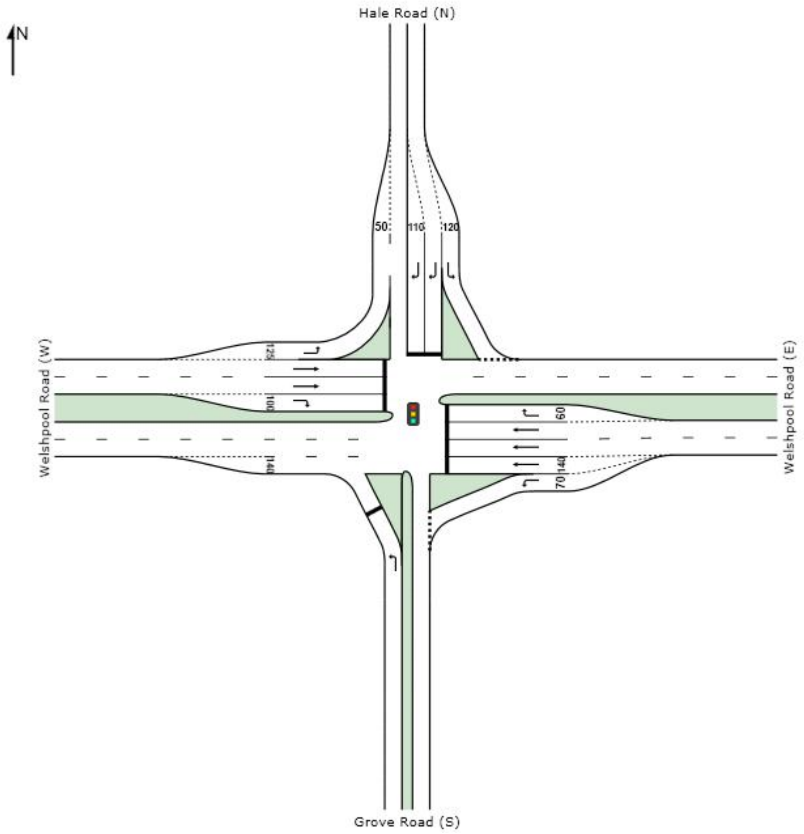
Title	**MKSEA Precinct 3** **SIDRA and AIMSUN Intersection Analysis**		
Client	Linc Property Pty. Ltd	**Project No**	CW937700
Date	16/01/2017	**Status**	Rev E
Author	Andreas Wang	**Discipline**	Traffic and Transport
Reviewer	Ray Cook	**Office**	Perth

1 Introduction

Cardno have been requested by Linc Property Pty Ltd to undertake intersection assessment of the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road for the 2031 AM and PM peak hour periods for the following intersection scenario:

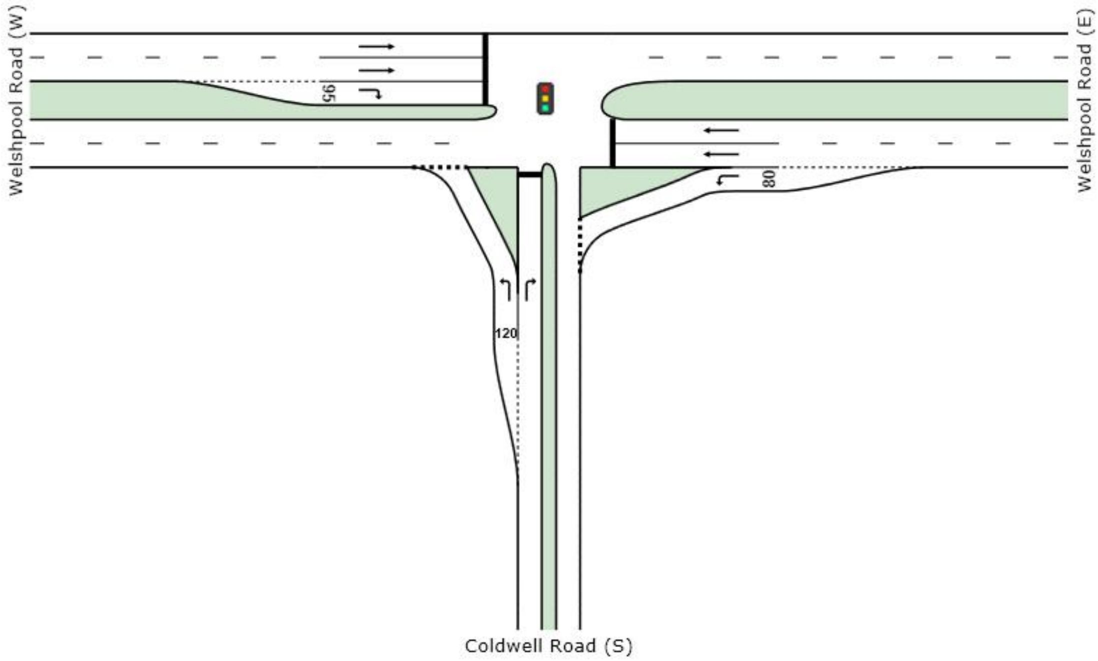
> **Scenario:** The intersection of Welshpool Road / Hale Road / Grove Road to allow for Left-In, Left-Out and Right-In (LILO-RI) turning movements to/from Grove Road (southern intersection approach). This scenario also assumes an Auxiliary Through Lane (ATL) in the westbound direction to provide additional capacity for the westbound through movement during the critical AM peak hour period. The SIDRA intersection form for the intersection of Welshpool Road / Hale Road / Grove Road is shown in **Figure 1**. This intersection form is notionally referred to in this document as "LILO-RI".

Figure 1 Intersection Form for Welshpool Road / Hale Road / Grove Road (LILO-RI)



The intersection of Welshpool Road / Coldwell Road was assumed to be a signalised intersection for this scenario. The SIDRA intersection form for the intersection of Welshpool Road / Coldwell Road is shown in **Figure 2.**

Figure 2 Signalised Intersection Form for Welshpool Road / Coldwell Road



1.1 Model Demands

In order to ensure robust assessment and to reduce ambiguity on the 'preferred' methodology for deriving model demand volumes, the model demand volumes for the intersection analysis have been derived by utilising the following 2 methodologies:

> **ROM24 Factored Demand Volumes:** Utilising this methodology, the model demands were estimated by using the ratios of the ROM24 2011 (existing) and 2031 peak hour demand volumes and applying these ratios to the existing observed traffic volumes. This methodology is generally considered more robust as it accounts for under-or-over estimation of modelled existing traffic volumes in ROM24 within the study area.

> **ROM24 Unfactored Demand Volumes:** Utilising this methodology, the model demands were estimated by using the Main Roads WA supplied 2031 peak period demand matrices from ROM24. This methodology generally results in higher demand volumes compared to the Factored Demand Volumes methodology and is considered a "sensitivity test" to evaluate the intersection performance if the traffic volumes exceed the demand volumes derived using the Factored Demand Volumes methodology.

1.2 Intersection Analysis

As requested by Main Road WA, the intersection analysis has been undertaken for the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road in SIDRA.

The demand matrices for the AIMSUN micro-simulation model were derived from the methodologies detailed above, with the intersection turning volumes for the SIDRA analysis extracted from the AIMSUN micro-simulation model results.

2 SIDRA Analysis

SIDRA analysis was undertaken for the intersections of Welshpool Road / Hale Road / Grove Road and Welshpool Road / Coldwell Road for the 2031 AM and PM peak hour periods for each demand methodology.

2.1 ROM24 Factored Demand Volumes

Utilising the ROM24 Factored Demand Volumes, the results for the SIDRA analysis for Scenario are shown in **Table 1** and **Table 2** for the intersection of Welshpool Road / Hale Road / Grove Road and in **Table 3** and **Table 4** for the intersection of Welshpool Road / Coldwell Road.

Table 1 SIDRA Summary for Intersection of Welshpool Road / Hale Road / Grove Road for 2031 AM– Factored Demand Volumes

Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Grove Road (S)											
1	L2	225	7.0	0.798	67.5	LOS E	14.8	109.9	1.00	0.90	28.7
Approach		225	7.0	0.798	67.5	LOS E	14.8	109.9	1.00	0.90	28.7
East: Welshpool Road (E)											
4	L2	23	22.7	0.020	9.1	LOS A	0.2	2.1	0.23	0.62	54.2
5	T1	1584	13.8	0.810	33.5	LOS C	30.6	239.3	0.85	0.77	42.7
6	R2	34	6.3	0.117	57.0	LOS E	1.8	13.6	0.89	0.73	31.8
Approach		1641	13.7	0.810	33.7	LOS C	30.6	239.3	0.84	0.77	42.5
North: Hale Road (N)											
7	L2	206	2.6	0.181	7.8	LOS A	2.4	17.4	0.25	0.63	54.5
9	R2	891	0.0	0.799	53.5	LOS D	27.1	189.9	0.99	0.90	32.7
Approach		1097	0.5	0.799	44.9	LOS D	27.1	189.9	0.85	0.85	35.3
West: Welshpool Road (W)											
10	L2	232	0.0	0.125	6.7	LOS A	0.0	0.0	0.00	0.57	61.0
11	T1	578	8.9	0.397	29.6	LOS C	12.9	97.4	0.76	0.65	44.7
12	R2	215	14.7	0.816	70.1	LOS E	14.4	113.4	1.00	0.90	28.3
Approach		1024	8.1	0.816	32.9	LOS C	14.4	113.4	0.64	0.69	42.2
All Vehicles		3987	8.3	0.816	38.5	LOS D	30.6	239.3	0.80	0.78	39.2

Table 2 SIDRA Summary for Intersection of Welshpool Road / Hale Road / Grove Road for 2031 PM – Factored Demand Volumes

Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Grove Road (S)											
1	L2	131	12.1	0.457	59.1	LOS E	7.6	58.7	0.95	0.80	30.3
Approach		131	12.1	0.457	59.1	LOS E	7.6	58.7	0.95	0.80	30.3
East: Welshpool Road (E)											
4	L2	11	20.0	0.009	9.3	LOS A	0.1	1.0	0.23	0.61	54.1
5	T1	764	13.1	0.260	7.4	LOS A	4.3	33.6	0.27	0.23	61.4
6	R2	142	2.2	0.459	59.6	LOS E	8.2	58.8	0.95	0.80	31.1
Approach		917	11.5	0.459	15.5	LOS B	8.2	58.8	0.37	0.32	53.3
North: Hale Road (N)											
7	L2	113	0.9	0.181	15.0	LOS B	2.8	19.7	0.46	0.68	49.6
9	R2	295	0.0	0.860	77.9	LOS E	10.3	72.3	1.00	0.95	26.8
Approach		407	0.3	0.860	60.5	LOS E	10.3	72.3	0.85	0.87	30.8
West: Welshpool Road (W)											
10	L2	1142	0.0	0.615	6.8	LOS A	0.0	0.0	0.00	0.57	60.8
11	T1	1363	13.4	0.702	18.1	LOS B	32.1	250.3	0.71	0.65	52.0
12	R2	247	7.7	0.836	70.3	LOS E	16.7	124.7	1.00	0.91	28.4
Approach		2753	7.3	0.836	18.1	LOS B	32.1	250.3	0.44	0.64	51.3
All Vehicles		4207	7.7	0.860	22.9	LOS C	32.1	250.3	0.48	0.60	47.6

Table 3 SIDRA Summary for Intersection of Welshpool Road / Coldwell Road for 2031 AM – Factored Demand Volumes

Signals - Fixed Time Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Coldwell Road (S)											
1	L2	99	8.5	0.205	13.0	LOS B	1.9	14.4	0.48	0.67	47.6
3	R2	71	13.4	0.594	58.4	LOS E	3.6	28.3	1.00	0.78	29.6
Approach		169	10.6	0.594	31.9	LOS C	3.6	28.3	0.69	0.71	38.1
East: Welshpool Road (E)											
4	L2	39	18.9	0.030	6.8	LOS A	0.2	1.9	0.19	0.56	51.6
5	T1	1549	13.9	0.679	11.6	LOS B	23.6	184.9	0.68	0.62	50.4
Approach		1588	14.0	0.679	11.5	LOS B	23.6	184.9	0.66	0.62	50.4
West: Welshpool Road (W)											
11	T1	466	9.7	0.159	2.2	LOS A	2.4	18.4	0.23	0.20	57.9
12	R2	109	11.5	0.653	55.9	LOS E	5.5	42.5	1.00	0.81	30.2
Approach		576	10.1	0.653	12.4	LOS B	5.5	42.5	0.38	0.32	49.3
All Vehicles		2334	12.8	0.679	13.2	LOS B	23.6	184.9	0.60	0.55	49.0

Table 4 SIDRA Summary for Intersection of Welshpool Road / Coldwell Road for 2031 PM – Factored Demand Volumes

Signals - Fixed Time Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Coldwell Road (S)											
1	L2	143	10.3	0.172	7.8	LOS A	1.4	10.9	0.28	0.61	51.0
3	R2	155	11.6	0.539	47.8	LOS D	7.1	54.8	0.96	0.80	32.4
Approach		298	11.0	0.539	28.6	LOS C	7.1	54.8	0.64	0.71	39.4
East: Welshpool Road (E)											
4	L2	18	11.8	0.013	6.3	LOS A	0.1	0.5	0.15	0.55	52.0
5	T1	765	11.3	0.368	11.9	LOS B	9.9	75.7	0.57	0.50	50.2
Approach		783	11.3	0.368	11.8	LOS B	9.9	75.7	0.56	0.50	50.2
West: Welshpool Road (W)											
11	T1	1434	12.6	0.569	7.5	LOS A	16.8	130.1	0.53	0.48	53.4
12	R2	51	12.5	0.438	57.3	LOS E	2.5	19.7	1.00	0.75	29.9
Approach		1484	12.6	0.569	9.2	LOS A	16.8	130.1	0.54	0.49	52.0
All Vehicles		2565	12.0	0.569	12.2	LOS B	16.8	130.1	0.56	0.52	49.6

2.2 ROM24 Unfactored Demand Volumes

Utilising the ROM24 Unfactored Demand Volumes, the results for the SIDRA analysis are shown in **Table 5** and **Table 6** for the intersection of Welshpool Road / Hale Road / Grove Road and in **Table 7** and **Table 8** for the intersection of Welshpool Road / Coldwell Road.

Table 5 SIDRA Summary for Intersection of Welshpool Road / Hale Road / Grove Road for 2031 AM - Unfactored Demand Volumes

Signals - Fixed Time Cycle Time = 130 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Grove Road (S)											
1	L2	259	6.5	0.766	62.7	LOS E	16.4	121.1	1.00	0.88	29.8
Approach		259	6.5	0.766	62.7	LOS E	16.4	121.1	1.00	0.88	29.8
East: Welshpool Road (E)											
4	L2	17	25.0	0.016	10.1	LOS B	0.2	1.9	0.27	0.62	53.3
5	T1	1699	12.5	0.861	37.1	LOS D	36.2	280.6	0.89	0.84	41.0
6	R2	281	0.7	0.791	64.5	LOS E	18.0	127.0	1.00	0.89	29.9
Approach		1997	11.0	0.861	40.7	LOS D	36.2	280.6	0.90	0.84	39.0
North: Hale Road (N)											
7	L2	516	1.0	0.464	9.4	LOS A	9.8	68.9	0.39	0.69	53.6
9	R2	893	0.0	0.893	67.4	LOS E	31.5	220.3	1.00	0.97	29.1
Approach		1408	0.4	0.893	46.1	LOS D	31.5	220.3	0.78	0.87	35.0
West: Welshpool Road (W)											
10	L2	781	0.0	0.421	6.7	LOS A	0.0	0.0	0.00	0.57	61.0
11	T1	622	13.9	0.445	30.4	LOS C	14.3	111.8	0.78	0.68	44.3
12	R2	279	11.7	0.870	72.4	LOS E	19.5	150.4	1.00	0.94	27.9
Approach		1682	7.1	0.870	26.4	LOS C	19.5	150.4	0.45	0.67	45.7
All Vehicles		5346	6.7	0.893	38.7	LOS D	36.2	280.6	0.73	0.80	39.1

Table 6 SIDRA Summary for Intersection of Welshpool Road / Hale Road / Grove Road for 2031 PM - Unfactored Demand Volumes

Signals - Fixed Time Cycle Time = 130 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Grove Road (S)											
1	L2	125	13.4	0.487	61.2	LOS E	7.4	58.1	0.96	0.80	29.7
Approach		125	13.4	0.487	61.2	LOS E	7.4	58.1	0.96	0.80	29.7
East: Welshpool Road (E)											
4	L2	11	20.0	0.009	9.1	LOS A	0.1	0.9	0.22	0.61	54.3
5	T1	715	13.1	0.278	13.2	LOS B	6.0	46.9	0.40	0.34	55.9
6	R2	226	1.4	0.800	68.9	LOS E	14.9	105.4	1.00	0.89	28.9
Approach		952	10.4	0.800	26.4	LOS C	14.9	105.4	0.54	0.47	45.7
North: Hale Road (N)											
7	L2	393	0.5	0.518	20.0	LOS B	14.6	102.5	0.68	0.79	46.5
9	R2	591	0.0	0.861	70.0	LOS E	20.3	141.9	1.00	0.94	28.5
Approach		983	0.2	0.861	50.0	LOS D	20.3	141.9	0.87	0.88	33.7
West: Welshpool Road (W)											
10	L2	1176	0.0	0.633	6.8	LOS A	0.0	0.0	0.00	0.57	60.8
11	T1	1254	14.6	0.743	24.6	LOS C	33.2	261.8	0.81	0.73	47.6
12	R2	231	8.2	0.861	74.1	LOS E	16.0	120.1	1.00	0.93	27.6
Approach		2660	7.6	0.861	21.0	LOS C	33.2	261.8	0.47	0.68	49.3
All Vehicles		4720	6.8	0.861	29.2	LOS C	33.2	261.8	0.58	0.68	43.7

Table 7 SIDRA Summary for Intersection of Welshpool Road / Coldwell Road for 2031 AM - Unfactored Demand Volumes

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Coldwell Road (S)											
1	L2	108	5.8	0.221	23.0	LOS C	3.7	26.9	0.61	0.71	42.2
3	R2	97	9.8	0.806	77.6	LOS E	6.7	50.7	1.00	0.86	25.7
Approach		205	7.7	0.806	48.8	LOS D	6.7	50.7	0.79	0.78	32.4
East: Welshpool Road (E)											
4	L2	47	20.0	0.039	8.1	LOS A	0.5	4.4	0.23	0.57	50.7
5	T1	1874	11.3	0.841	19.9	LOS B	46.8	359.0	0.84	0.79	45.2
Approach		1921	11.5	0.841	19.6	LOS B	46.8	359.0	0.83	0.78	45.3
West: Welshpool Road (W)											
11	T1	616	7.5	0.199	2.1	LOS A	3.7	27.4	0.21	0.18	58.0
12	R2	236	4.9	0.820	68.7	LOS E	15.7	114.7	1.00	0.89	27.4
Approach		852	6.8	0.820	20.6	LOS C	15.7	114.7	0.43	0.38	44.2
All Vehicles		2978	9.9	0.841	21.9	LOS C	46.8	359.0	0.71	0.67	43.8

Table 8 SIDRA Summary for Intersection of Welshpool Road / Coldwell Road for 2031 PM - Unfactored Demand Volumes

Signals - Fixed Time Isolated   Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Coldwell Road (S)											
1	L2	125	9.2	0.151	8.2	LOS A	1.3	10.2	0.30	0.61	50.8
3	R2	156	12.2	0.579	49.1	LOS D	7.3	56.4	0.98	0.81	32.1
Approach		281	10.9	0.579	30.8	LOS C	7.3	56.4	0.67	0.72	38.4
East: Welshpool Road (E)											
4	L2	18	11.8	0.013	6.5	LOS A	0.1	0.7	0.17	0.55	52.0
5	T1	822	10.5	0.423	14.6	LOS B	11.8	90.4	0.64	0.56	48.4
Approach		840	10.5	0.423	14.4	LOS B	11.8	90.4	0.63	0.56	48.4
West: Welshpool Road (W)											
11	T1	1548	11.4	0.601	7.3	LOS A	18.4	141.3	0.54	0.49	53.5
12	R2	93	6.8	0.444	51.6	LOS D	4.4	32.5	0.97	0.78	31.4
Approach		1641	11.2	0.601	9.8	LOS A	18.4	141.3	0.56	0.51	51.5
All Vehicles		2762	10.9	0.601	13.4	LOS B	18.4	141.3	0.59	0.55	48.9

2.3 Summary of SIDRA Analysis

2.3.1 Factored Demand Volumes

The SIDRA results from the analysis using the Factored Demand Volumes as input, suggest the overall intersection LOS was found to be acceptable for the 2031 AM and PM peak hours.

2.3.2 Unfactored Demand Volumes

The SIDRA results from the analysis using the Unfactored Demand Volumes as input, suggest that an acceptable LOS will also be acceptable for the 2031 AM and PM peak hours at the intersections.

For the 2031 AM peak hour, the westbound through movement at the intersection of Welshpool Road / Coldwell Road for Scenario 1 was found to result in overall intersection LOS B. Specifically, 2 right-in access movements from Welshpool Road (one at the intersection at Grove Road / Hale Road and one at the intersection of Coldwell Road), share the demand for the right-in turning movement across 2 intersections. This substantially reduces the amount of green time required for the right-in movements rather than trying to concentrate the RI movement at a single (Welshpool Road / Coldwell Road) intersection. This is particularly critical for the intersection of Welshpool Road / Coldwell Road for the 2031 AM peak hour due to the heavy directional westbound demand on Welshpool Road during this time period, as the turning movement for the right-in conflicts with the heavy westbound through movement. By providing 2 right-in access movements, the green time required for the right-in at the intersection of Welshpool Road / Coldwell Road can instead be allocated to the through movements.

2.3.3 Comparison of an Alternative Access Scenario

For the purposes of completeness and in response to MRWA request to consider an alternative access strategy, an assessment was also undertaken for an alternative access scenario (herein referred to as Scenario 2 with the preferred scenario being referred to as Scenario 1 – LILO-RI).

The intersection of Welshpool Road / Hale Road / Grove Road for Scenario 2 allows Left-In and Left-Out (LILO) turning movements to/from Grove Road (southern intersection approach) as well as a single free-flowing westbound through lane through the intersection. This intersection form also includes a double-right turn from Hale Road to Welshpool Road (westbound), merging to a single westbound lane approximately 100m to the west of the intersection. To the best of Cardno knowledge this form of intersection arrangement has not been used before in Western Australia and would specifically preclude the opportunity for right-in turning movement from Welshpool Road to Grove Road, as this movement would conflict with the free-flowing westbound through lane This intersection form is notionally referred to in this document as the “MRWA LILO”. The form of the intersection at Welshpool Road / Coldwell Road is the same under both scenarios.

A summary of the intersection Level of Service (LOS) and 95th percentile queue lengths for the intersection of Welshpool Road / Hale Road / Grove Road under both Scenarios is shown in **Table 9** and for the intersection of Welshpool Road / Coldwell Road in **Table 10**.

The analysis shows that Scenario 2 (MRWA LILO) is ‘trading off’ better performance for the intersection of Welshpool Road / Hale Road / Grove Road for substantially reduced performance of the Welshpool Road / Coldwell Road intersection. Scenario 1 (LILO-RI) is shown to provide an acceptable balance of performance between the Welshpool Road / Hale Road / Grove Road and the Welshpool Road / Road Coldwell intersections.

The analysis shows that under Scenario 2, the intersection of Welshpool Road / Coldwell Road will have insufficient capacity (i.e. LOS F) for the Unfactored Demand Volumes due to the heavy demand for the right-in turning movements for the 2031 AM peak hour period. Scenario 1 (LILO-RI) is therefore shown to be less sensitive to higher traffic volumes.

Table 9 Summary of Intersection LOS for Intersection of Welshpool Road / Hale Road / Grove Road

	Factored				Unfactored			
	S1 (LILO-RI)		S2 (MRWA LILO)		S1 (LILO-RI)		S2 (MRWA LILO)	
	2031 AM	2031 PM	2031 AM	2031 PM	2031 AM	2031 PM	2031 AM	2031 PM
LOS	D	C	B	B	D	C	C	D
95th Percentile Queue Length (m)	239	250	153	231	281	262	172	636*

* This queue length extends to the Welshpool Road / Roe Highway interchange and could potentially impact on the operation of the Roe Highway ramps

Table 10 Summary of Intersection LOS for Intersection of Welshpool Road / Coldwell Road

	Factored				Unfactored			
	S1 (LILO-RI)		S2 (MRWA LILO)		S1 (LILO-RI)		S2 (MRWA LILO)	
	2031 AM	2031 PM	2031 AM	2031 PM	2031 AM	2031 PM	2031 AM	2031 PM
LOS	B	B	C	B	C	B	F	B
95th Percentile Queue Length (m)	185	130	278	125	359	141	691	129

2.4 Commentary on AIMSUN Simulation Runs

In addition to the turning demand volumes extracted from the AIMSUN micro-simulation models, the following observations were made during the simulation runs:

- For the AM westbound movement, the MRWA LILO configuration require ~1,500 vehicles per hour (vph) to merge to a single through lane to go through the Welshpool Road / Hale Road / Grove Road intersection. Modelling shows this will create flow break-down mid-block on Welshpool Road east of Hale Road due to this merge.
  - It’s worth noting that this occurs in the model where vehicles behave perfectly according to the model algorithms and inputs. In reality, experience shows that the merger performance would be much worse and would likely result in vehicles (including heavy vehicles/B-doubles) coming to a complete stop on Welshpool Road and then having to

accelerate up to 70 km/h again. This phenomenon also doesn't get picked up in SIDRA analysis of the intersections and would impede the flow of traffic on Welshpool Road.

> Similarly, in Scenario 2 for the 2031 AM peak, ~900 vph are forecast to turn right from Hale Road to Welshpool Road, and then merge into a single lane within 100m of exiting a 90 degree turn from Hale Road. The realistic expectation performance of this merge appears problematic.

> For Scenario 2, the average delay for the left-turn from Grove Road to Welshpool Road has very few available gaps in traffic due to the uninterrupted through movement for the 2031 AM scenario. This creates potential safety issues with left-turning vehicles having to pick a gap in the traffic, especially for large vehicles pulling out into fast free-flowing traffic lane where there are no overtaking opportunities. The only gaps created occurs from the shadow of the red phase for the through movement at Welshpool Road / Coldwell Road, the effect of which is significantly reduced as a result of the flow break down at the merger point on Welshpool to the east of Hale Road.

3 Conclusions

Based on the analysis undertaken as part of this study, the intersection forms assumed for Scenario 1 LILO-RI are considered most appropriate to consider for implementation for the following reasons:

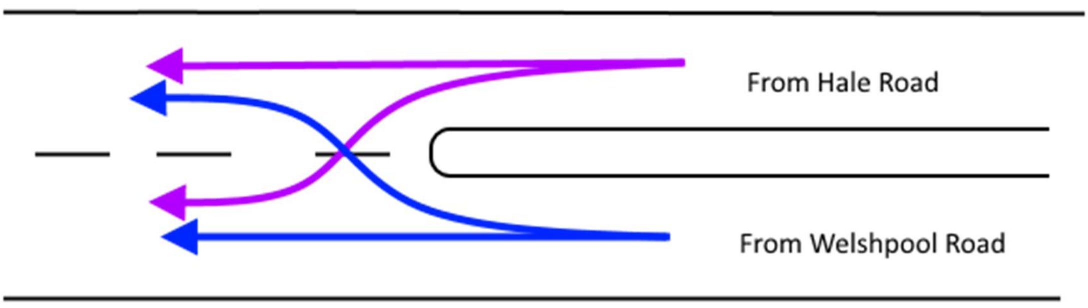
> While the MRWA LILO intersection configuration has some benefits when considered in isolation, the intersection of Welshpool Road / Coldwell Road is found to have insufficient capacity for the Unfactored Demand Volumes due to the demand for the heavy conflicting turning movements for the 2031 AM peak hour period.

> The provision of 2 right-in access locations was found to result in more green time allocated to the critical westbound through movement at the intersection of Welshpool Road / Coldwell Road for the 2031 AM peak hour period.

> The MRWA LILO configuration for the intersection of Welshpool Road / Hale Road / Grove Road requires approximately 1,500 vehicles per hour (in the 2031 AM peak hour period) to merge from 2 lanes to a single through lane to go through the Welshpool Road / Hale Road / Grove Road intersection and was shown to create flow break-down mid-block on Welshpool Road due to the merge.

> While not modelled as part of this study, the MRWA LILO configuration is likely to result in problematic weaving issues on the western departure side of the intersection of Welshpool Road / Hale Road / Grove Road as relatively slow moving vehicles coming from Hale Road wanting to go south on Roe Highway will be required to weave across fast moving through traffic on the inside lane that is used by westbound vehicles on Welshpool Road. This issue is shown schematically in **Figure 3** is considered potentially dangerous and would likely impede the flow of westbound traffic on Welshpool Road.

Figure 3 Schematic Representation of Potential Weaving Issue



> Similarly, although not as severe due to the red phase that occurs after the green phase for the right turn from Hale Road to Welshpool Road, westbound through traffic on Welshpool Road wanting to turn right onto Roe Highway will need to negotiate across what will be at times a heavily

congested outside lane with traffic exiting Hale Road. It is again noted that through traffic on Welshpool Road will be impacted, thereby reducing the effectiveness of the Welshpool Road westbound through lane. In addition, the merger of ~900 vehicles per hour in the AM peak for the MRWA LILO arrangement risks slow merging traffic exiting Hale Road, thereby congesting the Welshpool Road / Hale Road intersection, which has the potential to also block eastbound through traffic on Welshpool Road.

> Very few gaps were observed in the westbound traffic at the intersection of Welshpool Road / Hale Road / Grove Road in the MRWA LILO arrangement due to the uninterrupted westbound through movement. This creates potential safety issue with left-turning vehicles having to pick a gap in the traffic, especially for B-double vehicles pulling out into a free-flowing traffic lane where there are no overtaking opportunities.

> At face value, the MRWA LILO alternative intersection arrangement at Welshpool Road / Hale Road / Grove Road may seem to offer improved westbound flows during the AM peak hour. However, the arrangement introduces two major high volume mergers and furthermore involves weaving of traffic (including a large proportion of heavy vehicles) at differing speeds. The MRWA LILO intersection configuration is also considered to introduce potential traffic hazards which likely cannot be readily resolved without widening the bridge across the rail lines on Welshpool Road, and even then may impact on the Roe Highway / Welshpool Road interchange performance.

> The LILO-RI traffic arrangement is a traditional intersection treatment which is shown by modelling to perform adequately, to have an overall lesser network impact (by allocating the right-in turning movements from Welshpool Road to MKSEA Precinct 3 over two intersections), has better performance if traffic volumes increase (as shown in the Unfactored Demand Volume scenarios), allows traffic to position itself according to down-stream intended movements, thereby minimising weaving movements and overall appears to be the safer intersection treatment.

APPENDIX

B

SUMMARY OF NOTE OF TRAFFIC AND SAFETY ISSUES RELATED TO POTENTIAL ACCESS FORMS

SJR Civil Consulting Pty Ltd

7 November 2016

Linc Property Pty Ltd
Level 3
338 Barker Road
SUBIACO WA 6008

Attention: Steve Robertson

Dear Steve

MADDINGTON-KENWICK STRATEGIC INDUSTRIAL AREA
ROAD SAFETY REVIEW

I am pleased to confirm I have undertaken an independent peer review of the *Maddington-Kenwick Strategic Industrial Area (MKSEA) – Precinct 3 Road Safety Review of Proposed Welshpool Road East Access Points* produced by Cardno.

My comments, findings and recommendations have been added to the final document issued on 7 November 2016.

Should there be any queries regarding this review please contact me.

Regards

Stace Rogers Assoc Dip Civil Eng AMIEAust Senior Road Safety Auditor

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Technical Memorandum

Title	**Maddington-Kenwick Strategic Industrial Area (MKSEA) – Precinct 3 Road Safety Review of Proposed Welshpool Road East Access Points**		
Client	LincPropertyPty Ltd	**Project No**	
Date	30 November 2016	**Status**	Rev D - Final
Author	Sam Laybutt, Senior Road Safety Auditor	**Discipline**	Traffic and Transport
Peer Reviewer	Stace Rogers, Senior Road Safety Auditor, SJR Consulting	**Office**	Perth

1 Introduction

Cardno has been engaged to undertake a road safety review of two proposed access points to Welshpool Road East which will service the development of MKSEA Precinct 3.

This review is intended to be an objective road safety risk analysis comparing the different access options, as well as responding to specific road safety concerns which were raised by Main Roads WA during discussions with Linc.

This report has been prepared by Sam Laybutt, Senior Road Safety Auditor at Cardno, and independently peer reviewed by Stace Rogers, Senior Road Safety Auditor at SJR Civil Consulting.

2 Proposed Development and Traffic

The Maddington-Kenwick Strategic Industrial Area (MKSEA) will consist of three industrial precincts, encompassing a large area of recently re-zoned land bounded by Welshpool Road East, Tonkin Highway, Bickley Road, and Roe Highway.

As the proposed development will be industrial in nature, the anticipated traffic will consist of a mix of light vehicles and heavy vehicles, as well as pedestrians and cyclists.

3 Proposed Welshpool Road East Access Points

The following proposed access points have been assessed as part of this road safety review:

> Welshpool Road East / Hale Road intersection
  - Interim Scenario: Signalised Right-In + Priority Control Left-In, Left-Out

> Welshpool Road East / Coldwell Road intersection
  - Dual-lane roundabout (Main Roads preferred option) compared to a Signalised intersection (Linc preferred option)

The proposed Welshpool Road East / Hale Road intersection may be modified to a grade-separated intersection should Welshpool Road East be upgraded to an Expressway by MRWA post 2031.

It must be noted that this road safety review considers only potential changes in road safety risk as a result of proposed changes to the intersections. This report does not constitute a full road safety audit covering existing road safety risks at these locations.

Table 1 Analysis of Road Safety Risk – Proposed Signalised Right Turn into site at Hale Road intersection

Issue	Probability	Severity	Commentary
The proposed right turn pocket is located beyond a vertical crest and at the bottom of a downgrade. These factors increase the risk of rear-end crashes compared to flat approaches, particularly for heavy vehicles which take longer to stop.	Low	High	The proposed right turn pocket should be designed to meet Austroads recommended dimensions for the speed environment, allowing light vehicles to decelerate clear of through traffic. Heavy vehicles which intend to turn right into the site will be approaching at low speed due to the likelihood of being stopped at the Roe Highway intersection and then proceeding up a steep grade to cross the railway bridge. It is unlikely that a loaded heavy vehicle will be approaching the conflict point at a high speed. If the right turn into the site is not provided at this intersection, then the traffic which would have otherwise turned right will instead add to the queue of traffic heading straight through this intersection, resulting an increased risk of rear-end crashes compared to if a right-turn was provided. It is further noted that the signalised right-turn is an interim arrangement and will be replaced when the partial grade-separation of the intersection occurs. The level of risk is unlikely to increase in the future.
The proposed right turn into the site is located at the bottom of a downgrade. This potentially increases the risk of vehicles running the red light for the right turn into the site.	Low	Medium	The probability of vehicles running the red light at high speed is extremely low as the right turn is a low speed movement as drivers will be slowing down to negotiate the turn. If the right turn into the site was not available, all traffic would instead pass straight through the intersection at significantly higher speeds (70km/h) and therefore having both a higher probability of running the red light and more severe consequences. These vehicles would then need to turn right at Coldwell Road to reach site, shifting the risk of red-light running to this intersection and negating any reduction in risk gained by not providing the right-turn into the site at Hale Road. It is noted that there is an existing red light and speed camera at this intersection which encourages compliance with the traffic signals and speed limits, further reducing the potential road safety risk from the right turn into the site.
The proposed right turn into the site will be signal controlled and have a relatively short green time within the typical long cycle time operated by Main Roads at these intersections. The long cycle time increases the risk of drivers running the red light to avoid long waits for the next green phase.	Low	High	This risk is present across most intersections on roads controlled by Main Roads and this intersection does not create a higher risk level than other similar intersections. If motorists miss the right turn phase, they do have the option of instead continuing straight ahead and turning right into Coldwell Road as an alternative route which will reduce the risk of red-light running.
The proposed right turn into the site will introduce an additional point of mixing residential and industrial traffic.	High	Low	Residential and industrial vehicles will mix whether they exercise a right-in at this intersection or proceed straight ahead and turn at the Coldwell Road intersection. Refer to this safety review for an assessment of these interactions under a range of scenarios.

Issue	Probability	Severity	Commentary
Without the signalised right turn into the site providing clear gaps in traffic flow, heavy vehicles leaving the site are likely to have significant difficulties in selecting an appropriate gap. This increases the risk of heavy vehicles pulling out in front of other vehicles, resulting in side-swipe and similar crashes. In particular, there is a risk that heavy vehicle operators will see that westbound traffic is coming to a stop, pull out during the 'all red' time for that phase, but not be able to complete the turn, let alone get up to speed, before traffic begins turning right from Hale Road.	Medium	Medium	The proposed signalised right turn into the site provides a period during each cycle during which vehicles may turn left into Welshpool Road East with no conflict movements. This reduces the risk of frustrated drivers accepting insufficiently sized gaps. As the minimum green time for the right turn phase will meet the requirements of the RAV Route Assessment Guidelines, at least one sufficiently sized gap per cycle is likely for left turns out of the site. It is also considered that shifting the position of the 'left out' further to the west could result in Hale Road traffic being more visible to left turners, thus reducing the chance of drivers pulling out into an insufficient gap.
The proposed merge and diverge tapers for the westbound auxiliary through lane do not appear to be designed in accordance with Austroads Guide to Road Design Part 4A. The short taper on the merge could make merging more difficult by terminating the lane earlier than expected by drivers.	Medium	Low	Adjust the merge and diverge tapers to meet the requirements of Austroads Guide to Road Design Part 4 during the detailed design process.
There are no formal pedestrian or cyclist facilities at the intersection. The proposed development is likely to create some demand for pedestrians and cyclists to cross Welshpool Road East. Welshpool Road East is also currently a popular recreational cycling route, with cyclists travelling to/from Lesmurdie Hill. No cycle lanes are provided on Welshpool Road East which means cyclists must share the general traffic lanes with heavy vehicles and other traffic.	Medium	Medium	Amend the intersection design to include formal signalised pedestrian crossings across the east, north and south legs of the intersection. Amend the intersection design to include a cycle lane in the westbound direction throughout the extent of project works.
There is a risk of drivers performing illegal through or right turn out movements, utilising the proposed 'left turn' out of the site.	Low	High	Consider the relocation of the 'left out' to the west so that it is located opposite a solid median island in order to discourage through or right turn movements.
The proposed right turn into the site is located directly opposite the Hale Road leg which may encourage traffic from Hale Road to proceed straight ahead into the site.	Medium	Low	This movement from Hale Road into the site would take place under an existing signal phase, with no conflicting movements, and is desirable from a network permeability perspective. It should be formally provided for with traffic islands adjusted as necessary, subject to MRWA approval.

Table 2 Analysis of Road Safety Risk – Coldwell Road intersection roundabout versus traffic signals

Issue	Probability	Severity	Commentary
As stated in Main Roads 'Guidelines for the Selection of Intersection Control' (Nov 2015), the proposed dual-lane roundabout (Main Roads preferred option) is less safe for cyclists than the proposed signalised intersection, particularly given the percentage of heavy vehicles using the intersection. The significant swept paths for these vehicles make it difficult to reduce the design speed for light vehicles to 30km/h-40km/h which is the recommended design speed in Main Roads 'Guideline for the Selection of Intersection Control' where bicycles are expected to use a roundabout. Welshpool Road East is a significant commuter and recreational cycling route, catering for large numbers of cyclists travelling to and from Lesmurdie Hill. Until such time that a Principal Shared Path is provided by Main Roads along Welshpool Road East, the road will need to cater for these roads users.	High (Rbt) Low (Sigs)	High (Rbt) Low (Sigs)	The proposed signalised intersection (Linc preferred option) has significantly lower risks for cyclists and would enable the eventual provision of uninterrupted cycle lanes in both directions on Welshpool Road East. If the signalised intersection is adopted, the design should include the provision of cycle lanes in both directions through the extent of project works.
The proposed dual-lane roundabout (Main Roads preferred option) is less safe and more difficult to use for pedestrians and cyclists who want to cross Welshpool Road East to commute between the proposed development and the nearby residential areas in Wattle Grove. This risk is significantly increased by the projected high traffic volumes and heavy vehicle percentage as there is likely to be very few gaps in the traffic flow, particularly on the westbound carriageway in the AM Peak Period. There is currently no safe or controlled crossing of Welshpool Road between Roe and Tonkin Highways and the lack of a fine-grained road network within the proposed development means that pedestrian and cyclist crossing demand will be concentrated in the vicinity of Coldwell Road.	Medium (Rbt) Low (Sigs)	High (Rbt) Low (Sigs)	The proposed signalised intersection at Coldwell Road (Linc preferred option) would provide a fully controlled, safer crossing of Welshpool Road East to enable pedestrians and cyclists to access the proposed development. Statistical comparisons of cyclist and pedestrian crashes at multi-lane roundabouts compared to other intersection types are not comparable with motor vehicle crash statistics as these vulnerable road users will generally avoid using intersections which they feel are unsafe – either diverting or not making the trip at all.
The proposed dual-lane roundabout may be insufficient to accommodate large heavy vehicles making lane-correct through movements and right turns into Coldwell Road. Given the high traffic volumes on Welshpool Road East now, and into the future, it is very desirable from a safety perspective that these large vehicle movements can be made within a single lane, without the need to straddle multiple lanes. Straddling multiple lanes creates a risk of side-swipe crashes, as well as light vehicles attempting to pass heavy vehicles within the swept path area.	High (Rbt) Low (Sigs)	Medium (Rbt) Low (Sigs)	In order to accommodate large heavy vehicles the roundabout may need to be enlarged, thus requiring acquisition of additional land. The enlarged roundabout will result in higher speeds for light vehicles approaching and through the intersection, reducing any potential safety benefits of a roundabout over a signalised intersection. The proposed signalised intersection (Linc preferred option) could be designed to accommodate these vehicles within a significantly smaller footprint. If the proposed signalised right turn into the site at Hale Road is not provided, the level of risk at this intersection will be significantly increased as all traffic will be forced to pass through this intersection.

Issue	Probability	Severity	Commentary
Dual-lane roundabouts in very high-volume areas, such as Welshpool Road East, can be very difficult for large multi-combination vehicles to use as drivers can have difficult in picking safe gaps to enter the intersection. This is a particular concern for large vehicles entering the roundabout from Coldwell Road as the westbound through movement has very high demand in the AM Peak. Main Roads preliminary modelling of the roundabout has indicated that queues of up to 600m can be expected for westbound traffic and therefore drivers who reach the roundabout are likely to be more frustrated and drive in a more aggressive manner, increasing the risk of impact with large vehicles entering from Coldwell Road.	High (Rbt) Low (Sigs)	Medium (Rbt) Low (Sigs)	The proposed signalised intersection (Linc preferred option) would essentially eliminate this risk, as right turns would be fully signal controlled and the operation of the signals would provide clear gaps for left turns into Welshpool Road East.
Signalised intersections in metropolitan Perth generally have a higher frequency and severity of motor vehicle crashes. This is, in part, due to Main Roads policies regarding the selection of intersection treatments and the operation of traffic signal phasing, however it is generally accepted that roundabout intersections overall result in a lower crash rate than signalised intersections. Main Roads' 'Guidelines for the Selection of Intersection Control' suggests that the casualty crash exposure rate at roundabouts is in the order of 25% less than at signalised intersections, which is consistent with research undertaken in Melbourne.	Medium (Rbt) Medium (Sigs)	Medium (Rbt) Medium (Sigs)	Research by Cardno has indicated that site-specific factors can result in roundabout intersections having both a high number and higher severity of crashes. One of these factors is the roundabout being located between multiple sets of traffic signals, with heavily 'platooned' traffic flows entering the roundabout. This factor is present at Coldwell Road as it is located on an otherwise long corridor of signalised intersections. Another relevant factor when comparing the crash rates of roundabouts and traffic signals is that the provision of signal-controlled right turns (either partial filter or no filter) also contributes to a significant (approx 25% overall and up to 70% right turn crashes) reduction in the frequency of crashes at signalised intersections. It would be expected signal control for the right turn would be incorporated as part of the proposed signalised intersection (Linc preferred option) which would minimise the risk involved for this movement. The right turn from Coldwell Road into Welshpool Road East would also be controlled by signals with no conflicting movements, minimising the level of risk.

4 Conclusions

4.1 Welshpool Road East / Hale Road

The road safety review of the proposed Welshpool Road East / Hale Road intersection has compared the relative road safety risks of providing, and not providing, a signalised right turn into the site.

The addition of a right-in turning movement at the intersection of Welshpool Road East / Hale Road is likely to:

> Reduce the volume of traffic that would otherwise head straight through this intersection and therefore decrease the risk of rear-end crashes;
> Reduce the probability of vehicles entering the site from the west running a red light at speed by providing a lower speed right turn;
> Provide an alternative right-in access into the site that will improve the safety of the Welshpool Road East / Coldwell Road intersection; and
> Improve the safe egress of large vehicles leaving the site (left-out) by providing a period during the traffic signal cycle with no conflicting movements.

It is concluded that the level of road safety risk associated with the signalised right turn is acceptable and comparable to other similar intersections within the Perth metropolitan area. Further, it is concluded that not providing the signalised right turn into the site is likely to result in a higher level of risk for the left turn out of the site, as well as increasing the turning traffic volumes – and therefore level of risk – at the Welshpool Road East / Coldwell Road intersection.

It is further concluded that there are no road safety risks associated with the proposed signalised right turn into the site which are significant enough to prevent the signalised right turn from being implemented.

4.2 Welshpool Road East / Coldwell Road

A review of road safety risks for the proposed roundabout layout (Main Roads preferred option) at the Welshpool Road East / Coldwell Road intersection and these have been compared with the relative level of risk for a proposed signalised layout (Linc preferred option).

The key risks associated with the roundabout include:

> The ability of a roundabout intersection to satisfy the swept path requirements of RAV Network 7 vehicles, especially if the signalised right turn into the site is not provided at Hale Road.
> Difficulty for heavy vehicle operators in picking a gap to enter the roundabout from Coldwell Road due to the high traffic volumes.
> High levels of risk for cyclists passing through the intersection on Welshpool Road East, as well as crossing Welshpool Road East.
> High levels of risk for pedestrians crossing Welshpool Road East to reach the proposed development due to the level of anticipated traffic and the lack of a controlled crossing.
> Large radius roundabouts facilitate higher speeds for light vehicles approaching the intersection.

It was considered that a signalised intersection would mitigate many of these key risks associated with the roundabout intersection.

It was noted that overall roundabout intersections generally have approximately 25% lower crash rates (frequency and severity), however there are several site-specific factors at this intersection which are likely to both increase the crash rate of a roundabout intersection and reduce the crash rate of a signalised intersection.

Overall, it is concluded that the two proposed signalised intersections (Linc preferred option) represents an overall lower level of risk for all road users by providing a consistent signalised intersection treatment along Welshpool Road that, together with the provision of signal controlled right turns into and out of the site, will contribute to a more balanced and safer traffic environment.

On balance, it is considered that:

> The addition of the right-in movement at the intersection of Welshpool Road East / Hale Road is not unsafe and will improve the safety and performance of the Welshpool Road East / Coldwell Road intersection (either signalised or roundabout).

> There is an interaction or potential interaction between residential and industrial traffic under either access scenario. This safety assessment concludes that it is safer to have trucks turning right-in to the site at low speed under a separate green traffic signal phase (any interaction both for right-in and left-out movements is therefore at low speed and directly attributable to red light running) and to balance this movement with an alternative green light phase at a signalised intersection at Coldwell Road/Welshpool Road East that would provide a similar environment and ensure that drivers are not inclined to take risks trying to pick safe gaps.

> That in the site-specific context of the Welshpool Road East / Coldwell Road intersection, having regard to the volumes of traffic, proportion of heavy vehicles, existing intersection layouts along the balance of Welshpool Road East, MRWA policies and guidelines and the subject safety assessment confirms that a signalised intersection form is a more appropriate form of intersection control than a roundabout.

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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Shaping the Future

APPENDIX 4
LOCAL WATER MANAGEMENT STRATEGY

LOCAL WATER MANAGEMENT STRATEGY

MKSEA PRECINCT 3A OUTLINE DEVELOPMENT PLAN

Project Number EP14-056

Prepared for Linc Property Pty Ltd
January 2017

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Executive Summary

Linc Property Pty Ltd (Linc Property) propose to develop a number of landholdings within the *Maddington Kenwick Strategic Employment Area* (MKSEA) for industrial land uses. These landholdings (herein referred to as "the site") are located within the City of Gosnells (CoG) and Shire of Kalamunda (SoK) and collectively incorporate Precinct 3A of the MKSEA.

The site is currently zoned 'Rural' and 'General Rural' under the Metropolitan Region Scheme (MRS) and CoG Town Planning Scheme (TPS) No. 6 respectively. An amendment to the MRS (no. 1302/57) is currently being progressed by the Western Australian Planning Commission (WAPC) to rezone the site to 'Industrial', which is expected to be gazetted in early October 2016. This LWMS is intended to support both the structure plan (SP), and TPS amendment no. 165 within the City of Gosnells and a TPS amendment in the Shire of Kalamunda.

This Local Water Management Strategy (LWMS) for MKSEA Precinct 3A has been developed in accordance with *Better Urban Water Management*, *State Planning Policy 2.9 Water Resources, Planning Bulletin 92 Urban Water Management* and *Interim: Developing a Local Water Management Strategy*. Water will be managed using an integrated water cycle management approach, which has been developed using the philosophies and design approaches described in the *Stormwater Management Manual for Western Australia*.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Characteristics of both the existing and past environment within the site have been investigated. In summary, the environmental investigations conducted to date indicate that:

- The site receives 825 mm of average annual rainfall with the majority of rainfall received in June and July.
- Topography of the site ranges from 8 m Australian height datum (AHD) in the south west to 15 m AHD in the north east.
- The site is underlain by sand and clayey sand overlying sandy and gravelly materials, non-engineered fill and clayey sand and gravelly materials.
- The permeability of soils underlying the site was generally low, however was highly variable and ranges between 1.1 m/day and 12.0 m/day.
- The whole site is mapped as having a moderate to low risk of encountering acid sulfate soils (ASS) within 3 m of the surface.
- The majority of the site is listed as a multiple use wetland (MUW).
- The Yule Brook is located approximately 150 m south of the site.
- There are a number of existing man-made drains across the site, all draining toward the Yule Brook.
- Hydrological and hydraulic modelling within XPSWMM has been used to identify pre-development peak flows entering and leaving the site. The model has been prepared consistent with the Water Corporation modelling of Yule Brook and in further detail to the modelling of the greater MKSEA documented in the District Water Management Strategy (DWMS).
- Surface water quality within Yule Brook in the locality of the site has low TN and TP concentrations upstream and downstream of the discharge locations from site.

- Maximum groundwater levels (MGL) across the site range between 8 m AHD near the western boundary and 14 m AHD near Welshpool Road, and are either at the surface or very shallow beneath most of the site. Given the low permeability soils the MGL is more likely a reflection of seasonally perched groundwater rather than a permanent superficial aquifer.
- Groundwater quality beneath the site has low to moderate total nitrogen (TN) and total phosphorus (TP) concentrations.
- The site has historically been used for rural lifestyle and low scale agricultural purposes with some more recent light industrial activity in areas including turf farming and small freight haulage facilities.

A SP has been prepared for MKSEA Precinct 3A within the CoG and will incorporate predominantly freight and logistics uses. The land uses set out in the proposed SP generally align with those shown in the indicative structure plan prepared by CoG, allowing for the progression of industrial development within Precinct 3A of the MKSEA in accordance with the established planning framework. The land uses within the SP area also include a significant portion of the site proposed for acquisition by the Perth Transit Authority for future rail uses. This LWMS will also support the future planning over a portion of SoK land (also referred to as Precinct 3A).

The overall objective for integrated water cycle management for industrial developments is to minimise pollution and maintain an appropriate water balance. The MKSEA Precinct 3A LWMS design objectives seek to deliver best practice outcomes using a Water Sensitive Urban Design (WSUD) approach, including detailed management approaches for:

- Potable water consumption
- Flood mitigation
- Stormwater quantity and quality management
- Groundwater management.

The criteria proposed within this LWMS are based on the approved DWMS, the characteristics of the existing environment and a contemporary best-practice approach to integrated water cycle management.

The overall approach to water conservation is to minimise water requirements for the establishment and maintenance of swales and landscaped areas within the development. This will be achieved through the use of waterwise landscaping practices, including use of native vegetation where possible, and use of an average irrigation rate of 6,750 kL/ha/year.

Stormwater management focusses on five key aspects:

1. Conveyance of upstream flows entering the site via formalised channels
2. Conveyance of breakout flows from Yule Brook which enter the site
3. Catchment (lot scale) management
4. Stormwater peak flow rates
5. Stormwater runoff quality.

The principle behind the stormwater management strategy for MKSEA Precinct 3A is to maintain the existing hydrology by matching pre-development discharge rates and maintaining arterial flows through the site. Lot detention areas (LDA), a flood detention basin (FDB) and extended detention within roadside conveyance swales will be used to detain flows. These will be designed such that outflows from the site match pre-development flow rates to the Yule Brook.

Stormwater quality will be addressed using a treatment train approach. Initial treatment will be adopted as appropriate for the site geotechnical conditions and individual lot use. This will occur within the lot and therefore as close to source as possible using bio-retention areas within lot (or suitable alternative retention measures). Runoff from the road network will be conveyed within roadside conveyance swales. The grades of these swales are variable and generally very flat (1:650), which will allow in-line water quality treatment via extended detention during which time contact with vegetation and soils will be achieved. Further water quality treatment will be provided at the end of catchment, prior to discharge from the site.

Groundwater level management focusses on protecting properties from flooding due to inundation by groundwater. Fill will be used where the natural surface levels do not provide adequate clearance to groundwater. Note however that the main driver for final lot levels is minimum grades within the roadside conveyance swales, rather than the need to achieve clearance above groundwater.

The main objective of the management of groundwater quality is to maintain or improve runoff that could either be infiltrated to groundwater or that could be discharged from the site. This will be achieved by reducing the total nutrient load that originates from the development through treatment of surface water runoff from frequent events prior to infiltration to groundwater and through implementation of nutrient minimising landscape management practices.

The proposed design criteria and the manner in which they are proposed to be achieved are presented in **Table E 1**. This table provides a readily auditable summary of the required outcomes which can be used in the future detailed design stage to demonstrate that the agreed objectives for water management at the site have actually been achieved.

This LWMS demonstrates that, by following the recommendations detailed in the report, the site is capable of being developed.

Table E 1 Water management criteria and compliance summary

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Water Conservation	WC1	Minimise water requirements for the establishment and maintenance of swales and other landscaped areas	Use an average irrigation rate of 6,750 kL/ha/year to irrigate landscaped areas	Proponent	Landscape implementation
			Utilisation of WWG within road verges, drainage swales and landscaped areas	Proponent	Landscape design
	WC2	Minimise water use within lots	Promote the use of rainwater tanks within lots	Proponent	Point of sale
			Use of rainwater tanks within lots	Lot owner	Building construction
			Use of water efficient fittings within lots	Lot owner	Building construction
Groundwater management	GW1	Finished floor levels of buildings should have a minimum 500mm clearance from MGL.	Finished floor levels will be provided a minimum 500 mm clearance from MGL with fill used where necessary	Proponent/lot owner	Detailed design
	GW2	Conveyance swales and subsoil drains will be set at pre-development MGL, the underlying clay layer or existing drain inverts.	Conveyance swales have been set consistent with existing drain inverts. Subsoil drains will be set above existing drain inverts, and these will therefore be above the MGL.	Proponent	Detailed design
	GW3	Inverts of flood detention structures to be set at or above MGL, the underlying clay layer or existing drain inverts	Inverts of flood detention structures will be set approximately at or above MGL, the underlying clay layer or the inverts of immediately adjacent existing drain inverts.	Proponent	Detailed design
	GW4	Maintain or improve groundwater quality leaving the site	Direct stormwater to vegetated roadside swales for treatment	Proponent	Detailed design
			Minimise use of fertilisers within landscaped areas	Proponent	Landscape implementation
			Use drought tolerant roll on turf species	Proponent	Landscape implementation

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Surface water management	SW1	Provide conveyance of 100 year ARI flows which currently enter the site from upstream catchments	Upstream flows will be conveyed within roadside conveyance swales	Proponent	Detailed design
	SW2	Runoff from lots will be treated at source, within each lot	Appropriate treatment measures will be required on lot	Proponent	Detailed design
	SW3	Detain flows up to the 100 year ARI storm event within the boundary of each lot.	LDAs will be required on lot to detain flows up to the 100 year ARI event	Lot developer	Lot development approvals
	SW4	Runoff from road reserves will be treated at source and via extended detention within roadside swales.	Side entry pits with traps to remove gross pollutants and sediments will be provided to treat flows prior to entering swales	Proponent	Detailed design
			Bio-retention functions will be provided at the base of roadside swales with vegetation provided to uptake nutrients	Proponent	Detailed design
	SW5	Road reserve runoff and conveyance will be via kerbed road pavement, side entry pits and roadside/arterial conveyance swale	Runoff from road reserves will enter conveyance swales via side entry pits	Proponent	Detailed design
			Roadside conveyance swales will be provided to convey road reserve runoff to downstream FDB and/or discharge locations	Proponent	Detailed design
			Arterial flows from upstream catchments will be conveyed through the site in roadside conveyance swales	Proponent/Perth Transit Authority	Detailed design
	SW6	Minor roads to remain passable in the 10 year ARI storm event	The roadside conveyance swales will be sized to convey the 10 year ARI event runoff from road reserves thus ensuring roads remain passable in the 10 year ARI event	Proponent	Detailed design
	SW7	Detain flows up to the 100 year ARI storm event to maintain pre-development peak flow rates at key discharge locations	Conveyance swales will provide in-line detention of flows within Precinct 3A	Proponent	Detailed design
			Runoff will be detained in flood detention basins (FDB) designed to detain the 100 year ARI event with a discharge	Proponent	Detailed design

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
			rate to the Yule Brook (Out 2) to match pre-development peak flow rates		
	SW8	Finished floor levels should have a 300 mm clearance from the 100 year ARI water level within conveyance swales and the flood detention structure	Finished floor levels will have a minimum clearance of 300 mm from the 100 year ARI top water level within swales and the FDB with fill used where necessary	Proponent	Detailed design
	SW9	Apply appropriate non-structural measures to reduce pollutant loads	Minimise fertiliser use to establish and maintain vegetation within drainage reserves and road verges	Proponent	Landscape implementation
			Use drought tolerant turf species that require minimal water and nutrients	Proponent	Landscape implementation
			Education of lot owners regarding fertiliser use and nutrient absorbing vegetation species within lots	Proponent	Point of sale
	SW10	Perth Transit Authority land to detain flows up to the 100 year ARI storm event to meet pre-development peak flow rates.	Indicative flood detention requirement has been provided which indicates the approximate detention volume needed to achieve pre-development peak flow rates from the PTA land to Yule Brook via an arterial swale (at outlet 'Out 3')	Perth Transit Authority	Detailed design

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Appendices

1 Introduction

1.1 Background

Linc Property Pty Ltd (Linc Property) propose to develop a number of landholdings within the *Maddington Kenwick Strategic Employment Area* (MKSEA) Precinct 3A for industrial land uses. These landholdings (herein referred to as "the site") are located within the City of Gosnells (CoG) and the Shire of Kalamunda (SoK) and collectively incorporate Precinct 3A of the MKSEA, as shown in **Figure 1**. The ownership and lot details of the landholdings comprising the site are outlined in **Table 1** below and shown in **Figure 2**.

Table 1 Landholdings comprising the site (47 in total)

Lot no.	Road name	Plan or diagram	Certificate of Title	Proprietor
2	Grove Road	Diagram 65145	1665-202	Holoway, Jennifer Kay
2	Edward Street	Diagram 11206	1735-97	Downe, Patricia May Lloyd, Peter
4	Courtney Place	65526	1657-617	Bullen, Jules Robert Bullen, Dorothy Kathleen
4	Edward Street	Diagram 18761	1177-956	Lovegrove, Ann Margaret Lovegrove, Richard Anthony
5	Courtney Place	65526	1657-618	McHaffie, Peter Alexander Blair
5	Edward Street	Diagram 18761	2129-570	Zhao, Shanshan
6	Courtney Place	66249	1667-838	Vesperman, Valerie Clair Vesperman, David
7	Coldwell Road	Diagram 21712	1885-299	Farr, Gary Frederick
7	Courtney Place	66249	1667-839	Ding, Weihong Yang, Yunfeng
8	Coldwell Road	Diagram 21712	1934-281	White Holdings Pty Ltd
8	Courtney Place	66249	1667-840	Woods, Lori Alexis Christing Woos, Michael Sean
9	Coldwell Road	Diagram 21712	1203-739	Hopkins, Matthew Cassidy, Shane Joseph
9	Courtney Place	66249	1667-841	Li, Henry Kwan-Tai Li, Kitty Ki-Ting
10	Coldwell Road	Diagram 21712	1203-487	Simeon, Brian William
10	Courtney Place	68028	1694-511	D'Orazio, Catrriona Margaret
11	Edward Street	Diagram 59617	1571-285	Curnow, Garry Frederick Curnow, Rosemarie
11	Coldwell Road	Diagram 21712	1420-204	Harvey, Ross
11	Courtney Place	68028	1694-512	Davis, Kelvin Walter Davis, Carol Joan

Lot no.	Road name	Plan or diagram	Certificate of Title	Proprietor
12	Edward Street	Diagram 59617	1571-286	Williams, Rosemarie Ann
12	Courtney Place	Diagram 65526	1657-619	Tatnell, Don Lawrence Schulz, John Bernard
12	Coldwell Road	Diagram 21712	1203-484	Newitt, Marian Newitt, Peter Charles
13	Courtney Place	Diagram 65526	1657-620	Ferris, Roxanne Fay Feris, Paul Samuel John
13	Grove Road	Diagram 30074	1766-620	Hicks, Andrew Hicks, Helena
14	Courtney Place	Diagram 65525	1657-611	Karim, Fawziah Binti Abd
14	Grove Road	Diagram 30074	71-7A	Mcmanus, Alexandra Mcmanus, Gordon Joseph
14	Edward Street	Diagram 59617	1571-288	Mazza, Francesco Mazza, Pasqualina
15	Courtney Place	Diagram 65524	1656-697	Turriff, Phillip Neil Turriff, Judith Anne
16	Coldwell Road	Diagram 65525	1657-612	Reynolds, Jennifer Ann Reynolds, Richard William
16	Edward Street	Diagram 53218	1484-671	Raphael Road Pty Ltd
17	Edward Street	Diagram 53218	1484-672	Smith, Jennifer Anne Smith, Colin Lindsay
17	Welshpool Road East	Diagram 65525	1657-613	SDA Holdings Pty Ltd
18	Courtney Place	Diagram 65525	1657-614	International Family Investments Pty Ltd
21	Coldwell Road	Diagram 65524	1656-698	Marrell, Christina Patricia Edwards, Peter John
22	Coldwell Road	Diagram 65524	1656-699	Marrell, Christina Patricia Edwards, Peter John
23	Coldwell Road	Diagram 65524	1656-700	Del Paggio, Angela Domenica
40	Edward Street	Plan 31229	2526-888	Hayes, Janice Kaye Hayes, Trevor John
41	Edward Street	Plan 31229	2526-889	Downing, Beverly Ruth Downing, Colin Raymond Downing, Derek John
52	N/A	Diagram 84759	1975-718	Zurich Bay Holdings Pty Ltd
53	Edward Street	Diagram 84759	1975-719	Caruso, Christopher Victor Caruso, Suzanne Francene
101	Edward Street	Plan 44827	2612-439	Karu, Sandra Carolyn

Lot no.	Road name	Plan or diagram	Certificate of Title	Proprietor
102	Grove Road	Plan 44827	2612-440	Begg, Lisa-Kim Margaret Irene Moss, Scott Edward
200	N/A	Diagram 64949	1917-331	Buckland, Judith Anne
301	Grove Road	Diagram 98870	2175-931	Crampton, Susan
302	N/A	Diagram 98870	2175-932	Buckland, Judith Anne
500	Grove Road	Diagram 54660	1507-278	Buckland, Judith Anne
501	Grove Road	Diagram 54660	1507-279	Lovegrove, Ann Margaret Lovegrove, Richard Anthony
501	Edward Street	Plan 74500	2820-165	Balston, Richard William

1.2 Town planning context

The site is currently zoned ‘Rural’, ‘General Rural’ and ‘Special Rural’ under the Metropolitan Region Scheme (MRS), CoG Town Planning Scheme (TPS) No. 6 (CoG 2002) and SoK Local Planning Scheme (LPS) No. 3 (SoK 2007) respectively. An amendment to the MRS (no. 1302/57) is currently being progressed by the Western Australian Planning Commission (WAPC) to rezone the site to ‘Industrial’, which is expected to be gazetted in early October 2016.

The proposed industrial development of the site is in accordance with the strategic local and regional planning frameworks, which identify the MKSEA for future industrial land uses. The planning and environmental assessment context of the proposed development is discussed further in the *Environmental Assessment and Management Strategy* (Emerge Associates 2015b).

Local Planning Policy 5.8 Maddington Kenwick Strategic Employment Area Planning Framework (LPP 5.8) (CoG 2014) has been prepared by the CoG to guide the future phases of the planning and development process within the MKSEA. In accordance with LPP 5.8, a Structure Plan (SP) is to be prepared for each precinct of the MKSEA when they relate to a Special Control Area. Taylor Burrell Barnett Town Planning and Design (TBB) have prepared a SP to support and guide future industrial development within the site. Following the approval of a SP, industrial development will be achieved through subdivision approvals and/or development applications, in accordance with the approved SP layout.

This LWMS is intended to support both the SP and TPS amendments over corresponding land within the CoG and SoK.

1.3 Policy framework

There are a number of State Government policies of relevance to the site. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Water Plan* (Government of WA 2007)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006a)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Liveable Neighbourhoods Edition 4* (WAPC 2007)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)

- *State Planning Policy 2.10: Swan and Canning River System* (WAPC 2006b)
- *Town Planning Scheme No. 6* (CoG 2002)
- *Local Planning Scheme No. 3* (SoK 2007)
- *Local Planning Policy 4.7: Planning and development of public open space and streetscapes* (CoG 2015)
- *Local Planning Policy 5.8: Maddington Kenwick Strategic Employment Area Planning Framework* (CoG 2014).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urban developments should aim to achieve.

These are key inputs that relate either directly or indirectly to the site and include:

- *Better Urban Water Management* (WAPC 2008)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Australian Rainfall and Runoff* (Engineers Australia 1987)
- *Decision Process for Stormwater Management in Western Australia* (DoW 2009)
- *Developing a Local Water Management Strategy* (DoW 2008a)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *National Water Quality Management Strategy* (NWQMS) (ANZECC 2000)
- *Swan and Canning Water Quality Improvement Plan* (SCWQIP) (SRT 2009).

The guidance documents listed indicate a need for accurate water quality baseline data prior to urban development. This will ensure that any future development is able to fulfil the stormwater management requirements of DoW and engineering standards specified by local government, but will also ensure that realistic water management criteria that are practically achievable are adopted.

1.4 Previous studies

1.4.1 District Water Management Strategy

The *Maddington Kenwick Strategic Employment Area Precincts 2 and 3 District Water Management Strategy* (DWMS) (TME 2014) was prepared to support the rezoning of MKSEA Precincts 2 and 3 to 'industrial'.

The key management objectives detailed in the DWMS and relevant to Precinct 3A include:

- Water quality and environmental protection
    - o Utilisation of water sensitive urban design (WSUD), including bio-retention gardens, basins, swales and flow spreader devices to capture, detain, treat and convey all development runoff.
    - o Investigation of building design guidelines that encourage structural separation of potentially polluted runoff in work areas from the stormwater runoff pathways.
    - o Provision of lot owners with information relating to the establishment and maintenance of waterwise and nutrient wise gardens in their required landscape areas on each development.
    - o Monitoring of storm water outflow rates and quality post-development.
- Flood protection
    - o All habitable floor levels on lots to be designed to maintain a minimum separation clearance of 300 mm to the internal 100 year ARI flood levels.

  - Protection of buildings and infrastructure with conveyance and storage of flood waters via the open and piped drainage network and road reserves.
  - Discharge of the 10 year ARI flows to Yule Brook not to exceed pre-development flow rates.
  - Discharge of controlled 100 year ARI flood flows to the Yule Brook that will not cause adverse impacts.
  - Designated 100 year ARI flow paths to protect infrastructure from flood risks.
- Stormwater management
  - Utilisation of WSUD to treat, store, convey, control and discharge stormwater runoff.
  - Ensure pre-development flows continue to maintain water dependent ecosystems, or other agreed flow regimes deemed necessary to support key ecological functions.
  - Investigation of building design guidelines that encourage structural separation of potentially polluted runoff in work areas from the stormwater runoff pathways.
  - Encourage non-structural best management practices (BMPs) to reduce flow rates/potential contamination.
  - Utilise drainage pipes and swales to convey flows through the development.
  - Lot storage and treatment of all runoff from the 1 year 1 hour ARI event on lot.
  - Storage and treatment of the 1 year 1 hour ARI event in road reserves.
  - Monitoring of water quality during construction and post-development.
- Groundwater Management
  - Ensure development has no negative impact on the groundwater resource or ecosystems dependent on the resource.
  - A controlled groundwater level (CGL) is to be set at the average annual maximum groundwater (MGL) across the site, unless further studies demonstrate that an alternative level satisfies infrastructure and environmental considerations. The CGL and MGL may be refined as part of the LWMS process.
  - The CoG require a minimum 500 mm separation from the CGL (or critical groundwater level) to physical infrastructure, building footings and to the invert level of the stormwater management measures.
  - Installation of a sub-soil drainage pipe network and swale systems at the proposed CGL to control groundwater from rising above the level set.
  - Treatment of controlled groundwater and the stormwater runoff infiltration via bio-retention and potentially wetland systems.
  - Monitoring of the groundwater quality and levels across the subject land post-development to identify any future detrimental impacts on the groundwater resource.
  - Managed use of groundwater resources within acceptable allocation limits.
- Water conservation and servicing
  - Development to be connected to a potable reticulated water supply.
  - Encouragement of water efficient fixtures and fittings for all buildings constructed.
  - Encouragement of lot owners to install a suitable rainwater tank.
  - Sewerage wastewater collection and treatment for all of the subject land with a provision for potential grey/wastewater reuse after appropriate treatment.

The criteria detailed in this LWMS have considered the objectives that are relevant to MKSEA Precinct 3A detailed in the DWMS.

1.5 LWMS objectives

This LWMS has been developed in consideration of the objectives and principles detailed in the overarching DWMS, detailed in **Section 1.4** and *Better Urban Water Management* (WAPC 2008). It is intended to support the SP and TPS amendments within the CoG and SoK, and is further based on the following major objectives:

- Provide a broad level stormwater management framework to support future industrial development.
- Maintain existing arterial flow pathways through the site to service upstream catchments.
- Minimise the amount of fill that needs to be imported to develop the land, which will result in reduced land costs for future lot owners.
- Maintain overall existing peak flow rates within Yule Brook at Roe Highway as per Water Corporation requirements.
- Incorporate appropriate BMPs into the drainage system that address the environmental and stormwater management issues identified.
- Minimise ongoing operation and maintenance costs for the land owners and local government.
- Develop a water conservation strategy for the site that will ensure the efficient use of all water resources.
- Gain support from DoW and local government for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

Detailed objectives for water management within the site are further discussed in **Section 4**.

2 Proposed Development

TBB have prepared a range of planning documents, including TPS amendments and a SP for the site which covers an area of 93 hectares (ha), and outlines the future industrial land use across the site, including:

- Areas to be developed for industrial land uses.
- The provision and location of areas to accommodate stormwater drainage requirements.
- The proposed internal road network.
- Land to be resumed by PTA to meet future railway infrastructure requirements.

The MKSEA Precinct 3A SP and Landscape Concept Plan are provided in **Appendix A** and **Appendix B** respectively, with plans currently being progressed over land within the SoK.

The land uses set out in the proposed SP generally align with those shown in the Indicative Local Structure Plan (LSP), allowing for the progression of industrial development within Precinct 3A of the MKSEA in accordance with the established planning framework.

The proposed zoning is ‘General Industry’ with permissibility of uses as per the scheme text (provided in **Appendix A**). All uses are discretionary in the General Industry zone and their location will be considered in the context of any site area requirements (i.e. buffers, drainage requirements etc.).

The key elements of the water management approach are:

- Peak flow regime to key wetlands adjacent to Yule Brook will be maintained.
- Lots detain runoff from up to the 100 year ARI and provide treatment specific to land use.
- Conveyance of road reserve runoff by surface flow in open conveyance swales.
- Treatment of road reserve runoff via extended detention in conveyance swales.
- Peak flow rates to Yule Brook managed by catchment routing and flood detention up to the 100 year ARI event to existing discharge locations.
- PTA to accommodate pre-development flow regimes and to manage their portion of overall flood detention requirements within their land parcel as per Water Corporation requirements.
- Main flood routing of upstream flows and runoff from flood detention basins (FDBs) will be via arterial drains, located within either private land, drainage reserves or PTA land.
- Groundwater controlled via the inverts of a network of open swales, created by shaping the underlying clay layer.

The stormwater management strategy for MKSEA Precinct 3A has been progressed considering the greater MKSEA development, specifically across the entirety of Precinct 3. This ensures the most efficient and integrated drainage design across the development which minimises the infrastructure provided and ongoing maintenance required.

3 Pre-development Environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context for the site:

- *National Water Quality Management Strategy* (ANZECC 2000)
- *Regional 1:50 000 Geology Map Sheet* (Jordan 1986)
- *WA Atlas* (Landgate 2015)
- *Water Register* (DoW 2015b)
- *Perth Groundwater Atlas* (DoW 2015a)
- *Weather and Climate Statistics Data* (BoM 2015).

The CoG have previously commissioned a range of studies and investigations across the MKSEA to understand the environmental attributes and values of the area and to demonstrate the feasibility of industrial development. The various reports associated with these investigations have been reviewed as part of the preparation of this document and include:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *MKSEA Engineering Feasibility Study* (GHD 2005)
- *MKSEA Preliminary Transport Study* (Cardno BSD 2006)
- *MKSEA Surface Water and Groundwater Investigation and Monitoring Program* (Aquaterra 2008)
- *Preliminary Investigation of Aboriginal Heritage – City of Gosnells MKSEA* (ACHM 2009)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)
- *MKSEA Surface Water and Groundwater Monitoring and Investigation Report* (Endemic 2012)
- *District Water Management Strategy MKSEA Precincts 2 and 3* (TME 2014).

In addition to the above information, site-specific investigations have been conducted. These have aimed at providing more detail to the existing regional information. These site-specific investigations include:

- *Environmental Assessment and Management Strategy* (Emerge Associates 2015b)
- *Flora and Vegetation Survey* (Emerge Associates 2015a)

The above studies have been reviewed to determine any potential limitation of local surface water flow paths and existing surface and groundwater levels. This is important, as they can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Climate

The climate of the site (which applies to the wider Perth metropolitan region) is described as Mediterranean, with hot, dry summers and moderately wet, mild winters. The closest weather station to the site which records rainfall and temperature data is located approximately 3 km south of the site (Bureau of Meteorology (BoM) station number 9106). Based on weather data collected from 1961 to 2015, the area experiences an average of 825 mm of annual rainfall (Bureau of Meteorology 2015).

3.3 Geotechnical conditions

3.3.1 Topography

The site is generally low-lying, with elevation ranging from approximately 15 m Australian height datum (AHD) in the north east to 8 m AHD in the south west (DoW 2008b). On this basis, the site experiences a very minor south-westerly aspect.

Topographical contours are shown in **Figure 3**, indicating the elevation characteristics of the site.

3.3.2 Soils and geology

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986), indicates the site is comprised of:

- Clayey sand (Sc): silty in part, pale grey-brown, medium to coarse, poorly sorted, sub-angular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin.
- Sand (S_{10}): white to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin, over other units.

The mapped extent of the above soils units across the site is shown in **Figure 4**.

Results of geotechnical investigation are generally consistent with regional mapping and indicate that soils underlying the site are generally comprised of topsoil (Sand and Clayey Sand) overlying sandy and gravelly materials, non-engineered fill and clayey sand and gravelly materials (Douglas Partners 2016). However, it is noted that material presence and depths vary significantly across the site and therefore the location and configuration of any infiltration based infrastructure will need to consider local soil profile.

Results of on-site permeability testing indicate the permeability of soils underlying the site are generally low, but range between 1.1 m/day and 12.0 m/day (Douglas Partners 2016).

The full geotechnical report is provided in **Appendix C**.

3.3.3 Acid Sulfate Soils

Regional acid sulfate soils (ASS) risk mapping (DER 2006) indicates that the site is classified as having a moderate to low risk of ASS occurring within 3 m of the natural soil surface, as shown in **Figure 5**.

3.4 Surface water

3.4.1 Wetlands

A review of the *Geomorphic Wetlands on the Swan Coastal Plain* dataset (DPaW 2013) indicates that there are a number of geomorphic wetlands on site.

Table 2 provides details of the wetlands located within the site with their location shown in **Figure 6**.

Table 2 Geomorphic wetlands identified within the site

Unique Feature Identifier (UFI)	Wetland Type	Management Category
15254	Palusplain	Multiple Use
7632	Dampland	Multiple Use
7633	Sumpland	Multiple Use
13619	Palusplain	Multiple Use

Multiple use wetlands (MUW) extend across the vast majority of the site and generally indicate minimal separation between expressions of groundwater/perched water and natural surface levels.

3.4.2 Existing hydrological features

3.4.2.1 Yule Brook

Yule Brook is located approximately 150 m to the south of the site (as shown in **Figure 6**). The Yule Brook conveys flows west and ultimately to the Canning River and is part of the Water Corporation drainage network. A section of the Yule Brook located within Lot 71 Coldwell Road is shown in **Plate 1** with a long-section detailing the inverts and modelled flood levels prepared by Water Corporation provided in **Appendix D**.

Plate 1 Yule Brook

3.4.2.2 Existing drainage network

A site visit was carried out by Emerge Associates in December 2015 to establish the location and condition of the existing drainage network and other surface water features across the site. There is an existing network of drainage swales throughout the site located in road reserves that convey runoff from the road network downstream and ultimately to Yule Brook. These are either heavily modified or completely manufactured, and predominantly align with roads. The environmental values of these drains are very low to non-existent as they retain no natural features. An example road verge drainage swale is shown in **Plate 2**.

Plate 2 Road verge swale

An existing man made drainage channel runs south from Coldwell Road to the Yule Brook along the boundary of Lots 71 and 72 Coldwell Road (shown in **Figure 2** and **Figure 6**). Flows from the contributing road drainage swales discharge into the Yule Brook via this channel, shown in **Plate 3**.

Plate 3 Existing drainage channel

There are also a number of existing man made channels through properties within the site including Lots 4, 14, 12 and 40 Edward Street and Lots 200 and 501 Grove Road (as shown in **Figure 2** and **Figure 6**). The channel located in Lot 12 Edward Street is shown in **Plate 4.** The drainage channel within Lots 4, 14, 12 and 40 Edward Street ultimately discharge to the Yule Brook approximately 450 m south of the site (indicated as YUA028 on the long-section provided in **Appendix D**).

Plate 4 Drainage channel within Lot 12 Edward Street

Culverts are located where existing drainage channels cross Edward Street and Grove Road, as shown in **Plate 5** and **Plate 6** respectively.

Plate 5 Culvert beneath Edward Street

Plate 6 Culvert beneath Grove Road

While these existing manmade roadside drains and channels within properties perform a hydrological function in response to rainfall, they are not considered to maintain any natural streamline or ecological values that would need to be protected.

3.4.3 Surface water monitoring

3.4.3.1 Surface water flow rates

Surface water monitoring was carried out by Endemic between June 2009 and December 2010 across the greater MKSEA area which included (Endemic 2012):

- Surface water streamflow monitoring within the Yule Brook
- Surface water level monitoring within the Yule Brook and road verge drainage swales
- Surface water quality monitoring within the Yule Brook and road verge drainage swales
- Wetland water level monitoring.

There are no surface water monitoring locations within the site however the two locations within the Yule Brook (M1, M2 as shown in **Figure 6**) are upstream and downstream of the site and associated drainage discharge points (discussed in **Section 3.4.2.2**). A peak flow rate of 1.707 m^3/s was recorded at M1 (upstream of the site) in August 2009. However, a peak flow rate of 2.655 m^3/s was recorded at M2 (downstream of the site) in July 2009. These flow rates have not been attributed to a specific rainfall event, and are therefore only useful as a general indication of possible baseflow conditions within Yule Brook.

3.4.3.2 Surface water quality results

Monitoring at M1 and M2 was undertaken on 14 occasions between June 2009 and October 2010. The results of the monitoring are provided in **Table 3** with the full data set provided in **Appendix E**.

Table 3 Pre-development surface water quality results

Analyte	Units	NWQMS guideline trigger*	SCWQIP guideline trigger*	M1		M2	
				Average	St.dev	Average	St.dev
Temperature	ºC	-	-	14.39	2.28	14.75	2.48
pH		6.5-8.0	-	7.44	0.61	7.50	0.47
Electrical Conductivity (EC) **	mS/cm	0.12-0.30	-	0.81	1.55	1.12	2.19
Dissolved oxygen (DO)	mg/L	-	-	7.75	1.11	7.18	1.23
Redox	mV	-	-	3.52	50.01	-9.17	65.97
Total suspended solids (TSS)	mg/L	-	-	20.38	21.41	17.67	17.89
Total dissolved solids (TDS)	mg/L	-	-	343.69	610.25	247.38	162.40
Total nitrogen (TN)	mg/L	1.2	1 - 2	0.90	0.28	0.94	0.38
NOx-N	mg/L	0.15	-	0.35	0.21	0.44	0.34
NO2-N	mg/L	-	-	0.02	0.01	0.01	0.00
Nitrate-NO3	mg/L	-	-	0.36	0.22	0.41	0.31
Total kjehldahl nitrogen (TKN)	mg/L	-	-	0.55	0.32	0.54	0.26
Total phosphorous (TP)	mg/L	0.065	0.1 - 0.2	0.08	0.14	0.07	0.14
Filterable reactive phosphorous (FRP)	mg/L	0.04	-	0.01	n/a	0.01	n/a

*(ANZECC 2000); values taken from (Endemic 2012)

** measured EC concentrations detailed in the Endemic monitoring data provided in Appendix E appear to be incorrectly labelled as mS/cm and should be µS/cm, when taken in context with recorded TDS concentrations.

Surface water quality within Yule Brook is generally consistent upstream and downstream of the site discharge locations. Both TN and TP concentrations are within guideline trigger values provided in the SCWQIP (SRT 2009) and NWQMS (ANZECC 2000).

Additional monthly surface water and groundwater quality monitoring is currently being undertaken (during winter 2016) by Emerge Associates as part of an ongoing hydrological monitoring program. Results from the monitoring program will be used to inform the final detailed design and will be presented in subsequent UWMPs, and to assist in setting trigger values to which the development will be compared.

3.4.4 Pre-development surface runoff modelling

Pre-development modelling was carried out to support the DWMS (TME 2014) and detailed modelling of the Yule Brook system has been carried out by Water Corporation (long-section and hydrographs provided in **Appendix D**).

Emerge Associates have prepared a 2D pre-development hydrological model to characterise the existing environment (using XPSWMM) and enable comparison to the post-development environment (discussed further in **Section 7**). The Emerge Associates pre-development model has been constructed to be consistent with the catchments, long sections and inflow hydrographs provided by the Water Corporation. The modelling assumptions report provided in **Appendix F** presents the detailed methods and assumptions used to develop the model.

The results of the pre-development model were analysed to better understand the existing arterial drainage and flow pathways from Yule Brook and to assess the hydrological interaction between the site and Yule Brook. **Figure 7** shows pre-development arterial drainage and flow pathways from Yule Brook during the 100 year ARI event - excluding local rainfall on grid. Excluding rainfall on grid allows for visual identification of break out flows from Yule Brook. The arterial flows shown in **Figure 7** indicate:

- A number of break out flows from Yule Brook enter Precinct 3A.
- The site provides a significant amount of detention for break out flows due to its large flat nature.
- Break out flows are conveyed through the Precinct 3A and discharge at two locations in the south western corner, ultimately connecting back into Yule Brook.

In particular, the break out flows can be described as follows:

- Breakout flow ‘BF1’ occurs upstream of the Welshpool Road culvert with flows conveyed north west along the northern side of Welshpool Road reserve.
    - Part of ‘BF1’ crosses Welshpool Road at ‘BF1.1’ re-entering Precinct 3B and ultimately Yule Brook with the remainder of ‘BF1’ conveyed to the north west.
    - A small portion of ‘BF1’ enters Precinct 3A at the intersection of Coldwell Road and Welshpool Road ‘Inflow 1’ and is conveyed along Coldwell Road in a south westerly direction.
    - Further portions of ‘BF1’ enter the northern boundary of the site at ‘Inflow 2’ and ‘Inflow 3’.
    - The remainder of ‘BF1’ conveyed north of Welshpool Road away from the site.
- A secondary break out flow ‘BF2’ enters the site along a wide section of Coldwell Road.
    - A portion of ‘BF2’ is conveyed along Coldwell Road ultimately discharging to Yule Brook via an existing drain at ‘Out 1’.
    - The remainder and majority of ‘BF2’ is conveyed through the site to the north east.
- Whilst some manner of detention is provided within the lower lying areas of Precinct 3A, the breakout flows are ultimately conveyed via an existing drain under Grove Road and Edward Street.
    - The majority of flows in the existing drain are discharged from the site at ‘Out 2’ and are ultimately conveyed to Yule Brook at ‘Precinct 3 discharge to wetland’.
    - A minor portion of flow breaks out of the existing drain and flows in a south westerly direction towards and along Roe Highway and ultimately back into Yule Brook via ‘Out 3’.

Figure 8 presents 2D inundation results combining arterial drainage and runoff from the site (i.e. including runoff on grid) and shows overall inundation and peak flows during the 100 year ARI event. A summary of the pre-development 100 year ARI and 10 year ARI peak inflows and outflows is provided in **Table 4**.

Table 4 Pre-development peak inflows and outflows

Location	100 Year 36 Hour Peak Flow (m^3/s)	10 Year 36 Hour Peak Flow (m^3/s)
Yule Brook flows and break outs		
Yule Brook US	15.9	12.4
BF1	1.2	0.0
BF1.1	0.5	0.0
BF2	2.6	0.9
Out 1	0.3	0.1
Southern catchment input	2.6	2.4
Precinct 3 discharge to flow pathway upstream of wetland	1.2	0.6
Yule Brook DS	18.6	15.0
Inflow to Precinct 3A		
Inflow 1	0.1	0.0
Inflow 2	1.0	0.0
Inflow 3	0.1	0.0
BF2	2.6	0.9
Effective total inflow	*3.8*	*0.9*
Outflow from Precinct 3A		
Out1	0.3	0.1
Out 2	0.8	0.5
Out 3	1.2	0.6
Effective total outflow	*2.3*	*1.1*

It is noted the discharge to the existing drainage channel 'Precinct 3 discharge to flow pathway upstream of wetland' (as shown in **Figure 7**) enters the REW (UFI 7635) prior to discharging to Yule Brook. Frequent event flows conveyed by the drain are likely to provide some measure of support for the ecological values within the wetland and it is therefore proposed to match existing pre-development base flows (i.e. the 1 year 1 hour event) in the post-development environment. Pre-development outflows for the 1 year 1 hour ARI event were calculated to be 0.02 m^3/s. This approach will ensure downstream water-dependant ecosystems are protected, as discussed in **Section 7.2.2**.

3.5 Groundwater

3.5.1 Groundwater levels

Information on groundwater from the DoW online *Water Register* (DoW 2015) indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan unconfined aquifer
- Perth – Leederville confined aquifer
- Perth – Yarragadee North confined aquifer.

Groundwater data from the *Perth Groundwater Atlas* show that maximum groundwater levels across the site range between 7 m AHD and 12 m AHD (DoW 2015b). The nearest DoW monitoring bore (WIN 4883) is located approximately 3 km to the north west of the site and a number of water bodies are located between the site and this bore. It is therefore not considered that the DoW bore is appropriate to calibrate site specific maximum groundwater levels (MGL).

Groundwater monitoring was carried out by Endemic for 18 months commencing in July 2009 (Endemic 2012) with 11 monitoring bores installed across the broader DWMS area (approximate locations are shown in **Figure 3**). Two of these were located within Precinct 3A. Data loggers were installed in each of the bores with manual measurements taken quarterly for calibration purposes. MGL recorded range between approximately 8 m AHD in the south west and 13 m AHD in the north east of the site. The monitoring results showed that the site is subject to the seasonal perching of groundwater and is highly responsive to rainfall (Endemic 2012).

Emerge Associates have installed an additional nine bores across the site in June 2016 as part of an ongoing monitoring programme to provide greater coverage and resolution of groundwater data. The locations of the additional bores are shown in **Figure 3**.

While calibration against the longer term DoW monitoring bore is not considered to be appropriate, groundwater level data collected in July 2016 has been calibrated to the historic MGL at GW11 (10.27 m AHD; September 2009). The results of the calibration indicate that groundwater ranges between 8 m AHD in the south west of the site and 14 m AHD in the north east and flows in a westerly direction.

The calibrated MGL contours are shown in **Figure 3** with groundwater level data collected to date provided in **Appendix E**. Note the calibrated data does not account for variability of geology across the site (as discussed in **Section 3.3.2**) and the calibrated data should therefore be considered as a guide with final detailed design to be based upon further review of additional data collected as part of ongoing monitoring. Groundwater and surface water data is still being collected, and this will be presented in subsequent UWMPs, and used to inform detailed civil design of the site.

3.5.2 Groundwater quality

Water quality monitoring was carried out at two locations within the site (shown in **Figure 3**) on 9 occasions between September 2009 and December 2010. Monitoring included sampling of physio-chemical parameters in situ and laboratory analysis of nutrients, metals and other analytes (Endemic 2012). The measured groundwater quality is summarised in **Table 5** and details the parameters significant to, and managed within, this LWMS (i.e. physio-chemical parameters and nutrient concentrations).

Table 5 Groundwater quality

Analyte	Units	NWQMS guideline trigger*	SCWQIP guideline trigger*	GW01		GW11	
				Ave	St dev	Ave	St dev
Temp	ºC	-	-	21.81	13.94	16.63	7.78
pH		6.5-8.0	-	4.84	4.01	4.17	3.81
EC	mS/cm	0.12-0.30	-	8.28	14.40	2.22	4.13
DO	mg/L	-	-	1.04	1.84	2.41	3.05
Redox	mV	-	-	-18.60	26.39	-0.34	6.17
TSS	mg/L	-	-	542.29	1004.92	512.01	1111.62
TDS	mg/L	-	-	12.07	16.70	1.18	0.94
TN	mg/L	1.2	1 - 2	3.46	3.86	1.57	1.39
NO_x-N	mg/L	0.15	-	0.04	0.03	0.18	0.25
NO_2-N	mg/L	-	-	0.00	-	<0.1	-
Nitrate-NO_3	mg/L	-	-	0.17	0.19	0.26	0.24
TKN	mg/L		-	5.20	3.18	2.07	0.81
TP	mg/L	0.065	0.1 - 0.2	0.41	0.39	0.57	0.36
FRP	mg/L	0.04	-	0.02	-	0.08	0.03

*(ANZECC 2000); values taken from (Endemic 2012)

As shown in **Table 5**, groundwater beneath the site has a low pH and low salinity. TN and TP concentrations are considered ‘Low’ to ‘Moderate’ in relation to SCWQIP (SRT 2009) and NWQMS (ANZECC 2000) guidelines trigger values. These concentrations are representative of the historical land use of the site including small scale agriculture and farming (discussed in **Section 3.6**).

Additional groundwater quality monitoring is currently being undertaken (in Winter 2016) as part of Emerge Associates’ ongoing monitoring program and the results to be provided within future UWMPs.

3.6 Current and historical land uses

A review of historic aerial photography indicates that the site has been predominately used for rural lifestyle and small scale agricultural land uses, although recently some areas have been subject to other light industrial uses such as turf farming and small freight haulage facilities. The majority of the site was cleared of remnant vegetation prior to 1953 to support such land uses with isolated patches of remnant vegetation in degraded condition, subject to partial clearing and high levels of weed invasion.

A search of the Department of Environment Regulation's (DER) Contaminated Sites Database (DER 2015) found there to be no registered contaminated sites within or in proximity to the site.

3.7 Summary of existing environment

In summary, the environmental investigations conducted to date indicate that:

- The site receives 825 mm of average annual rainfall with the majority of rainfall received in June and July.
- Topography of the site ranges from 8 m AHD in the south west to 15 m AHD in the north east.
- The site is underlain by sand and clayey sand overlying sandy and gravelly materials, non-engineered fill and clayey sand and gravelly materials.
- The permeability of soils underlying the site was generally low, however was highly variable and ranges between 1.1 m/day and 12.0 m/day.
- The whole site is mapped as having a moderate to low risk of encountering ASS within 3 m of the surface.
- The majority of the site is listed as an MUW.
- The Yule Brook is located approximately 150 m south of the site.
- There are a number of existing man-made drains across the site, all draining toward the Yule Brook.
- Hydrological and hydraulic modelling within XPSWMM has been used to identify pre-development peak flows entering and leaving the site. The model has been prepared consistent with the Water Corporation modelling of Yule Brook and in further detail to the modelling of the greater MKSEA documented in the District Water Management Strategy (DWMS).
- Surface water quality within Yule Brook in the locality of the site has low TN and TP concentrations upstream and downstream of the discharge locations from site.
- Maximum groundwater levels (MGL) across the site range between 8 m AHD near the western boundary and 14 m AHD near Welshpool Road, and are either at the surface or very shallow beneath most of the site. Given the low permeability soils the MGL is more likely a reflection of seasonally perched groundwater rather than a permanent superficial aquifer.
- Groundwater quality beneath the site has low to moderate TN and TP concentrations.
- The site has historically been used for rural lifestyle and small scale agricultural purposes with some more recent light industrial activity in areas including turf farming and small freight haulage facilities.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future Urban Water Management Plans (UWMP) must achieve. The water management strategy covers stormwater management, groundwater management and water consumption.

4.1 Water conservation

Water conservation design criteria are proposed which are consistent with the guidelines presented in *Better Urban Water Management* (WAPC 2008) and in consideration of the criteria proposed in the DWMS (TME 2014). This LWMS proposes the following water conservation criteria:

Criteria WC1 Minimise water requirements for the establishment and maintenance of swales and other landscaped areas.

Criteria WC2: Minimise water use within lots.

The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.2 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. This LWMS proposes the following groundwater management criteria:

Criteria GW1 Finished floor levels of buildings should have a minimum 500mm clearance from MGL.

Criteria GW2 Conveyance swales and subsoil drains will be set at pre-development MGL, the underlying clay layer or existing drain inverts.

Criteria GW3 Inverts of flood detention structures to be set at or above MGL, the underlying clay layer or existing drain inverts.

Criteria GW4 Maintain or improve groundwater quality leaving the site.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

4.3 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3.4**. This principle and the guidance documents discussed in **Section 1.3** and **1.4** have guided the stormwater management criteria.

This LWMS proposes the following stormwater management design criteria:

Criteria SW1 Provide conveyance of 100 year ARI flow which currently enters the site from upstream catchments.

Criteria SW2 Runoff from lots will be treated at source, within each lot.

Criteria SW3 Detain flows up to the 100 year ARI storm event within the boundary of each lot.

Criteria SW4 Runoff from road reserves will be treated at source and via extended detention within roadside swales.

Criteria SW5 Road reserve runoff and conveyance will be via kerbed road pavement, side entry pits and roadside/arterial conveyance swales.

Criteria SW6 Minor roads to remain passable in the 10 year ARI storm event.

Criteria SW7 Detain flows up to the 100 year ARI storm event to maintain pre-development peak flow rates at key discharge locations.

Criteria SW8 Finished floor levels should have a 300 mm clearance from the 100 year ARI water level within conveyance swales and the flood detention structure.

Criteria SW9 Apply appropriate non-structural measures to reduce pollutant loads.

Criteria SW10 Perth Transit Authority land to detain flows up to the 100 year ARI storm event to meet pre-development peak flow rates.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

5 Water Source Allocation, Infrastructure, Fit-for-Purpose and Water Use

5.1 Fit-for-purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that scheme water is not wasted. Fit-for-purpose principles have been utilised in the water conservation strategy for MKSEA Precinct 3A.

5.1.1 Scheme water

The MKSEA Precinct 3A operates within the Water Corporation Integrated Water Supply System (IWSS) and therefore will be supplied by scheme water for potable and non-potable uses.

5.1.2 Groundwater

Groundwater can be used for irrigation of drainage reserves and road verges instead of utilising scheme water. Irrigation of road verges will be the responsibility of the adjacent lot owner. The local government will not be responsible for ongoing irrigation of drainage reserves or road verges.

There is approximately 1.5 ha of drainage reserve plus some additional landscaped areas proposed within the site. At an average irrigation rate of 6,750 kL/ha/yr, approximately 13,500 kL/year will be required. There may also be some irrigation required of the vegetation within roadside swales, and at a nominal 50% of the conveyance swale requiring irrigation an additional 8,100 kL/year would be required.

There is an existing groundwater licence associated with Lot 501 Grove Road held by the current landholders (R. Lovegrove) with an allocation of 65,150 kL/year from the Perth - Superficial Swan aquifer. This allocation (or part thereof) can be transferred to the proponent for irrigation purposes. A transfer application will be investigated by the proponent with the status of any groundwater application or allocation gained confirmed in future UWMPs. The specific requirements for the groundwater allocation will be confirmed as part of the groundwater licence transfer application.

The DoW *Online Water Register* (DoW 2016b) indicates that the site is located in the Perth groundwater area within the City of Gosnells sub area. In the event a transfer of the existing groundwater licence was not successful, the *Online Water Register* (DoW 2016b) indicates (as at 09/08/2016) groundwater is available from the superficial aquifer. In the event the aquifer becomes fully allocated or an application for groundwater allocation was unsuccessful, the proponent would then be required to secure a licence via a trade partner in order to meet irrigation requirements.

The use of groundwater for irrigation at an average rate of 6,750 kL/ha/yr will help to achieve **Criteria WC1**.

5.2 Water conservation measures

5.2.1 Estate scale conservation measures

Water use can be reduced on a development scale within drainage reserves, swales and landscaped areas by employing Water Wise Gardening (WWG) measures and minimising soft landscaping. The following water efficiency measures will be used within the development:

- Improve soil with conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Design and install the irrigation system according to best water efficient practices.
    - Control systems must be able to irrigate different zones with different irrigation rates.
    - Emitters must disperse coarse droplets or be subterranean.
    - Utilise subsoil irrigation where appropriate.
- Minimise the amount of turf areas.
- Where turf is used it should be drought tolerant.
- Mulch garden beds to 75 mm with a product certified to Australian Standard AS4454.
- Minimise use of fertilisers and utilise slow release fertilisers.

WWG principles will be adopted within drainage reserves and swales (where required) within the development. Irrigation of road verges will be the responsibility of the adjacent lot owner.

The above measures will assist in achieving **Criteria WC1**.

5.2.2 Lot scale conservation measures

In order to ensure that water is used efficiently, lot owners will be encouraged to utilise rainwater tanks and water efficient fixtures. Given the large lot industrial uses the water savings achieved by these measures are likely to be nominal.

5.2.2.1 Rainwater tanks

Lot owners will be encouraged to install rainwater tanks to collect rainwater for appropriate non-potable water uses. The use of rainwater tanks will assist in achieving **Criteria WC2**.

5.2.2.2 Water efficient fittings

The water conservation strategy for Precinct 3A proposes that all buildings use WEFA where appropriate. Water efficient fittings and toilets can be mandated through the building licence process. The use of water efficient fittings will assist in achieving **Criteria WC2**.

5.3 Wastewater management

The MKSEA Precinct 3A development may be serviced with reticulated sewer or via ATUs depending on final lot sizes and funding outcomes from the Water Corporation's capital works program.

5.4 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria, and how these are addressed within the MKSEA Precinct 3A SP is provided in **Table 6**.

Table 6 Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1		Use an average irrigation rate of 6,750 kL/ha/year to irrigate landscaped areas

Criteria number	Criteria description	Manner in which compliance will be achieved
	Minimise water requirements for the establishment and maintenance of swales and other landscaped areas	Utilisation of WWG within road verges, drainage swales and landscaped areas
WC2	Minimise water use within lots	Use of rainwater tanks within lots
		Use of water efficient fittings within lots

6 Groundwater Management Strategy

The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.2**.

6.1 Groundwater level management

The primary objective for groundwater level management is to ensure that finished floor levels have appropriate clearance from groundwater (see **Section 4.2**).

6.1.1 Groundwater levels

As discussed in **Section 3.5.1**, MGL varies across the site between 8 m AHD and 14 m AHD.

Finished floor levels of buildings will be required to have a minimum clearance of 500 mm from MGL consistent with Local Government requirements. This will be achieved via imported fill where necessary.

The invert of conveyance swales (discussed further in **Sections 7.1.2.4**) will be set at existing roadside drain inverts (where applicable) or will be set approximately at or above MGL or the underlying clay layer along any proposed or re-aligned roads. Inverts of flood detention structures will also be set approximately at or above MGL or the underlying clay layer. It is noted the FDBs (discussed further in **Section 7.1.2.5**) should be configured with an invert set above the invert of the roadside swale which flows through it, if it is proposed to maintain usability and amenity for public access. The form of access will be confirmed as part of detailed design, in consultation with CoG, and detailed in future UWMPs.

The roadside swales currently act, and will continue to act, as a groundwater control. Treatment of the first 15 mm will be achieved through interaction with vegetation and extended detention as discussed in **Section 7.1.2.4**. Subsoil drainage is not proposed across the site to control groundwater across lot areas. However, some subsoil drainage may be provided beneath lot detention areas (LDAs) to ensure that they dry out in a timeframe which does not allow creation of mosquito breeding habitat and to ensure that localised groundwater mounding does not occur (discussed in **Section 6.1.2**). Subsoils will need to be configured to discharge into the roadside swale system with inverts set at or above the swale invert (and therefore subsoil drains will have a free draining outlet and the inverts would be above the groundwater control provided by the swale inverts).

The above measure will ensure that **Criteria GW1**, **GW2** and **GW3** are achieved.

6.1.2 Water balance

The pre-development environment consists of sand overlying sandy-clay as detailed in **Section 3.3.2** (with the full geotechnical report provided in **Appendix C**). The existing initial loss characteristics of the site are assumed to be approximately 8 - 9 mm per unit area, and the pre-development lots are close to 100% pervious.

Once developed, lots will be approximately 95% impervious area (roof and car parks/paved areas) and 5% pervious landscaped areas. This will inhibit infiltration across 95% of lot areas and further, approximately 60% of road reserves will also be impervious. There will therefore be minimal opportunity for runoff to infiltrate onsite and cause a rise in groundwater.

The at-lot stormwater management approach is to detain the 100 year ARI (critical duration) event to maintain pre-development peak flow rates (discussed further in **Section 7**). Retention and direct infiltration of runoff on lot will be minimal as the infiltration area available will be minimal, and the majority of runoff will therefore be discharged from lot and conveyed downstream. The exception to this will be where localised geotechnical conditions and the intended development of the individual lot indicate that onsite infiltration is preferable. There may be some localised mounding of groundwater at the front of lots where landscaped impervious areas will be located. To address this sub-soil connection points will be provided to prevent any localised groundwater mounding at the front of lots. The sub-soil network would be directed into roadside swales prior to discharge from site with subsoil inverts set approximately at or above roadside swale inverts. Subsoil drains may also be used beneath road reserves to ensure pavement integrity. These would also discharge into the roadside swales.

6.2 Groundwater quality management

The main objective for the management of groundwater quality is to maintain or improve the existing groundwater quality on site. This can be achieved by treating surface runoff prior to infiltration via application of appropriate WSUD measures, thereby reducing the total nutrient load into the groundwater that originates from the development.

The reduction of nutrient load to the groundwater will be achieved in the development by:

- Directing first flush stormwater to vegetated treatment areas (detailed further in **Section 7.1.2.4**.
- Fertiliser use to establish and maintain vegetation within drainage reserves and road verges will be minimised.
- Drought tolerant turf species that require minimal water and nutrients will be used.
- Roll-on turf will be used within the drainage reserves and road verges, to prevent the high nutrient input requirement during establishment of the turf.

The above measures will improve the quality of the water prior to it infiltrating into the underlying groundwater, and will assist in achieving **Criteria GW4**.

It is not expected that using roadside swales set approximately at MGL will cause any dewatering of the site, or additional conveyance of nutrients from the site. This is because the inverts proposed are predominantly already existing, and any dewatering and conveyance of nutrients that would have occurred would have happened historically. Further, future development of the site will involve large lot industrial that expected to have minimal to non-existent nutrient requirements.

6.3 Groundwater criteria compliance summary

A summary of the proposed groundwater quantity design criteria and how these are addressed within MKSEA Precinct 3A is provided in **Table 7**.

Table 7 Groundwater criteria compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Finished floor levels of buildings should have a minimum 500mm clearance from MGL	Finished floor levels will be provided a minimum 500 mm clearance from MGL with fill used where necessary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW2	Conveyance swales and subsoil drains will be set at pre-development MGL, the underlying clay layer or existing drain inverts	Conveyance swales will be set consistent with existing drain inverts. Subsoil drains will be set at or above the conveyance swale inverts
GW3	Inverts of flood detention structures to be set at or above MGL, the underlying clay layer or existing drain inverts	Inverts of flood detention structures will be set above the inverts of immediately adjacent existing drain inverts
GW4	Maintain or improve groundwater quality leaving the site	Direct stormwater to bio-retention areas for treatment
		Minimise use of fertilisers within landscaped areas
		Use drought tolerant roll on turf species

7 Stormwater Management Strategy

The principle behind the stormwater management strategy for MKSEA Precinct 3 is to maintain the existing hydrology by matching pre-development flow rates leaving the site and maintaining flow paths across the site for upstream (arterial) flows.

The Stormwater management strategy focusses of five key aspects:

1. Conveyance of upstream flows entering the site via formalised channels
2. Conveyance of breakout flows from Yule Brook which enter the site
3. Catchment (lot scale) management
4. Stormwater peak flow rates
5. Stormwater runoff quality.

The post-development modelling uses a linked 1D/2D approach, and has been developed in close consultation with Water Corporation to ensure that the detention volumes proposed will meet Water Corporation flow requirements within Yule Brook.

Each component of the stormwater management network and the resulting detention volumes have been designed to achieve the objectives and criteria stated in **Section 4.3**.

7.1 WSUD strategies

A number of WSUD strategies at a lot scale and estate scale will be required to maintain flows and detain catchment runoff (detailed further in **Sections 7.1.1** and **7.1.2** respectively). Combining a number of WSUD techniques in a treatment train is the most effective manner in which to treat catchment runoff. Treatment trains incorporate multiple WSUD techniques to ensure primary, secondary and tertiary treatment of stormwater is achieved. Examples of possible WSUD techniques are discussed below.

7.1.1 Lot scale WSUD measures

The water quality treatment measures to be applied at-lot will not necessarily be based on retaining a nominal volume or storm event. Rather, they should be based on an assessment of the geotechnical capacity of each lot (to accept infiltration) and the treatment requirements of the lot use (which will often not be known until individual lot development). Regardless of which type of treatment is adopted, it should be appropriate for the lot use and site characteristics. As a guide, where it is possible to adopt WSUD measures and onsite infiltration is possible, the aim should be to treat the first 15mm of runoff if practicable.

Surface-based WSUD measures that may be considered within lots could include:

- Bio-retention areas
- Rain gardens
- Vegetated swales/landscaping strips and infiltration areas.

The uptake of these will be guided by the site-specific geotechnical conditions and the ultimate use of the lot.

7.1.1.1 Lot soakage

Onsite soakage may be provided within lots (via soakwells or alternative measures) to collect sediments from runoff. The use of or volume for these is not proposed to be mandated, and would be based on the individual lot owner's assessment of the most effective treatment approach to address their individual requirements. Lot soakage would typically receive first flush runoff for very localised catchments and could be used in a treatment train with other measures proposed in this LWMS.

The use of lot soakage will assist in achieving **Criteria SW2** and **SW3**.

7.1.1.2 Lot detention areas

Lots will detain flows, up to the 100 year ARI event, within a LDA. The area designed to detain the 100 year ARI event can potentially be within car park areas or other open spaces within lots. A maximum flooding depth of 300 mm is recommended within car park areas. In detaining runoff, the LDA is designed to reach maximum capacity in a large storm event and discharge runoff at a reduced rate that approximates the pre-development peak flows. It is the lot owner's responsibility to ensure the appropriate volume of storage is provided within the lot and that flows leaving the site are consistent with the pre-development environment. Required storage volumes per unit area within lots are provided in **Section 7.2.1**.

A low flow discharge or subsoil connection point may be required to ensure that LDAs dry out due to the low permeability of the underlying soils, particularly where WSUD based measures are adopted.

Runoff from events greater than the 100 year ARI event will discharge from the lot via appropriately sized gully pits, discharge piping or weir structures (where outlets are adjacent to roadside conveyance swales - detailed in **Section 7.1.2.4**) into the downstream roadside swales and ultimately the FDB prior to discharge from the site at pre-development peak flow rates.

The use of LDAs will assist in achieving **Criteria SW3**.

7.1.1.3 Grease and sediment traps

Certain land uses can produce sediments and hydrocarbons to a level that cannot be treated by GPTs. Grease and sediment traps can be used as a secondary level treatment system to remove these smaller particles. Grease and sediment traps must be regularly maintained to ensure the efficiency of the device.

Depending on the final nature of the development and specific land uses, these may be applicable to some lots within the site. These are more likely to be required where there is either a high vehicle/ traffic load, or where vehicle servicing/maintenance is to be carried out onsite.

The use of grease and sediment traps will assist in achieving **Criteria SW2**.

7.1.1.4 Oil-water separators

Oil-water separators can be used to provide water quality treatment at a lot scale, particularly for small industrial or commercial lots where larger BMPs are not feasible due to site constraints. There are a range of systems available which incorporate some combination of filtration media, hydrodynamic sediment removal, oil and grease removal, or screening to remove pollutants from stormwater.

Oil-water separators are best used in commercial, industrial and transportation type land uses i.e. areas that are expected to receive high sediment and hydrocarbon loadings, such as car parks and service stations. Depending on the final nature of the development and specific land uses, these may be applicable to some lots within the site.

The use of oil-water separators will assist in achieving **Criteria SWQ2**.

7.1.2 Estate scale WSUD measures

7.1.2.1 Side entry pit traps

Side entry pits with sediment traps will be provided at entry points to the roadside conveyance swales (discussed in **Section 7.1.2.4**), including lot connection points, to collect debris and sediments. Side entry pit traps are suited to developments with the potential for high litter and debris volumes. They require regular maintenance to ensure their efficiency and prevent blockages which can result in flooding issues upstream.

The use of side entry pits will assist in achieving **Criteria SW3**, **SW4** and **SW5**.

7.1.2.2 Gross pollutant traps

Stormwater runoff can transport nutrients and gross pollutants to downstream water bodies. A Gross Pollutant Trap (GPT) is considered a primary level treatment system, removing a proportion of these large pollutants and, in some cases, the smaller particles such as sediments and hydrocarbons. The pollutants captured in the GPT must be regularly removed to ensure the efficiency of the device.

GPTs are best suited to land uses with high gross pollutants such as commercial development, or for collecting gross pollutants during the construction phase of the development. Depending on the final nature of the development and specific land uses, these may be applicable to some lots within the site.

The use of GPTs will assist in achieving **Criteria SW2**.

7.1.2.3 Trash racks

Trash racks are usually permanent structures which intercept trash and other debris to protect the environmental quality of water. Trash racks are to be constructed upstream of all permanent retention basins and will require regular maintenance to remove debris and silt and ensure their ongoing efficiency. Trash racks may also be incorporated in the design of GPTs.

The use of trash racks will assist in achieving **Criteria SW2**.

7.1.2.4 Roadside swales

Roadside swales will be located within widened (25-30m) road verges. These will be used to convey runoff from the adjacent road reserve and upstream arterial flows to a downstream FDB (detailed in **Section 7.1.2.5**) prior to discharge. Roadside swales are designed with a maximum 100 year ARI flooded depth of 1.0 m and 1:6 side slopes and are 8.4-15 m wide. A typical cross section of a roadside swale is provided in **Appendix G** and shows indicatively that the invert of the swale will be at or close to MGL, and that roads and lots will have a suitable clearance above MGL. The swale profiles can be revised in the future to meet localised site requirements, provided that the detention volumes specified in this LWMS are achieved.

The design of the conveyance swales will be such that maximum top water levels within swales will remain at least 300 mm below finished floor levels of adjacent lots to ensure protection from flooding during a 100 year ARI rainfall event (see the preliminary earthworks strategy in **Appendix G**).

Roadside swales will also provide treatment of runoff through interaction with vegetation and extended detention. Treatment zones will be provided in the flatter sections of the swale (i.e. those which are close to 1:740 longitudinal grade) where flow rates will be reduced and there will be the opportunity for contact with vegetation to improve water quality.

The base of treatment zones will be vegetated with reeds and rushes suitable for removing nutrients and capable of surviving in wet conditions for extended periods. The steeper conveyance sections of the swales (i.e. those closer to 1:250 longitudinal grade) and side slopes will be planted with either reeds and rushes (though at a reduced planting density), ground cover planting, informally managed turf and/or compacted clay (i.e. natural existing soil profile). The proposed landscape treatments are illustrated in the landscape plans provided in **Appendix B**. The upper slopes of both sections of swales (i.e. those portions above the wetted perimeter) may be more formally turfed and managed as such to provide amenity to the swales.

The landscape treatments within the roadside swales provide water quality treatment of runoff prior to discharge to the FDB (detailed in **Section 7.1.2.5**) and from the site. The shallow grade of the swale and inclusion of vegetation will ensure an extended detention period in which treatment can occur.

As discussed in **Section 6.1.1**, inverts of conveyance swales will be set consistent with existing roadside drain inverts or will be set at or above MGL or the underlying clay layer along any proposed or re-aligned roads.

The alignment of roadside swales has also considered the requirement to convey major event flows from upstream areas and flows which also breakout from the existing Yule Brook (predominantly over Coldwell Street). The alignment of roadside swales will ensure that the existing hydrological regime is maintained, and specifically so that the flow regime which discharges through downstream wetland areas (within Precinct 3B) can be maintained.

The use of roadside swales will achieve **Criteria SW1**, **SW3**, **SW4**, **SW5** and **SW6**, while the design of the basins will ensure that **Criteria SW8** is achieved.

7.1.2.5 Flood detention basins

FDBs will be utilised to detain major event flows (up to the 100 year ARI event) before discharge from site in order to maintain the pre-development peak flow rates leaving the site.

The swale network will discharge to a FDB via overtopping of the swale embankment (or similar arrangement). The invert of the basin will have a minimum clearance above the invert of the channel of 300 mm to ensure it does not remain permanently wet, as shown in the indicative landscape plan provided in **Appendix B**. Concept designs show that these areas can potentially provide amenity and in these instances will have a maximum depth of 1.2 m and side slopes of 1:6 to 1:3. There are up to four FDBs proposed in Precinct 3A, and it is not anticipated that all will be provided with the same landscaped finish. All will provide some form of water quality treatment via vegetation, however it is likely that only key FDBs that will be accessible and useable will be landscaped to provide public amenity to the estate. The size and spatial requirements for the FDBs are further discussed in **Section 7.2.2** Indicative locations for these consider catchment, land tenure and local government boundaries, and are shown in **Figure 9**.

The design of the FDBs will be such that maximum top water levels will remain at least 300 mm below finished floor levels of adjacent lots to ensure protection from flooding during extreme rainfall events (see the preliminary earthworks strategy in **Appendix G**).

The FDBs may be vegetated with ground cover planting and informally managed turf with reeds and rushes provided within the low flow channel, consistent with the roadside swales. The landscaping treatment can provide some amenity to a key the FDB during dry periods when it is not utilised for runoff detention. The use of FDBs will achieve **Criteria SW7**, while the design of the basins will ensure that **Criteria SW8** is achieved.

The main FDB (Basin A) will discharge from the site at two locations. The first will be in to the existing drain along the south eastern boundary of the Precinct 3A structure planning area (Out 2), consistent with the existing flow regime (and which feeds the downstream wetland adjacent to Yule Brook). This discharge will eventually flow into the wetland adjacent to Yule Brook and it is therefore important that this flow regime is maintained.

A second discharge will be west site towards the PTA land at a location consistent with an existing overland flow path. Outlets from both the south eastern (Out 2) and the western (Western overland flow path) corners of the FDB will be configured in such a way as to maintain the pre-development flows to the wetland (Precinct 3 discharge to wetland) and also maintain pre-development peak flows within Yule Brook. The post-development peak flow requirements are further described in **Section 7.2**).

7.1.3 Perth Transit Authority

The manner in which the PTA land will be drained is yet to be determined in detail. However, the principle for drainage will be guided by the site constraints, being the generally flat slope of the land, the need to maintain gentle grades for rail infrastructure and to accommodate upstream inflows to the land which currently occur. This will mean that all PTA land drains southwards towards Yule Brook with an approximate 1:500 grade. There is uncertainty as to how much of the site will be impervious, and therefore the assumptions made for the PTA are consistent with the remainder of the industrial area, i.e. 95% of the PTA land will be impervious. PTA will require their own FDB (Basin B), which would nominally be located as far south towards Yule Brook as is practical to allow for appropriate treatment and detention of as much of the site as possible. The location and configuration of this has not been determined, however based on Water Corporation requirements and modelling assumptions, the PTA catchment will need to provide approximately 15,000 m^3 of detention storage.

The PTA land will also receive runoff from the FDB (Basin A) during major flow events (described in **Section 7.2**), which approximates the pre-development environment (where overland flow heads west via shallow sheet flow until reaching the existing railway and Roe Highway, and then flowing south towards Yule Brook). The post-development discharge will be via a swale or pipe outflow along the southwestern boundary of Precinct 3A, from the FDB (Basin A).

7.2 Drainage design assessment

As described in **Section 7.1.2.5**, the development drainage strategy is to detain the 100 year ARI event to maintain pre-development peak flow rates. This LWMS proposes to utilise LDAs, conveyance swales and FDBs to detain runoff from across the development. Flows from upstream catchments (e.g. breakout flows and along Welshpool Road) will also be maintained within the roadside conveyance swales.

The sizing of storage areas and swales has been determined using XPSWMM hydrological and hydraulic modelling software. The post-development model uses a 1D-2D coupled hydraulic and hydrological model using parameters consistent with those in the pre-development model, as detailed in **Section 3.4**. The post-development modelling assumptions and parameters are detailed in the modelling assumptions document provided in **Appendix F**. The changes within Precinct 3A in the post-development environment have been modelled using a 1D approach. The inputs and outputs from/to the broader area (including Yule Brook) have been modelled using a 2D approach, which is linked to the 1D catchments within Precinct 3A. This allows breakout flows from Yule Brook at Welshpool Road to be fully accounted for.

The post-development catchments and locations of stormwater features are shown in **Figure 9**.

7.2.1 Lot drainage

Runoff from major events (up to the 100 year ARI event) will be detained within LDAs prior to discharge from lot, as detailed in **Section 7.1.1.2**. A detention storage of 350 m^3/ha is required within lots. This storage volume and peak flow rates have been calculated using XPSWMM.

Lot soakage will also be provided (as discussed in **Section 7.1.1.1**) to provide treatment of initial runoff through collection of sediments. The design of lot drainage discussed will achieve **Criteria SW2** and **SW3**.

7.2.2 Development drainage

7.2.2.1 Breakout flows

As discussed in **Section 3.4.4**, the site in its existing form maintains some manner of detention for breakout flows from Yule Brook along Welshpool Road and over Coldwell Road (i.e. 'Inflow1', 'Inflow 2', 'Inflow 3' and 'BF2' as shown in **Figure 7**). The development of the site will require it to be filled, altering these pre-development flow paths and removing the existing detention storage. In order to maintain the pre-development hydrology, the flows along Welshpool Road will be routed to conveyance swales and a detention basin as shown in **Figure 9**. Flows from 'BF2' will not enter the site as Coldwell Road will have been filled once constructed. These flows will be retained within Precinct 3B, consistent with the ultimate development scenario (where Precinct 3B will provide flood conveyance and detention as per Water Corporation requirements). Breakout flows 'Inflow1', 'Inflow 2' and 'Inflow 3' from Welshpool Road will be captured and conveyed to an FDB via roadside swales adjacent to the proposed road reserve as shown in **Figure 9**.

7.2.2.2 Conveyance swales

Runoff from road reserves will enter the roadside conveyance swales via side entry pits designed to trap sediments prior to entering the swale (as discussed in **Section 7.1.2.1**). Treatment will occur in-line due to vegetative uptake of nutrients and will be enhanced by the long residence time provided by vegetation (i.e. a high Mannings 'N') and flat grades (as detailed in **Section 7.1.2.4**). The locations of proposed roadside conveyance swales are shown in **Figure 9**.

The north-south conveyance swale (adjacent to the future railway) will not be within road reserve and therefore will be within private lot. The configuration of this swale may therefore need to be modified to suit the intended land uses immediately adjacent to the future railway. The important criteria to guide the future designs of swales (and the overall flood detention system) is that the storage volumes outlined in **Table 8** are achieved, regardless of final swale and FDB configuration.

7.2.2.3 Flood detention basins

Runoff from events up to the 100 year ARI event will be conveyed within the roadside conveyance swales. Flows will then be discharged to a downstream FDB (detailed in **Section 7.1.2.5**) prior to discharge from site to either the south eastern discharge channel (Out 2 shown in **Figure 9**) or to the western overland flow pathway towards PTA land. The XPSWMM surface runoff modelling of the site has represented the detention storages as nodal reservoirs which nominally have 1:6 side slopes and 1.2 m depth. The specific design of the FDBs will be confirmed during detailed design and documented in future UWMPs (as discussed in **Section 8.3**).

The outlets from Basin A were modelled as a throttled pipe and overflow weirs that will discharge to the existing south eastern drain (at Out 2) which ultimately discharges to the wetland adjacent to Yule Brook, and to the west towards the future PTA land. The outlet configurations have been designed so that flow rates from frequent events are generally maintained (and thereby maintaining the existing hydrology of the wetland adjacent to Yule Brook) and so that pre-development flows from a 100 year ARI event are not exceeded.

The FDB located within PTA land (Basin B indicated in **Figure 9**) will nominally need to have a capacity of 15,000 m^3 as indicated by Water Corporation modelling. While understood to be considered a part of Precinct 3A, Lot 2008 has not been included in the Precinct 3A catchment assessment undertaken by Water Corporation or Emerge and therefore has separate flood detention requirements which are in addition to those detailed in **Table 8**. According to the assumptions used in the Water Corporation and LWMS modelling Lot 2008 will need to provide its own lot detention and also a portion of the broader flood detention as per the approach taken for the remainder of Precinct 3A. On this basis Lot 2008 will need to provide approximately 4,000m^3, plus the at-lot detention volume. Note that the location and configuration of these FDBs is yet to be determined, and is the responsibility of others and therefore not detailed in this LWMS.

The FDB located in the Shire of Kalamunda portion of Precinct 3A (Basin C) will need to provide 7,000m^3 of storage. A nominal location is provided, however it is expected that the location and configuration (and number of basins) would be revised to account for localised catchments within the Shire of Kalamunda portion of Precinct 3A. The nominal location of FDBs are shown in **Figure 9**.

A summary of 100 year ARI event basin design assumptions provided in **Table 8.** Peak outflows at the discharge locations from Precinct 3A are presented in **Table 9.**

Table 8 10 year ARI and 100 year ARI event detention volumes and design assumptions

Detention storage	100 Year ARI event		10 Year ARI event	
	TWL area (m^2)	Volume (m^3)	TWL area (m^2)	Volume (m^3)
Total lot detention		23,400		18,050
Swale 1		2,700		650
Swale 2		11,700		1,400
Swale 3		7,200		700
Swale 4		5,900		400
Total swale detention		27,500		3,150

Detention storage	100 Year ARI event		10 Year ARI event	
	TWL area (m^2)	Volume (m^3)	TWL area (m^2)	Volume (m^3)
Basin A – Linc acquisition area	13,400	14,200	11,900	7,000
Basin B – PTA Land	14,100	15,000	12,700	8,350
Basin C – Shire of Kalamunda portion of Precinct 3A	6,950	7,000	6,000	3,750
Basin D – Coldwell Road North	4,000	3,800	3,600	2,800
Total FDB storage	38,450	40,000	34,200	21,900
Total detention provided		90,900		43,100

The design of the development drainage discussed above will achieve **Criteria SW1**, **SW3**, **SW4**, **SW5**, **SW6** and **SW7**.

Table 9 Post-development peak inflows and outflows

Location	100 Year 36 Hour peak flow (m^3/s)		10 Year 36 Hour peak flow (m^3/s)	
	Pre-development	Post-development	Pre-development	Post-development
Inflow to Precinct 3A				
Inflow 1	0.1	0.1	0.0	0.0
Inflow 2	1.0	1.0	0.0	0.0
Inflow 3	0.1	0.1	0.0	0.0
Effective total inflow	***1.2***	***1.2***	***0.0***	***0.0***
Outflow from Precinct 3A				
Out 2 (to wetland)	0.8	0.8	0.5	0.5
Out 3	1.2	0.6	0.6	0.6
Effective total outflow	**2.0**	**1.4**	**1.1**	**1.1**

Note that 'Out 1' is not shown above as under the ultimate development scenario this outflow will no longer exist.

As shown in **Table 9**, there are some minor variations between pre- and post-development flow regimes at locations discharging to Yule Brook, however the flow regime to the wetland is maintained. The above flow regimes are consistent with Water Corporation allowable flows at Roe highway, and maintain the pre-development 100 year ARI peak flow rate of 18.6m^3/s at the Roe Highway culverts. Given that the peak flow regime within Yule Brook is maintained **Criteria SW1** has been achieved.

Flow rates at discharge locations to Yule brook can be further refined at detailed design stage based on a refined FDB and swale design process. Most importantly, the XPSWMM modelling has demonstrated that the flow regime in Yule Brook and the wetland can be maintained.

7.2.3 Yule Brook

The flow regime within Yule Brook has been modelled by Water Corporation and by Emerge Associates. The XPSWMM modelling undertaken by Emerge Associates has used the hydrograph inputs and outputs at key locations provided by Water Corporation to ensure that the water management strategy is based on an approach consistent with Water Corporation expectations of flow rates within Yule Brook. The input/out locations and peak flow conditions for Yule Brook are summarised in **Table 9** and shown on **Figure 9**.

The modelling undertaken by Emerge Associates has used a linked 1D-2D approach, based on a digital elevation model (DEM) generated from LiDAR data. This was done to ensure that a thorough understanding of the flow pathways within and through the site has guided the water management approach. As discussed in **Section 3.4.4**, pre-development modelling shows that there are breakout flows at the crossing with Welshpool Road of 1.2 m^3/s in the 100 year ARI event (at BF1), which run along Welshpool Road, and enter back into both Precincts 3A and 3B. These breakout flows are shown in **Figure 7**.

The post-development modelling undertaken of Precinct 3A assumes that the existing scenario where the culvert under Welshpool Road is undersized, and Precinct 3B surrounding Yule Brook has not been developed or filled. It is envisaged that in the short term Precinct 3A would be developed prior to Precinct 3B. It is assumed that a 50m wide flood channel (to be achieved via either fill or flood levees) will be ultimately adopted. Future revisions of surface runoff modelling are expected, and this is further discussed in **Sections 8.1** and **8.3**.

It is also envisaged that in the short term the existing culvert beneath Welshpool Road would not be upgraded, and therefore the breakout flows along Welshpool Road would continue. Should the upstream culvert be upgraded in the future and flows be retained within the Yule Brook corridor, the size of the conveyance swales within Precinct 3A could potentially be reduced.

The FDB sizes calculated within Precinct 3A will not be sensitive to the flood elevations in Yule Brook. This was tested using a 1D modelled approach to a sensitivity analysis and using the TWLs from the three scenarios as steady state tailwater conditions. Note the assumption of steady state tailwater conditions introduces an element of conservatism to the runoff modelling. The results of the sensitivity analysis indicate that Out2 is sufficiently removed both vertically and horizontally from Yule Brook such that the minor changes in tailwater do not impact the water management approach within Precinct 3A.

7.3 Non-structural water quality measures

The structural measures proposed within the site provide both a storage and treatment function to stormwater runoff, as detailed in **Section 7.1**. A number of non-structural measures will also be implemented to help reduce nutrient loads within stormwater runoff.

These measures include:

- Street sweeping on a regular basis.

- Minimising fertiliser use to establish and maintain vegetation within drainage reserves and road verges.
- Drought tolerant turf species that require minimal water and nutrients will be used.
- Education of lot owners regarding fertiliser use and nutrient absorbing vegetation within lots.

The above measures will assist in achieving **Criteria SW10**.

7.4 Stormwater criteria compliance summary

A summary of the proposed stormwater design criteria and how these are addressed is given within **Table 10**.

Table 10 Stormwater management criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Provide conveyance of 100 year ARI flows which currently enter the site from upstream catchments	Upstream flows will be conveyed within roadside swales
SW2	Runoff from lots will be treated at source, within each lot	Appropriate treatment measures will be required on lot
SW3	Detain flows up to the 100 year ARI storm event within the boundary of each lot	LDAs will be required on lot to detain flows up to the 100 year ARI event
SW4	Runoff from road reserves will be treated at source and via extended detention within roadside swales	Side entry pits with traps to remove gross pollutants and sediments will be provided to treat flows prior to entering swales
		Bio-retention functions will be provided at the base of conveyance swales with vegetation provided to uptake nutrients
SW5	Road reserve runoff and conveyance will be via kerbed road pavement, side entry pits and roadside/arterial conveyance swale	Runoff from road reserves will enter conveyance swales via side entry pits
		Roadside conveyance swales will be provided to convey road reserve runoff to downstream FDB and/or discharge locations
		Arterial flows from upstream catchments will be conveyed through the site in roadside conveyance swales
SW6	Minor roads to remain passable in the 10 year ARI storm event	The roadside conveyance swales will be sized to convey the 10 year ARI event runoff from road reserves thus ensuring roads remain passable in the 10 year ARI event
SW7	Detain flows up to the 100 year ARI storm event to maintain pre-development peak flow rates at key discharge locations to the Yule Brook	Roadside conveyance swales will provide in-line detention of flows within Precinct 3B
		Runoff will be detained in a FDB designed to detain the 100 year ARI event with a discharge rate to the Yule Brook (Out 2) to match pre-development peak flow rates

Criteria number	Criteria description	Manner in which compliance will be achieved
SW8	Finished floor levels should have a 300 mm clearance from the 100 year ARI water level within conveyance swales and the flood detention structure	Finished floor levels will have a minimum clearance of 300 mm from the 100 year ARI top water level within swales and the FDB with fill used where necessary
SW9	Apply appropriate non-structural measures to reduce pollutant loads	Street sweeping on a regular basis
		Minimise fertiliser use to establish and maintain vegetation within drainage reserves and road verges
		Use drought tolerant turf species that require minimal water and nutrients
		Education of lot owners regarding fertiliser use and nutrient absorbing vegetation species within lots
SW10	Perth Transit Authority land will detain flows up to the 100 year ARI storm event to meet pre-development peak flow rates.	Indicative detention volumes have been provided in this LWMS which indicates the approximate land area that will need to be set aside to achieve pre-development peak flow rates from the PTA land to Yule Brook

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008c).

While strategies have been provided within this LWMS that address planning for water management within the site, future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification include:

- Modelling of local road drainage network
- Stormwater storage within lots
- FDB and conveyance swale configurations
- Imported fill specifications and requirements
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Nutrients and management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program
- Status of groundwater abstraction license.

These are further detailed in the following sections. As stated above, ongoing monitoring of groundwater will be detailed in the UWMP, however in this LWMS is outlined broadly in **Section 9**.

8.1 Modelling of local road drainage network

It is expected that the surface runoff modelling will be revised in the future, once the approach to stormwater management within the PTA land is known, and once the water management approach in Precinct 3B has been further developed.

Verification of proposed subdivision drainage designs within MKSEA Precinct 3A will be undertaken by modelling the catchments serviced by the drainage network. Such modelling will allow verification that the development undertaken within the MKSEA Precinct 3A is consistent with this LWMS. The design of the drainage system to date has been undertaken at an appropriate level for the SP and runoff-routing computer modelling of the stormwater drainage system will be reviewed once detailed drainage design has commenced for the area. It is anticipated that this will occur during the subdivision design process and detailed within the future UWMPs.

The exception to the requirement to revise the surface runoff modelling is if the catchment details and basin designs are consistent with the assumptions made in this LWMS. If this were the case it would be acceptable to provide design calculations for the drainage network and retention/detention areas to demonstrate compliance with the LWMS.

8.2 Stormwater storage and infiltration within lot

The MKSEA Precinct 3A stormwater management strategy assumes that all lots will detain runoff from the 100 year ARI event to allow pre-development flow rates leaving the site to be maintained (as discussed in **Section 7.1.1.2**). It is the lot owner's responsibility to ensure that the appropriate storage is provided within lot, consistent with the details provided in **Section 7.2.1**.

Lot designs, including stormwater drainage, are to be approved by local government at building approval stage prior to construction, and therefore will not be available for inclusion in the UWMP. Further, it is not known what size lots will be, nor the uses or development format of the lots. The UWMP will however investigate potential WSUD measures that may be possible once lot configurations and treatment requirement are known. The UWMP should clearly identify the roles and responsibilities for implementing lot-scale storage and treatment structures.

As discussed in **Section 6.1.1**, subsoil drainage may be provided beneath lot detention areas to ensure they dry out and to ensure that localised groundwater mounding does not occur. Subsoil drains will need to discharge into the roadside swale system with inverts at or above the swale invert. The inclusion of subsoil drains beneath lot detention areas will need to be considered as part of detailed design at UWMP stage.

The UWMP will also need to demonstrate that provision has been made for each lot to connect to the drainage network and that these connections comply with the allowable outflow from each lot (provided in **Section 33** of this LWMS). This provides some measure of control that the developer can implement to ensure that pre-development peak flow rates from each lot are not exceeded. It is acknowledged that some form of planning control may be required to ensure that the required lot storage is provided. The manner in which this will occur will be summarised in the future UWMP.

8.3 FDB and conveyance swale configurations

While the MKSEA Precinct 3A drainage catchments have been defined based on the earthworks model presented in **Appendix G**, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design. The exact location and shape of the FDBs and the conveyance swales will still need to be specified and presented within the future UWMPs. The nominal locations and configurations of these will be revised in consideration of land use requirements and to comply with CoG design standards as necessary. It will be acceptable for these to be revised and combined as necessary to meet the volumetric requirements specified by the Water Corporation and presented in this LWMS.

In order to review the final development drainage configurations, the hydrological model that has been developed to support this LWMS may need to be refined in light of stakeholder feedback or to accommodate other design considerations, such as land use. It is expected that the civil drainage designs will be progressed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. The ultimate aim of revising the hydrological model will be to confirm that the post-development runoff volumes are able to meet the performance criteria proposed in **Section 4** of this LWMS.

8.4 Imported fill specifications

As discussed previously the use of clean fill may be required to ensure the FDBs remain as dry basins and the sufficient clearance from the 100 year ARI flood levels and MGL is maintained. Soils beneath bio-retention areas would ideally have a high PRI to ensure at-source nutrient retention leading to the protection of the underlying aquifer. The in situ soils can potentially provide the necessary treatment should the PRI be sufficient.

8.5 Implementation of water conservation strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation strategies will be incorporated into the design and the ongoing maintenance of all landscaped areas. Landscape design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMPs produced for the development. The manner in which the proponent intends to promote water conservation measures discussed in this LWMS to future lot owners will also be discussed within the future UWMP.

8.6 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007).

Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the drainage reserves. It is expected that the future UWMPs will provide a schedule of management and maintenance actions including timing and responsible parties.

8.7 Nutrients, management and maintenance requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within roadside conveyance swales and the FDBs will require ongoing maintenance. Ongoing management and irrigation of road verges will be the responsibility of the lot owner. Drainage reserves will be irrigated by groundwater under the proponents groundwater licence (discussed in **Section 8.10**) and maintained by the proponent until such time as the assets are handed over to the local government.

The design of conveyance swales will be developed to minimise the potential for nutrients to be mobilised quickly from site. This could be done by ensuring that the core of swales is vegetated with reeds and rushes and not with fertilised turf. Any formal garden beds within either swales or FDBs will be located away from areas more likely to be seasonally inundated.

Ongoing nutrient inputs will need to be carefully managed to avoid mobilisation to downstream environments. This will include the use of low phosphorous and/or slow release fertlisers.

The treatment for and design of swales in private lots will be different from those in the public realm, as those in road reserves will need to meet CoG design standards, while those in private lots will also need to consider the need to coordinate with the ultimate land use (e.g. for lots immediately adjacent to the future railway line).

It is expected that the future UWMPs will set out the design (e.g. landscape surface treatments) maintenance actions (e.g. nutrient application), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Alternatively, these actions could be specified within a dedicated Swale Management Plan, whichever is most appropriate. Given that approval from the local government and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.8 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed either in the future UWMPs or a separate Construction Management Plan (CMP).

8.9 Monitoring and evaluation program

It will be necessary to confirm that the management measures that are implemented are able to fulfil their intended management purpose, and are in a satisfactory condition at a point of management hand-over to the local government. A post-development monitoring program will be developed to provide this confirmation, and it will include details of objectives of monitoring, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations.

These monitoring programs are discussed in **Section 9** of this LWMS and will be further detailed at the UWMP stage.

8.10 Groundwater license status

A transfer of the existing groundwater licence associated with Lot 501 (as discussed in **Section 5.1.2**) is being investigated by the proponent. It is expected that future UWMPs will demonstrate that adequate allocation of water has been obtained to irrigate drainage reserves and road verges within Precinct 3A, or that an appropriate contingency plan has been established in the event that a reduced water allocation is obtained. No ongoing irrigation of drainage reserves will be required by local government. The ongoing irrigation of road verges will be the responsibility of the adjacent lot owner.

9 Monitoring and Maintenance

9.1 Management and maintenance

It is proposed that the overall condition of the development will be monitored on a bi-annual basis. This monitoring will be implemented after the completion of the civil and landscaping works and will continue for a period of two years.

A visual assessment will be undertaken to monitor the overall condition of the development, with the aim to ascertain that the maintenance activities are achieving the overall management objectives for the development. The parameters that will be monitored include:

- Nutrients and water quality
- Gross pollutants
- Terrestrial weeds
- Irrigation
- Vegetation density
- Paths, walkways and other infrastructure.

The management and maintenance objectives will be detailed within future UWMPs along with details of the corresponding monitoring program.

9.2 Water quality monitoring

9.2.1 Pre-development monitoring

In addition to the groundwater and surface water monitoring data presented in the DWMS, additional groundwater and surface water monitoring is currently being undertaken by Emerge Associates as detailed in **Section 3**. Groundwater and surface water data will be presented in subsequent UWMPs and used to inform detailed design.

9.2.2 Post-development monitoring

Post-development monitoring will be carried out to ensure that the proposed storage and treatment measures, detailed in **Section 7**, are working efficiently. An upstream-downstream comparison for both surface water and groundwater across the site is proposed to confirm that the water treatment infrastructure is performing as intended.

9.2.3 Recommended program for UWMP

The proposed locations for surface water and groundwater monitoring will be selected to provide an indication of the effects of the development on water quality leaving the site.

Water quality monitoring will be conducted on a quarterly basis. A summary of the post-development monitoring program is shown in **Table 11**. The post-development monitoring will be conducted for two years post construction of the development.

Table 11 Monitoring program summary

Monitoring Type	Locations	Frequency	Parameters
Groundwater	Bores upstream and downstream of a key drainage reserve	Quarterly (typically Jan, April, July, Oct)	*In situ* pH, EC, temperature. Sample TSS, TN, TKN, NH_4, NO_X, TP, FRP.
Surface Water	Discharge locations to Yule Brook	Quarterly (typically Jan, April, July, Oct) when water is present to do so	*In situ* pH, EC, temperature. Sample TSS, TN, TKN, NH_4, NO_X, TP, FRP.

9.2.4 Post-development trigger values

Groundwater water quality targets have been derived from background levels measured during monitoring prior to development, provided in **Table 5**. Surface water quality targets have been identified in consideration of the water quality monitoring carried out within Yule Brook, provided in **Table 3**. Trigger values have also been established in consideration of the NWQMS (ANZECC 2000) and the SCWQIP (SRT 2009) guideline trigger values. The trigger criteria proposed are shown in **Table 12**.

Table 12 Water quality trigger values

Analyte	pH	EC (mS/cm)	TN (µg/L)	TP (µg/L)	FRP (µg/L)	NOx (mg/L)	TKN (µg/l)
Groundwater	6.5 - 8.0	4.5	2.1	0.4	0.04	0.15	3.10
Surface water	6.5 - 8.0	0.8	1.2	0.1	0.04	0.34	0.46

The change of landuse from small scale agriculture to freight and logistics, and implementation of the proposed water management strategies (detailed in **Sections 6** and **7**) are expected to result in a reduction in groundwater nutrient concentrations across the site. It is therefore proposed that the post-development trigger values provided in **Table 12** are dynamic values, and should be assessed in the context of additional data gained from any continued monitoring. The trigger values proposed recognise the existing site conditions and change in landuse, and work toward achieving the target concentrations for the receiving Swan Canning river systems (SRT 2009) over time.

9.3 Contingency action plan

A Contingency Action Plan (CAP) will be detailed and implemented as a part of each UWMP. The CAP is effectively a plan of steps that will be undertaken should certain water quality criteria be reached.

9.3.1 Trigger criteria

As indicated, the trigger values proposed in **Section 9.2.4** have been derived from water quality levels measured during pre-development monitoring. These values should be reviewed for each UWMP to include additional data gained from any continued monitoring.

9.3.2 Contingency actions

If the results from the initial monitoring occasion indicate that nutrient concentrations exceed the nominated trigger values, a number of contingency measures may be employed.

The first action that should be undertaken if trigger criteria are exceeded is to repeat the monitoring to remove the potential for sampling error. If the repeat monitoring still shows results which breach the trigger value, the next action will be to compare groundwater monitoring results for the upstream (incoming) nutrient concentrations with the downstream (outgoing) nutrient concentrations.

If the downstream nutrient concentrations are >20% higher than the upstream nutrient concentrations, the following actions should be undertaken:

1. Review nutrient application practices to identify source if possible.
2. Conduct surveillance of subdivision area to determine any other potential and obvious nutrient inputs, including within lot treatment structures.
3. Remove source if possible (e.g. fertiliser input, etc.).

If the downstream nutrient concentrations are found to be generally consistent with the upstream concentrations the next action will be to conduct a site-specific comparison of background data collected within the site prior to development. There is some amount of variability (both spatially and temporally) in nutrient concentrations experienced across the site and the trigger values may need to be modified following additional monitoring. This information should then be used as a management tool in consultation with local government to determine if the trigger values should be revised.

Following the implementation of the above contingency measures the water quality will be re-sampled. If the results of the analysis still show water quality characteristics which breach the trigger values an additional set of upstream/downstream monitoring bores should be installed at another key representative area, or samples taken from another surface water location. The additional bores/locations will be sampled as per the ongoing sampling regime already being undertaken. If the results from the second area demonstrate results consistent with the first area, DoW and local government will be informed of the results, and the proponent will work with DoW and local government to determine if the results are representative of a broader catchment management issue, and whether any additional contingency actions need to be implemented onsite.

9.4 Reporting

A post-development monitoring report will be prepared on conclusion of the two year monitoring period, and will be provided to the local government and the DoW. Interim results (spreadsheet) can be provided to either local government or DoW on request during the monitoring program.

10 Implementation

The LWMS is a key supportive document for the SP for all of Precinct 3A in both CoG and SoK. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with an integrated water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMPs.

10.1 Roles and responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the CoG and SoK. The responsibility for working within the framework established within the LWMS rests with the developer of the land/land holders. It is anticipated that future UWMPs will be developed in consultation with the CoG/SoK and DoW and in consideration of other relevant policies and documents.

The responsibility to implement and maintain within lot water quality treatment measures that are appropriate to the land use will be with the lot owner/lot developer. The sizing and design of LDAs for detention of major event runoff within lot will be the responsibility of the lot owner/lot developer.

Provision of lot drainage connection points, maintenance of swales and provision and maintenance of the FDBs are the responsibility of the proponent.

10.2 Funding

Local drainage infrastructure will be funded locally within the SP area. Funding for within-lot drainage infrastructure will be the responsibility of the lot owner. Estate scale drainage infrastructure will be funded by the proponent.

10.3 Review

It is not anticipated that this LWMS will be reviewed, unless additional land parcels/lots are added to the SP area prior to subdivision, or the SP undergoes significant change post-lodgement of the LWMS. If additional areas are required to be covered by the LWMS it is most likely that an addendum to cover these areas could be prepared. If the SP is substantially modified surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

It is possible that the conveyance requirements for the swales will be reduced when the culvert beneath Welshpool Road is updated to eliminate breakout flows. At this time it would be appropriate to revise the modelling and to update the swale designs, so that the infrastructure is not sized to be greater than is required, and so that this land could be developed for industrial uses, consistent with the remainder of Precinct 3A.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals will be supported by a UWMP.

10.4 Conclusions and recommendations

The recommended approach to water management for MKSEA Precinct 3A includes:

- Retain the existing flow regime to key wetlands adjacent to Yule Brook.
- Lots detain runoff from up to the 100 year ARI and provide treatment specific to land use.
- Conveyance of road reserve runoff by surface flow in open swales.
- Treatment of road reserve runoff via extended detention in conveyance swales.
- Peak flow rates to Yule Brook managed by catchment routing and flood detention up to the 100 year ARI event. This occurs within all land within Precinct 3A, including the PTA land.
- Groundwater controlled to existing MGL/underlying clay layer/existing groundwater controls via network of open swales.

This LWMS demonstrates that, by following the recommendations detailed above, the site is capable of being developed for the intended industrial use.

11 References

11.1 General references

Australian Cultural Heritage Management (ACHM) 2009, Preliminary Investigation of Aboriginal Heritage - City of Gosnells Maddington Kenwick Strategic Employment Area (MKSEA), Report prepared for the City of Gosnells.

Australian and New Zealand Environment and Conservation Council (ANZECC) 2000, Australia and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy Australian and New Zealand Environment and Conservation Council.

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FIGURES

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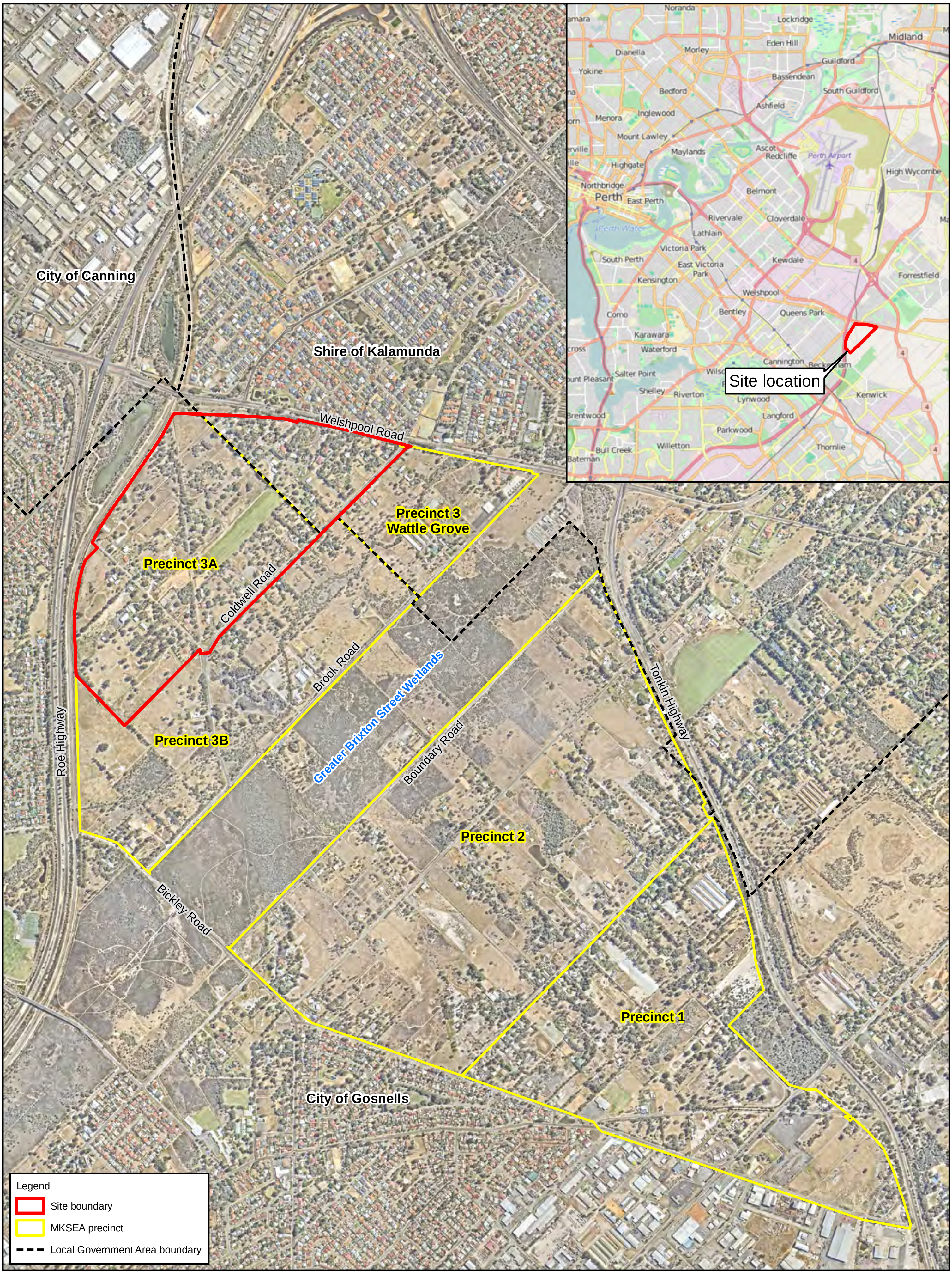

Figure 1:	Location Plan
Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(09)--F27a

Drawn:	KNM	Date:	11/08/2016
Approved:	DPC	Date:	30/08/2016
Checked:	RLE	Scale:	1:20,000@A4

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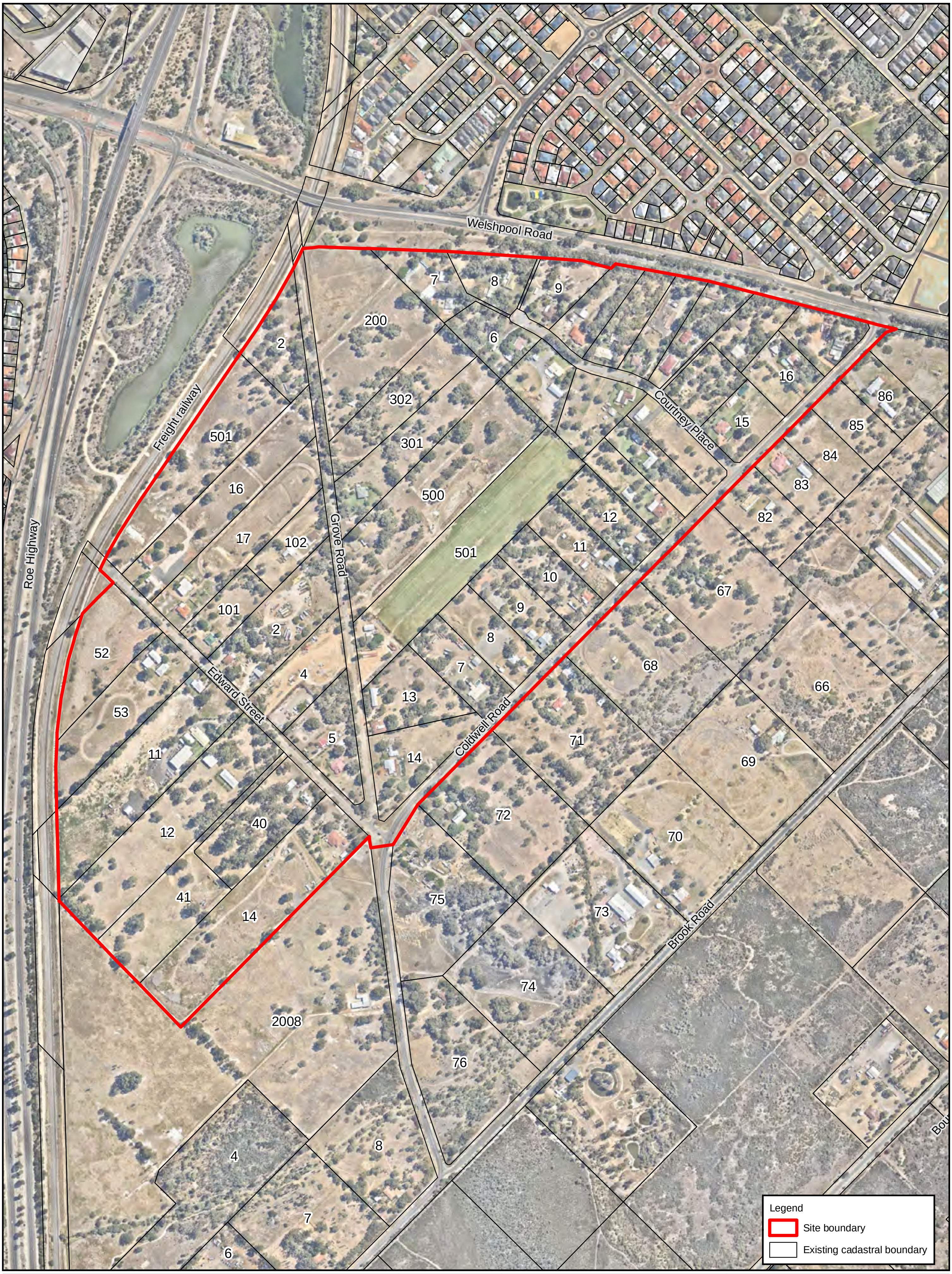

Figure 2:	**Site Plan**	**Plan Number: EP14-056(09)--F28a**	
Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan	Drawn: KNM	Date: 11/08/2016
		Approved: DPC	Date: 30/08/2016
Client:	Linc Property Pty Ltd	Checked: SMF	Scale: 1:8,000@A4

0 100 200 300 Metres

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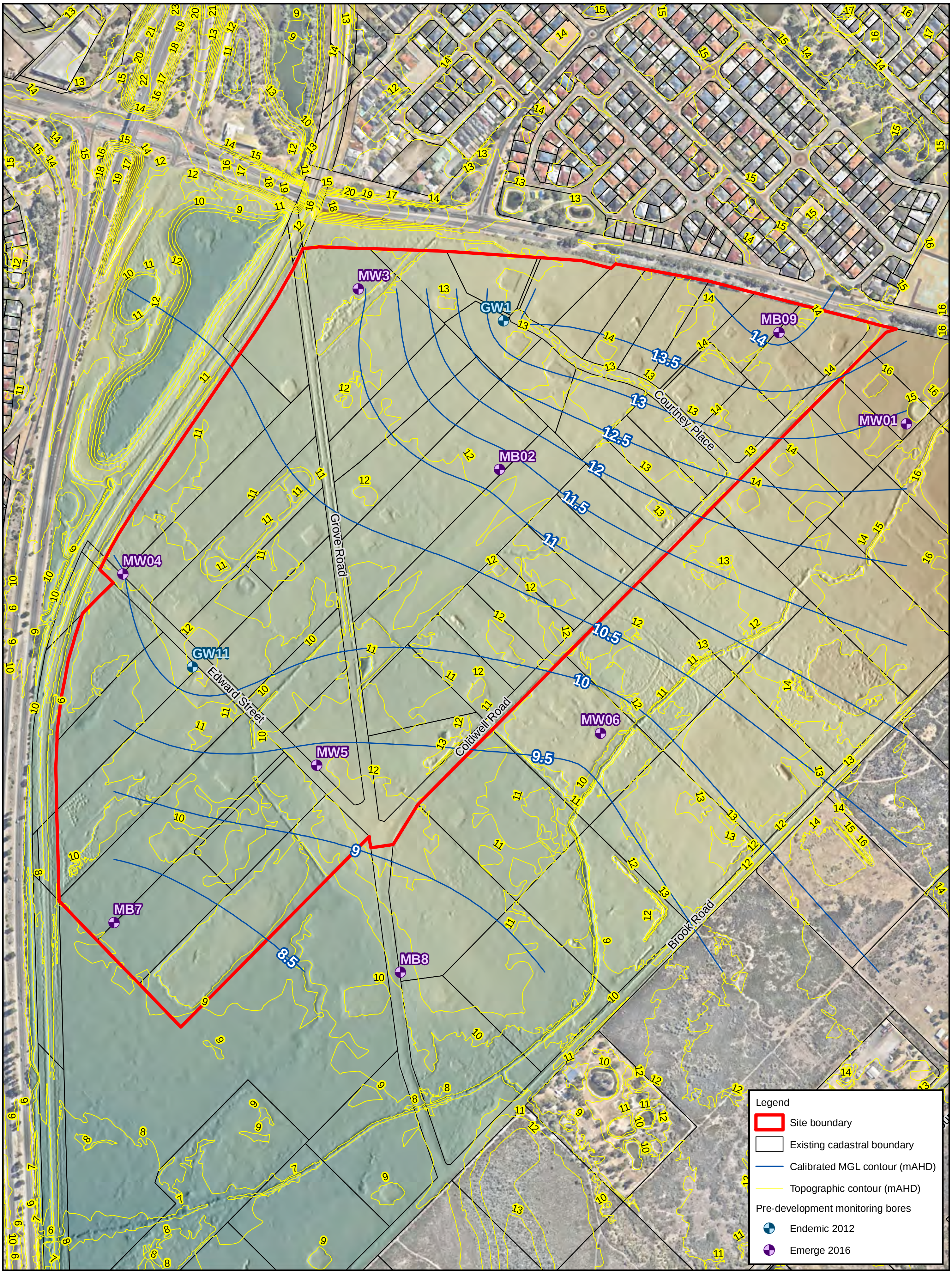

Figure 3:	**Site Topography and Groundwater Contours**
Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(09)--F29a

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Approved:	DPC	Date:	30/08/2016
Checked:	SMF	Scale:	1:8,000@A4

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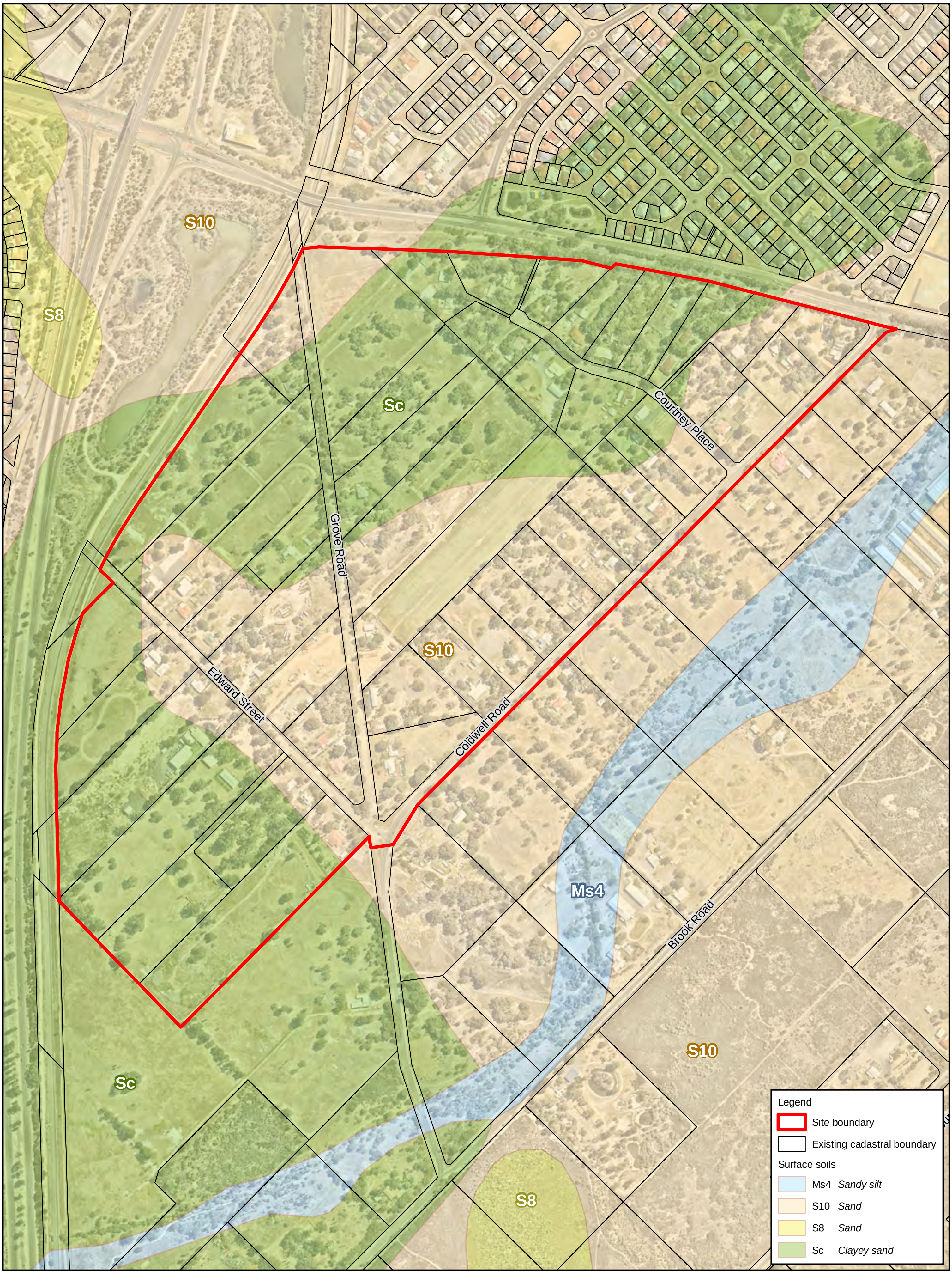

Figure 4:	**Environmental Geology**	**Plan Number: EP14-056(09)--F30a**			
Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan	Drawn: KNM	Date: 22/12/2015		
		Approved: DPC	Date: 30/08/2016		
		Checked: RLE	Scale: 1:8,000@A4		
Client:	Linc Property Pty Ltd	0 100 200 300 Metres			

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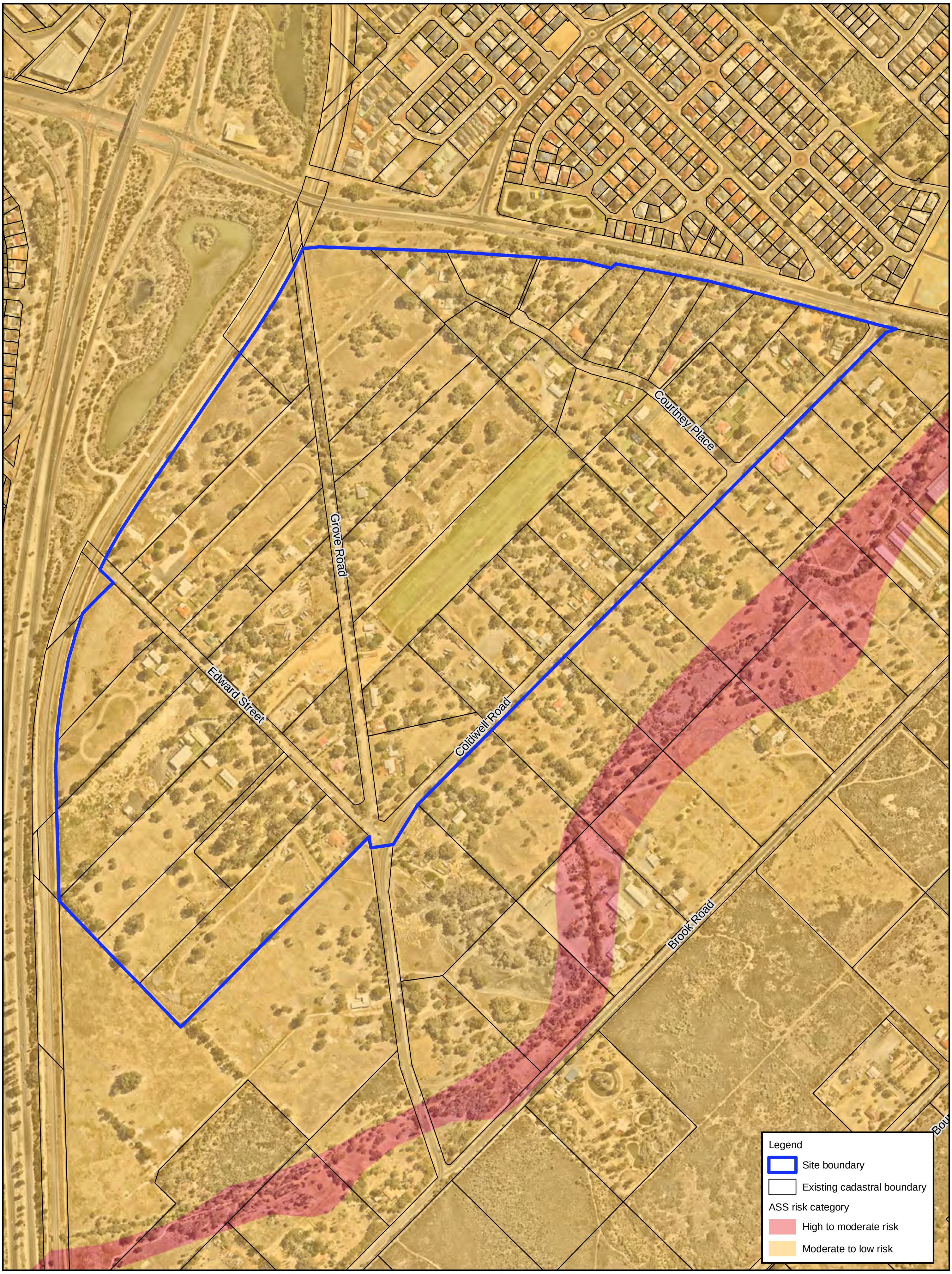

Figure 5: **Acid Sulfate Soils Risk**

Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(09)--F31a

Drawn:	KNM	Date:	11/08/2016
Approved:	DPC	Date:	30/08/2016
Checked:	SMF	Scale:	1:8,000@A4

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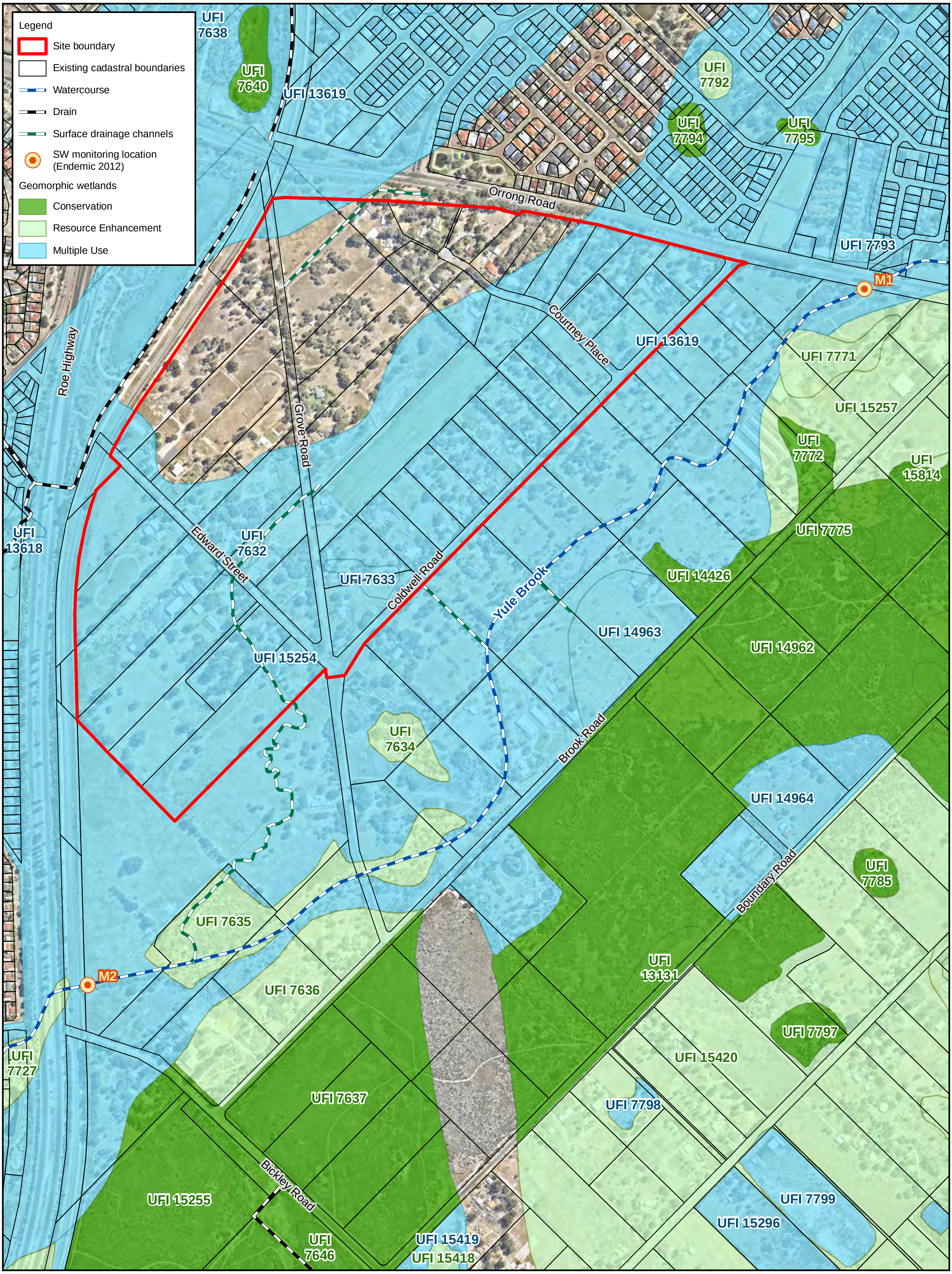

Figure 6:	Surface Water Features and Wetlands
Project:	Local Water Management Strategy MKSEA Precinct 3A Outline Development Plan
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(09)--F33a	
Drawn: KNM	Date: 06/09/2016
Approved: DPC	Date: 06/09/2016
Checked: RLE	Scale: 1:10,000@A4

0 100 200 300 Metres

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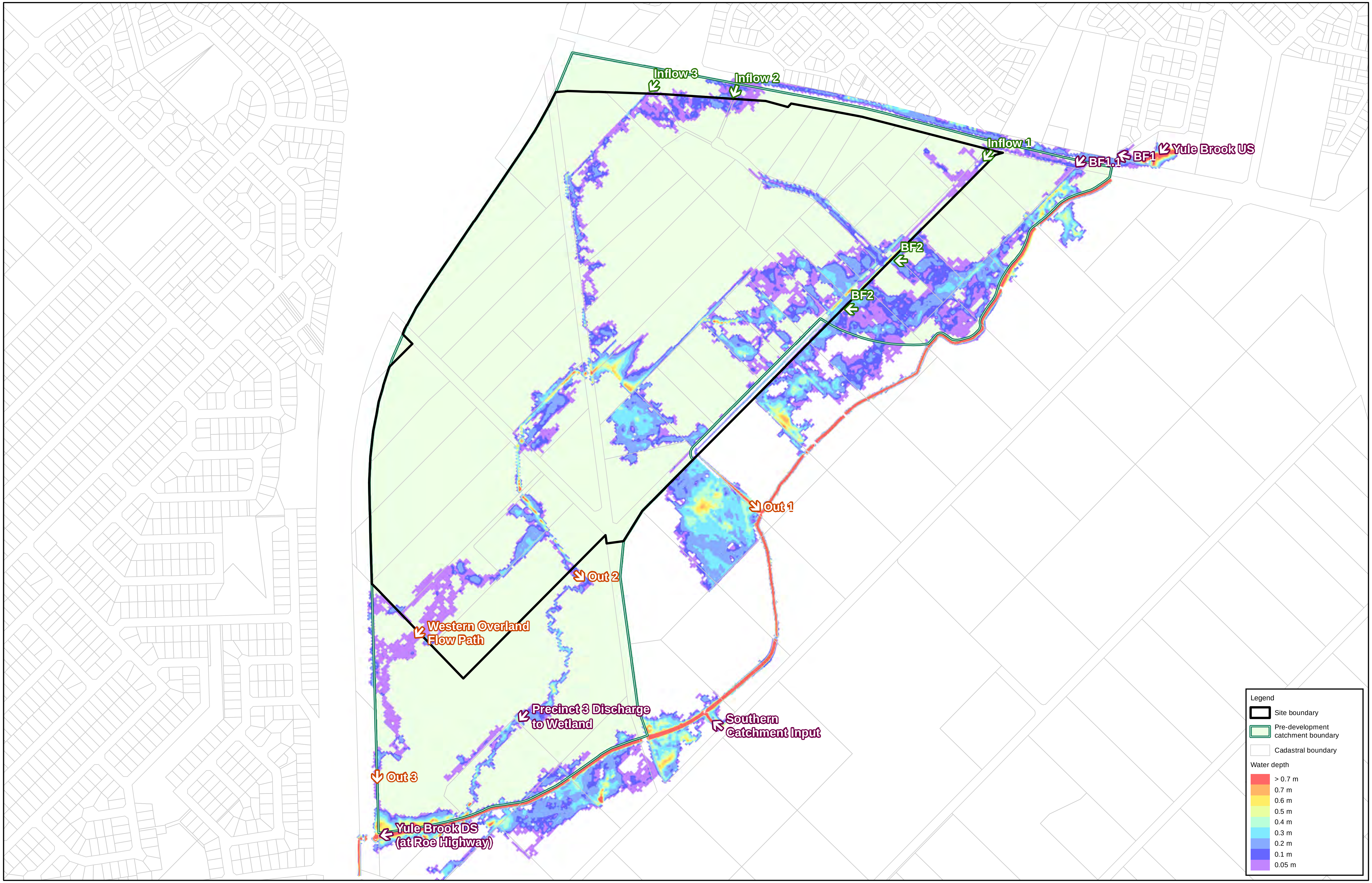

Figure 7:	**Pre-development 100 Year ARI Arterial Flow (Excluding Rainfall on Grid)**
Project:	MKSEA Local Water Management Strategy
Client:	Linc Property Pty Ltd

Plan Number: EP14-056(09)--F64a

Drawn:	KNM	Date:	18/01/2017
Approved:	DPC	Date:	18/01/2017
Checked:	AP	Scale:	1:7,500@A3

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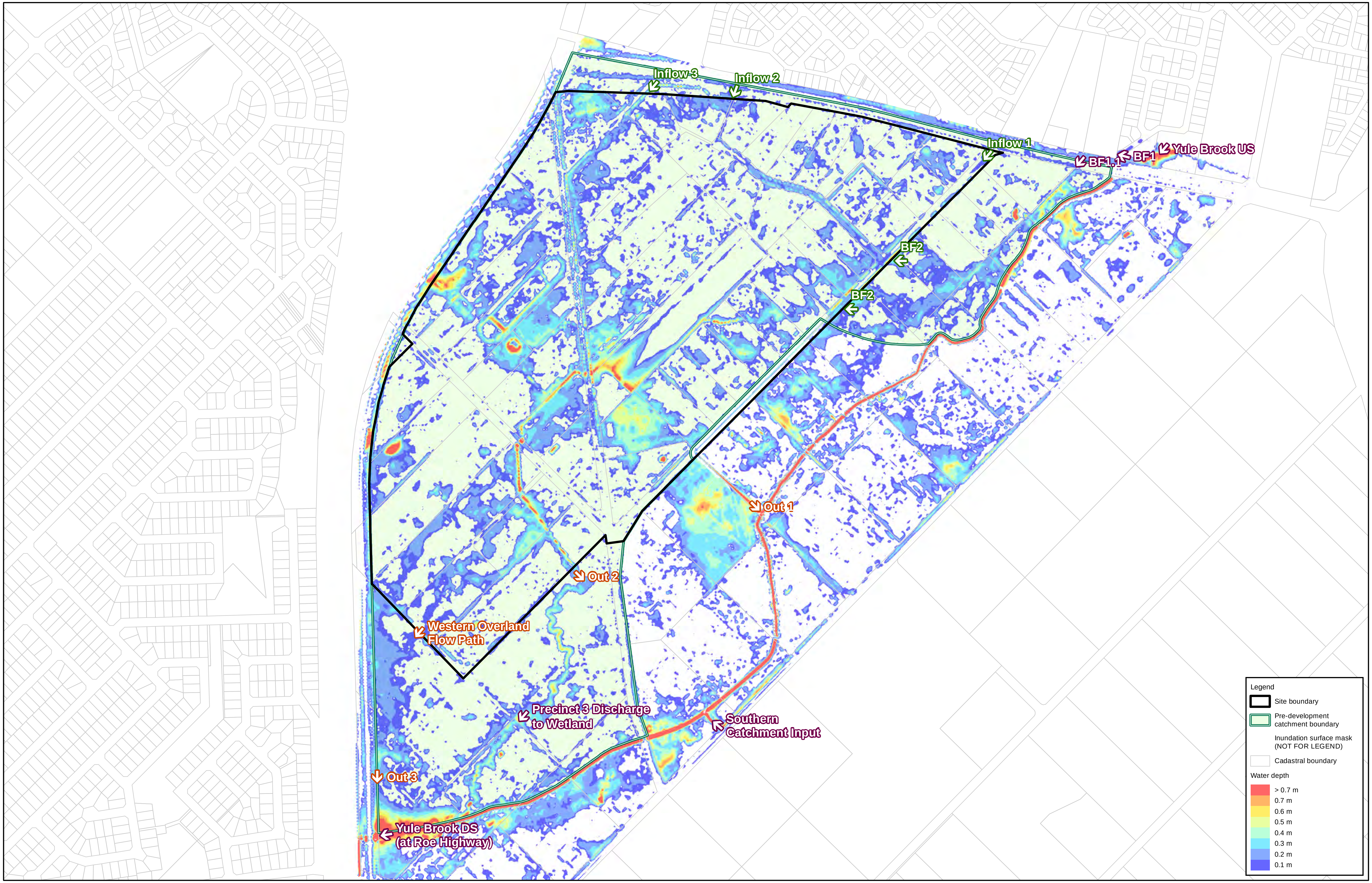

Figure 8:	Pre-development 100 year ARI inundation (Including Rainfall on Grid)
Project:	MKSEA Local Water Management Strategy
Client:	Linc Property Pty Ltd

N

Plan Number: EP14-056(09)--F65a

Drawn:	KNM	Date:	02/09/2016
Approved:	DPC	Date:	18/01/2017
Checked:	AP	Scale:	1:7,500@A3

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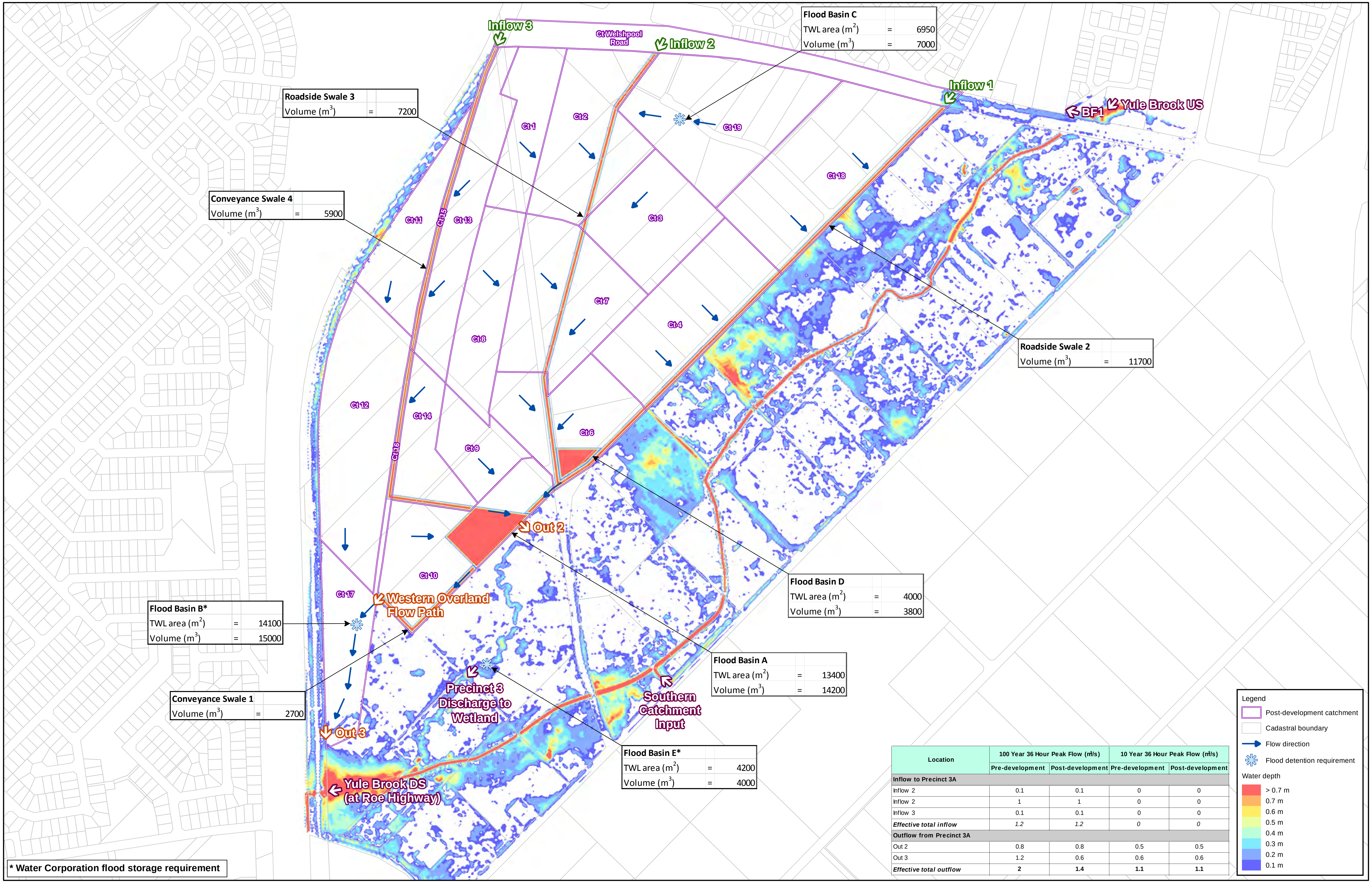

Location	100 Year 36 Hour Peak Flow (m^3/s)		10 Year 36 Hour Peak Flow (m^3/s)	
	Pre-development	Post-development	Pre-development	Post-development
Inflow to Precinct 3A				
Inflow 2	0.1	0.1	0	0
Inflow 2	1	1	0	0
Inflow 3	0.1	0.1	0	0
Effective total inflow	*1.2*	*1.2*	*0*	*0*
Outflow from Precinct 3A				
Out 2	0.8	0.8	0.5	0.5
Out 3	1.2	0.6	0.6	0.6
Effective total outflow	**2**	**1.4**	**1.1**	**1.1**

Figure 9:	**Post-development 100 Year ARI Inundation (Including Rainfall on Grid)**
Project:	MKSEA Local Water Management Strategy
Client:	Linc Property Pty Ltd

N

Plan Number: EP14-056(09)--F66a

Drawn:	KNM	Date:	18/01/2017
Approved:	DPC	Date:	18/01/2017
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APPENDIX A

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MKSEA PRECINCT 3A STRUCTURE PLAN

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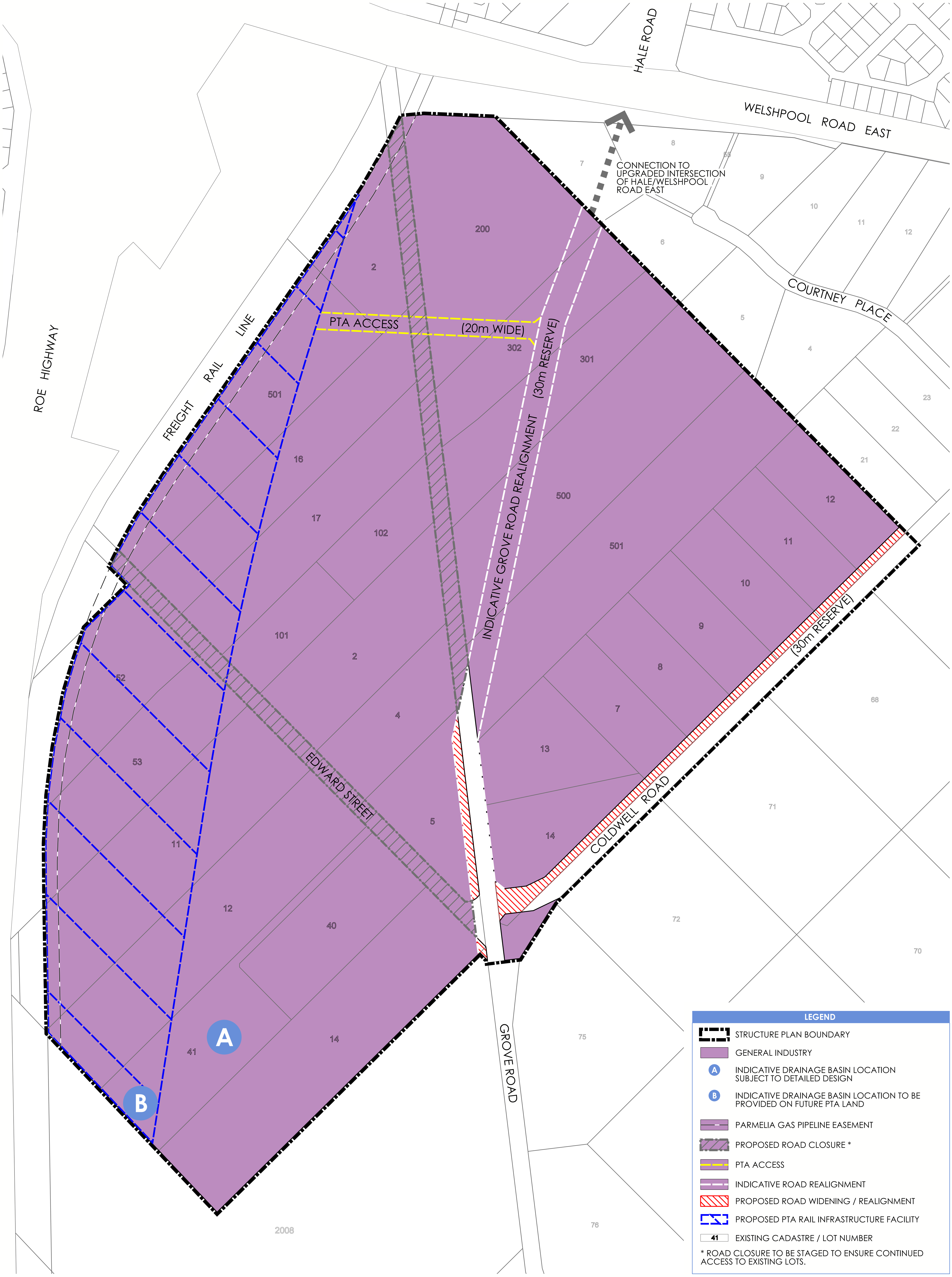

PLAN 1 | STRUCTURE PLAN

Maddington - Kenwick Strategic Employment Area - Precinct 3A

A LINC PROPERTY PROJECT

0m 25 50 75m

s: 1:2,000@A1
d: 3 May 2016
p: 15/073/024K

Taylor Burrell Barnett Town Planning and Design
187 Roberts Road Subiaco Western Australia 6008
p: (08) 9382 2911 f: (08) 9382 4586
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APPENDIX B

LANDSCAPE CONCEPTS

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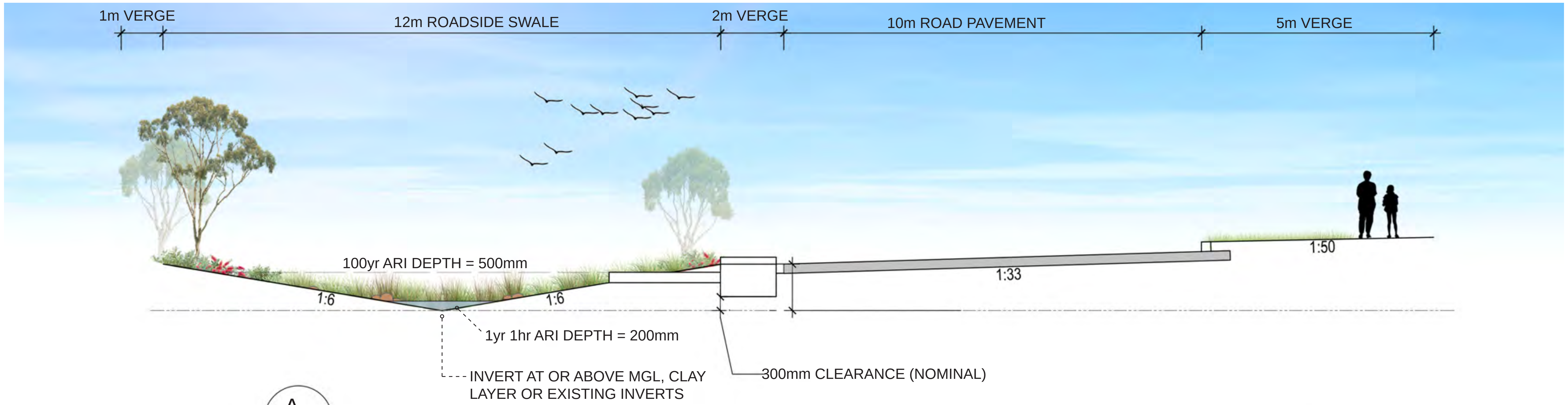
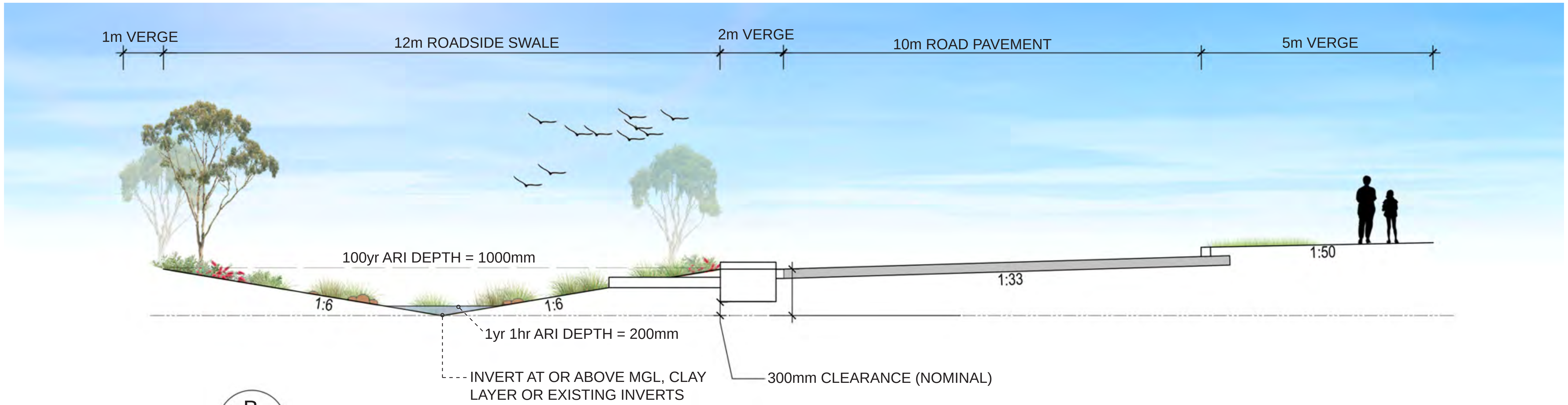


A

TYPICAL 1:350 TREATMENT SECTION

SCALE 1:100



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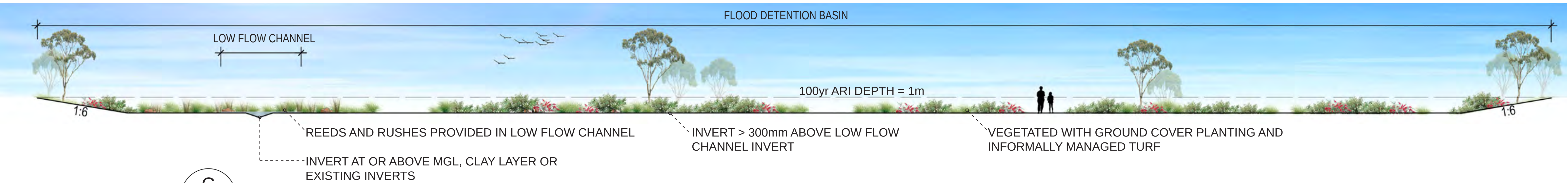
SCALE 1:100



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DETENTION BASIN CONCEPT SECTION

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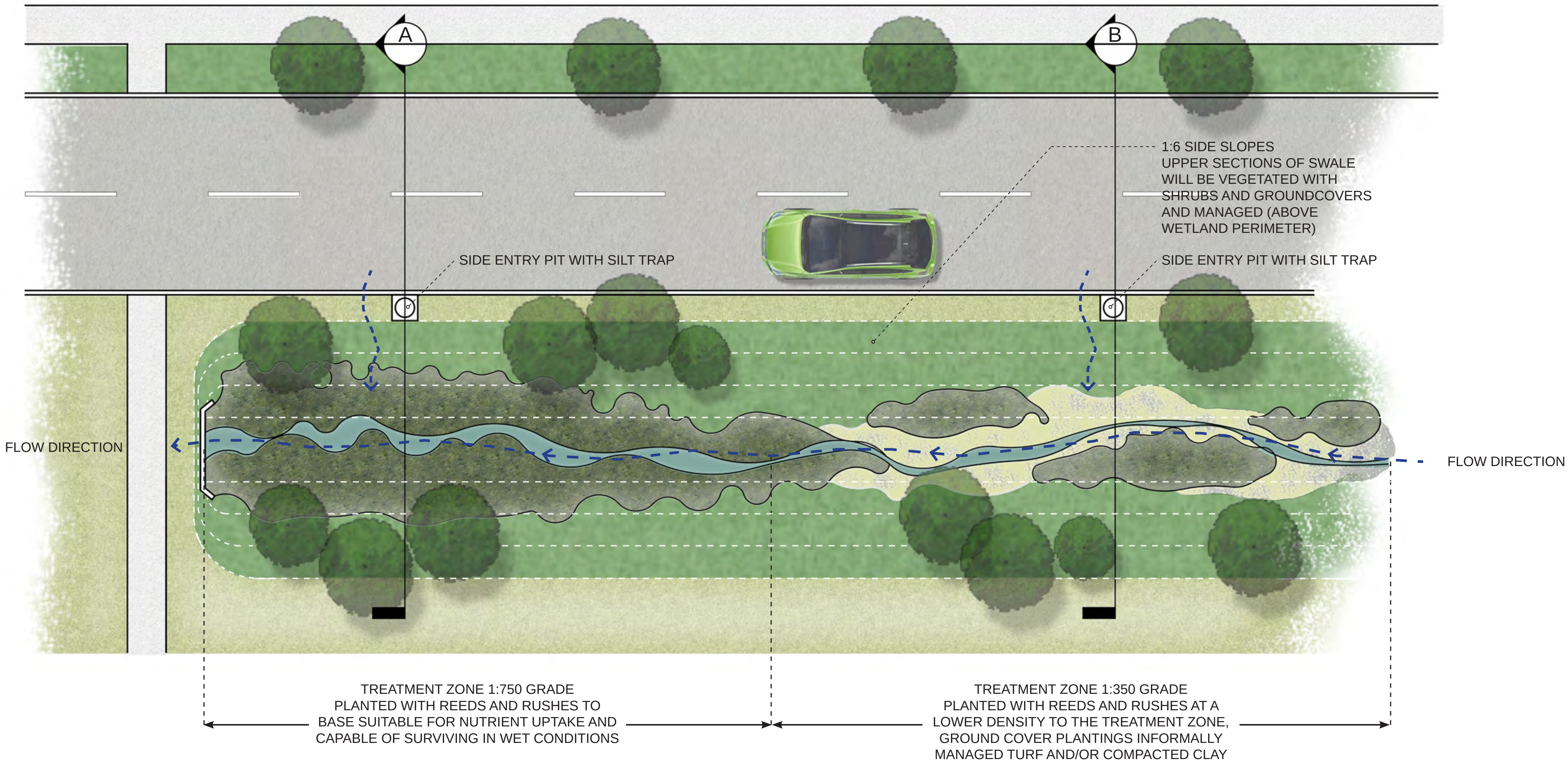
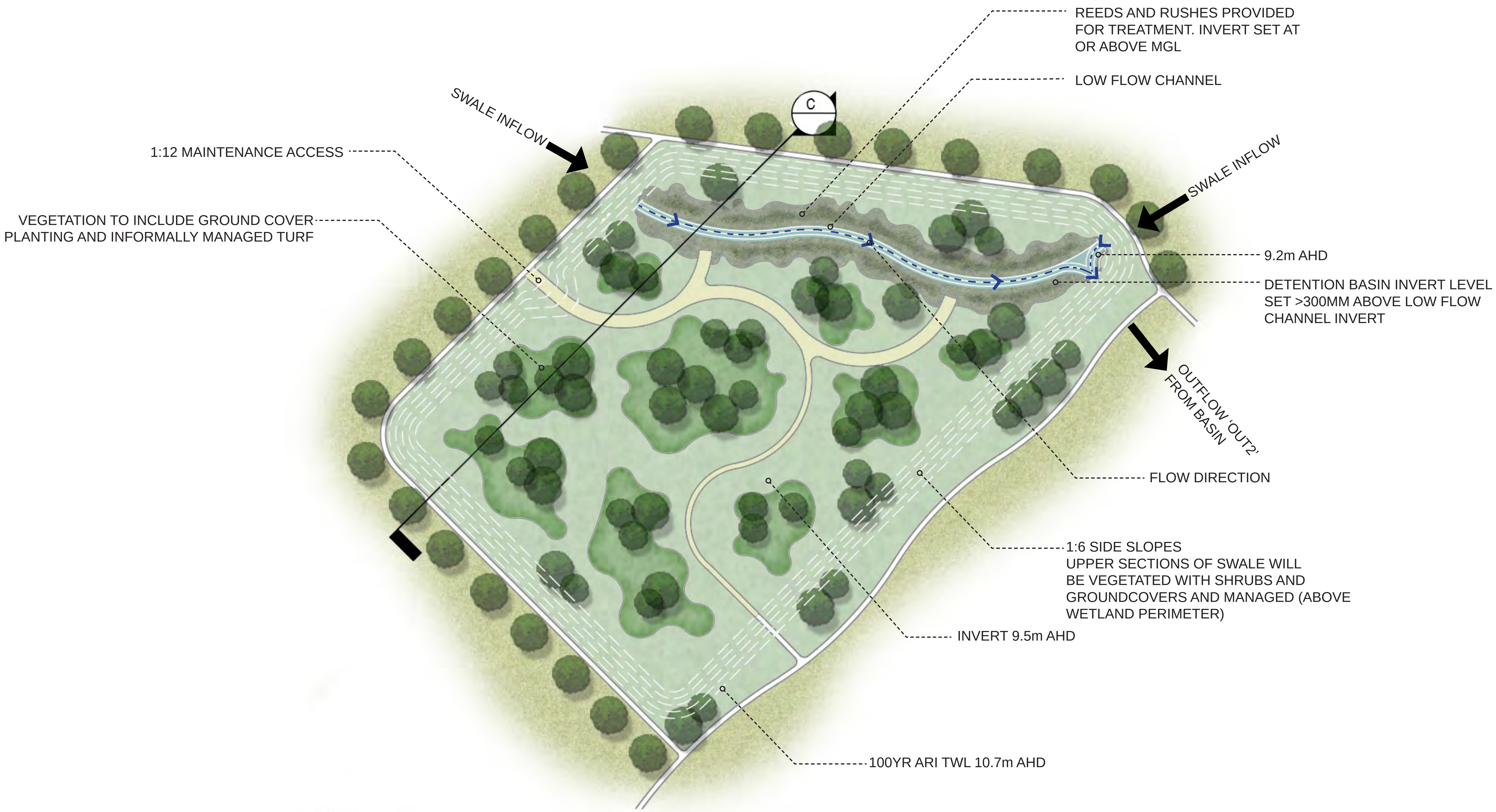


01 ROAD SIDE SWALE

TYPICAL

SCALE 1:200



02
-
DETENTION BASIN CONCEPT

SCALE 1:1000

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APPENDIX C

GEOTECHNICAL REPORT

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Factual Report on Geotechnical Investigations

Proposed Industrial Subdivision
Coldwell Road, Kenwick

Prepared for
Linc Property Pty Ltd

Project 88698.07
August 2016

Douglas Partners
Geotechnics | Environment | Groundwater

Document History

Document details

Project No.	88698.07	Document No.	R.001.Rev1
Document title	Factual Report on Geotechnical Investigations Proposed Industrial Subdivision		
Site address	Coldwell Road, Kenwick		
Report prepared for	Linc Property Pty Ltd		
File name	88698.07.R.001.Rev1		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Revision 0	Sergio Neves	Dan Reaveley	28 July 2016
Revision 0	Sergio Neves	Dan Reaveley	9 August 2016

Distribution of copies

Status	Electronic	Paper	Issued to
Revision 0	1	1	Linc Property Pty Ltd (Steve Robertson)
Revision 1	1		Linc Property Pty Ltd (Steve Robertson)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		9/8/2016
Reviewer		9/8/2016

bsi. ISO 9001 Quality Management

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Page

Factual Report on Geotechnical Investigations
Proposed Industrial Subdivision
Coldwell Road, Kenwick

1. Introduction

This factual report presents the results of geotechnical investigations undertaken by Douglas Partners Pty Ltd for a proposed industrial subdivision within the proposed Maddington Kenwick Strategic Employment Area (MKSEA) in Kenwick, WA. The investigations were commissioned in several emails dated 5 January, 20 April and 5 July 2016 by Mr Ben Lisle and Mr Brett Chivers of Linc Property Pty Ltd, and was undertaken in accordance with Douglas Partners' proposals PER150614(Rev1) dated 18 December 2015 and PER160163 (Rev1) dated 20 April 2016.

The purpose of the investigations was to assess the subsurface conditions beneath the proposed development areas as described in Section 2, and thus provide factual information to Linc Property Pty Ltd in order to assist in the planning and the civil design of the proposed development.

The geotechnical investigations included the excavation of 127 test pits, seven in-situ permeability test and laboratory testing of selected samples.

2. Site Description

The proposed development area comprises 27 individual allotments with a combined area of approximately 50 ha (Refer to Drawing 1, Appendix B). It is bounded by Coldwell Road and Yule Brook to the southeast, Edward Street, rural properties and a proposed PTA Rail Infrastructure Facility area to the southwest and northwest, and rural properties and Welshpool Road East to the north and northwest.

At the time of the geotechnical investigations, the proposed development area comprised farmland and associated farm buildings, with Lot 501 (No.92) Grove Road being used as a turf farm. Grove Road crossed the site at its centre in a northwest-southeast direction. Vegetation generally consisted of short pasture grass, tall grass and reeds and lawn areas, with some bushes and trees up to approximately 15 m in height.

The ground surface level falls to approximately RL 10 m at the south western corner of the site, from a high point of approximately RL 15.0 m at the north eastern corner of the site.

The Armadale 1:50,000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site are likely to comprise the following units:

- A thin layer of Bassendean sand overlying clayey materials of the Guildford Formation, possibly at shallow depth;
- Clayey sand materials of the Guildford Formation; and

- Sandy silt alluvium associated with Yule Brook, which occurs on the eastern boundary of the site.

The Perth Groundwater Atlas (2004) indicates that in May 2003, the groundwater level was between RL 6 m along the south western site boundary and RL 9 m at the eastern corner of the site (i.e. between 3 m to 4 m below existing surface level). It is noted that given the likely presence of shallow clay and based upon our experience in the area, a perched groundwater table is possible at shallow depths.

Published acid sulphate soil risk mapping indicates that the site is mostly located within an area of “moderate to low risk of acid sulphate soils occurring within 3 m of natural soil surface”. An area of “high to moderate risk” is shown immediately adjacent to the south eastern site boundary, associated with the sandy silt deposits in the vicinity of Yule Brook.

3. Field Work Methods

Field work was carried out between 14 December and 23 December 2015, 28 April and 4 May 2016 and on 8 July 2016 and comprised the excavation of 127 test pits, seven in-situ permeability tests and dynamic cone penetrometer (DCP) or Perth sand penetrometer (PSP) testing, depending on the encountered ground conditions, adjacent to each test pit.

The test pits (TP1 to TP9, TP14 to TP16, TP24 to TP39, TP41 to TP94, TP96 to TP112, TP01 to TP13 and TP201 to TP213) were excavated to a maximum depth of 3.0 m using a backhoe with a 600 mm toothed bucket. The test pits were logged in general accordance with AS1726-1993 by a suitably experienced geotechnical engineer from Douglas Partners. Soil samples were recovered from selected locations for subsequent laboratory testing.

The PSP and DCP tests were carried out adjacent to the test pits in accordance with AS 1289.6.3.3 and AS 1289.6.3.2, to assess the in situ density of the shallow soils.

Seven in-situ permeability tests (TP14, TP41, TP52, TP63, TP77, TP105 and TP110) were carried out using either the falling head method or the constant head method at depths of between 0.5 m and 0.7 m below existing ground levels. The location, depths of testing, and results are discussed in detail in Section 4.3.

Test locations were determined using GPS coordinates and site features, and are marked on Drawing 1 in Appendix B. Surface elevations at each test location were estimated from a survey plan provided by Linc Property Pty Ltd, Google Earth or the Perth Groundwater Atlas, and are quoted in m AHD.

4. Field Work Results

4.1 Ground Conditions

A summary of the ground conditions encountered at the test locations is given in the next page:

- **Topsoil** (Sand and Clayey Sand) – between 0.05 m and 0.4 m in thickness, comprising sand and clayey sand, with some silt, gravel and roots and a trace of cobbles.
- **Non-engineered Filling and Filling** (Sand, Sandy Gravel, Gravelly Sand, Clayey Sand and Sandy Clay) – apparently loosely to well compacted non-engineered granular filling with various amounts of deleterious materials, and apparently well compacted granular and cohesive filling. Weakly cemented sand filling was also recorded at particular test locations between 0.1 m and 0.8 m in thickness
- **Sandy and Gravelly Materials** (Sand, Slightly Silty Sand, Gravel, Gravelly Sand and Sandy Gravel) – generally medium dense to very dense, becoming loose at particular test locations, sandy and gravelly materials, with various quantities of clay and silt. Weakly cemented sand (coffee rock) was also encountered at particular test locations, approximately varying between 0.2 m and 0.35 m in thickness.
- **Clayey Sandy and Gravelly Materials** (Slightly Clayey to Clayey Sand, Sandy Clay, Gravelly Clayey Sand, Clayey Sandy Gravel and Sandy Silt) – generally firm to hard clayey sandy and gravelly materials, with pockets of ironstone. A soft sandy silt layer becoming stiff with depth was recorded at a test location undertaken adjacent to the Yule Brook.

A summary of the depths below existing surface level and relative level to the base of the non-engineered filling and filling, and sandy gravelly materials, is summarised in Table 1 below.

Table 1: Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of non-engineered Filling and Filling (m)	Level to Base of non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
January 2016	TP1	9.90	-	-	0.80	9.10
	TP2	10.10	-	-	0.90	9.20
	TP3	10.10	0.5[6]	9.60[6]	-	-
	TP4	9.80	-	-	0.50	9.30
	TP5	9.80	-	-	0.70	9.10
	TP6	10.20	0.60 or 1.10[6]	9.60 or 9.10[6]	1.70	8.50
	TP7	10.50	-	-	1.20	9.30
	TP8	10.00	-	-	0.30	9.70
	TP9	9.90	-	-	1.00	8.90
	TP14	10.20	-	-	-	-
	TP15	11.20	0.20	11.00	>1.80	<9.40
	TP16	10.80	1.00	9.80	1.60	9.20
	TP24	10.80	-	-	1.80	9.00

Table 1 (continued): Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of non-engineered Filling and Filling (m)	Level to Base of non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
January 2016	TP25	12.00	-	-	>2.50[5]	<9.50[5]
	TP26	11.30	-	-	>2.00	<9.30
	TP27	11.00	0.20[4]	10.8[4]	0.80	10.2
	TP28	10.60	-	-	0.30	10.30
	TP29	11.50	-	-	2.40	9.10
	TP30	11.30	0.50[4]	10.80[4]	1.10	10.20
	TP31	11.10	-	-	0.60	10.50
	TP32	11.10	0.80	10.30	1.20	9.90
	TP33	11.10	0.70	10.40	1.70	9.40
	TP34	11.00	-	-	1.50[5]	9.50[5]
	TP35	10.30	0.70 or 0.85[6]	9.60 or 9.45[6]	1.90[2]	8.40[2]
	TP36	10.80	0.80	10.00	1.40	9.40
	TP37	10.80	0.60[3]; [4]	10.20[3]; [4]	1.70	9.10
	TP38	11.00	0.60[3]	10.40[3]	1.00[2]	10.00[2]
	TP39	11.50	-	-	>2.30	<9.20
	TP41	11.30	-	-	2.20	9.10
	TP42	12.00	-	-	>2.00	<10.00
	TP43	12.40	-	-	>2.00	<10.40
	TP44	12.60	-	-	>2.50	<10.10
	TP45	12.00	-	-	>2.50	<9.50
	TP46	12.80	1.00	11.80	1.60	11.20
	TP47	12.20	1.30	10.90	1.60	10.60
	TP48	11.30	0.35	10.95	0.85	10.45
	TP49	9.70	2.20[3]	7.50[3]	-	-
	TP50	10.80	-	-	0.50	10.30
	TP51	11.20	-	-	0.60	10.60
	TP52	11.60	-	-	0.90	10.70
	TP53	11.60	-	-	1.10	10.50

Table 1 (continued): Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of non-engineered Filling and Filling (m)	Level to Base of non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
January 2016	TP54	11.90	-	-	1.10	10.80
	TP55	12.30	-	-	0.60	11.70
	TP56	12.40	-	-	0.45	11.95
	TP57	11.20	0.20	11.00	0.70	10.50
	TP58	11.50	-	-	0.60	10.90
	TP59	11.90	0.20	11.70	0.60	11.30
	TP60	12.40	-	-	0.60	11.80
	TP61	12.60	-	-	0.60	12.00
	TP62	12.40	-	-	1.30	11.10
	TP63	11.80	0.30	11.50	-	-
	TP64	11.60	-	-	0.80	10.80
	TP65	12.20	-	-	0.50	11.70
	TP66	12.60	-	-	0.40	12.20
	TP67	12.40	-	-	0.60	11.80
	TP68	12.00	-	-	0.50	11.50
	TP69	12.00	-	-	0.50	11.50
	TP70	11.80	-	-	0.65	11.15
	TP71	11.90	0.45	11.45	1.10	10.80
	TP72	12.00	-	-	1.20	10.80
	TP73	12.20	-	-	1.00	11.20
	TP74	12.00	-	-	0.40	11.60
	TP75	11.80	-	-	0.80	11.00
	TP76	11.60	-	-	0.80	10.80
	TP77	12.00	-	-	1.10	10.90

Table 1 (continued): Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of non-engineered Filling and Filling (m)	Level to Base of non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
January 2016	TP78	12.00	0.50	11.50	1.30	10.70
	TP79	11.50	-	-	0.50	11.00
	TP80	11.60	-	-	0.80	10.80
	TP81	11.30	-	-	0.80	10.50
	TP82	11.50	-	-	0.60	10.90
	TP83	11.20	0.60	10.60	0.90	10.30
	TP84	11.60	0.90	10.70	1.10	10.50
	TP85	11.10	-	-	0.80	10.30
	TP86	11.40	0.40	11.00	1.10	10.30
	TP87	11.90	0.40 or 1.0[6]	11.50 or 10.90[6]	1.40	10.50
	TP88	11.60	0.40[4]	11.20[4]	-	-
	TP89	11.80	0.75	11.05	1.50	10.30
	TP90	12.10	0.80	11.30	1.70	10.40
	TP91	12.10	0.80[4]	11.30[4]	1.10	11.00
	TP92	12.10	-	-	0.45	11.70
	TP93	12.00	0.70[4]	11.30[4]	1.40	10.60
	TP94	12.00	0.70	11.30	-	-
	TP96	12.20	1.20[7]	11.00[7]	1.50[5]	10.70[5]
	TP97	12.40	1.40	11.00	2.10	10.30
	TP98	12.40	1.30[7]	11.10[7]	2.20	10.20
	TP99	11.40	1.20[4]	10.20[4]	-	-
	TP100	12.40	1.10	11.30	1.80	10.60
	TP101	12.10	1.90	10.20	-	-
	TP102	12.60	1.30	11.30	2.00	10.60

Table 1 (continued): Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of non-engineered Filling and Filling (m)	Level to Base of non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
January 2016	TP103	12.80	1.20	11.60	-	-
	TP104	13.00	0.60	12.40	-	-
	TP105	13.20	0.30	12.90	0.80	12.40
	TP106	13.60	-	-	0.40	13.20
	TP107	13.90	-	-	0.30	13.60
	TP108	13.90	-	-	1.40	12.50
	TP109	9.60	1.00	8.60	1.30	8.30
	TP110	12.50	0.60	11.90	1.30	11.20
	TP111	12.60	0.40	12.20	1.10	11.50
	TP112	12.60	-	-	0.50[5]	12.10[5]
April-May 2016	TP201	13.00	0.40	12.60	-	-
	TP202	13.00	-	-	0.60	12.40
	TP203	13.50	-	-	0.70	12.80
	TP204	13.00	0.30	12.70	0.70	12.30
	TP205	13.00	-	-	0.90	12.10
	TP206	13.00	-	-	0.90	12.10
	TP207	15.00	0.90	14.10	1.60	13.40
	TP208	15.50	0.90	14.60	1.40	14.10
	TP209	15.00	0.30	14.70	1.90	13.10
	TP210	16.00	0.90	15.10	>1.0	<15.00
	TP211	16.00	0.60	15.40	>1.0	<15.00
	TP212	16.00	0.70	15.30	>1.0	<15.00
	TP213	16.00	>0.80	<15.20	-	-

Table 1 (continued): Summary of Depth to the Base of Non-engineered Filling and Filling, Surface Sand, Sandy Silt, Gravel Gravelly Sand and Sandy Gravel zone and Approximate Relative Levels

Ground Investigation	Test Location	Surface Level (m AHD) [1]	Depth to Base of Non-engineered Filling and Filling (m)	Level to Base of Non-engineered Filling and Filling (m AHD)	Depth to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m)	Level to Base of Sand, Sandy Silt, Gravel, Gravelly Sand and Sandy Gravel Zone (m AHD)
July 2016	TP01	14.00	1.80	12.20	-	-
	TP02	14.00	0.30	13.70	1.50	12.50
	TP03	15.00	0.30	14.70	0.60	14.40
	TP04	16.00	0.70	15.30	1.50	14.50
	TP05	12.00	0.80	11.20	-	-
	TP06	10.00	0.20	9.80	0.90	9.10
	TP07	10.00	-	-	0.70	9.30
	TP08	11.00	-	-	0.90	10.10
	TP09	11.00	-	-	0.50	10.50
	TP10	11.00	-	-	0.50	10.50
	TP11	12.00	-	-	0.70	11.30
	TP12	13.00	-	-	1.40	11.60
	TP13	13.00	0.25	12.75	0.50	12.50
	TP14	13.00	1.00	12.00	1.50	11.50

Notes: [1] Surface level from a survey plan provided by Linc Property Pty Ltd, Google Earth or the Perth Groundwater Atlas.
[2] Layers of organic sand were recorded between 0.4 m and 0.65 m in thickness.
[3] Layers of organic filling were recorded between 0.25 m and 0.70 m in thickness.
[4] Includes cemented filling.
[5] Cemented sand (Coffee Rock) approximately varying between 0.2 m and 0.35 m in thickness.
[6] Depth or level of possible filling.
[7] Recorded as filling (topsoil).

4.2 Groundwater

Groundwater was observed within four test pits excavated between 12 December and 24 December 2015, and within eight test pits excavated on 8 July 2016. It is expected that the groundwater within two of test pits, TP35 and TP106 is perched groundwater. The test pits were immediately backfilled following sampling, which precluded longer-term monitoring of groundwater levels. No free groundwater was observed within any of the test pits excavated on 28 April 2016 and 4 May 2016. Groundwater levels are summarised in Table 2.

Table 2: Summary of Observed Groundwater Levels

Date	Test Location	Surface Level [1] (m AHD)	Groundwater Depth (m)	Groundwater Level [2] (RL m AHD)
18 December 2015	TP35	10.30	1.90[3]	8.40[3]
16 December 2015	TP67	12.40	2.40	10.00
17 December 2015	TP78	12.00	2.90	9.10
21 December 2015	TP106	13.60	1.70[3]	11.90[3]
8 July 2016	TP01	14.00	1.30[3]	12.70[3]
	TP02	14.00	1.20[3]	12.80[3]
	TP03	15.00	1.30[3]	13.70[3]
	TP04	16.00	1.70[3]	14.30[3]
	TP06	10.00	1.30[3]	8.70[3]
	TP07	10.00	0.70[3]	9.30[3]
	TP08	11.00	0.90[3]	10.10[3]
	TP11	12.00	1.90[3]	10.10[3]

Notes [1]: Surface level interpolated from a survey plan supplied by Linc Property Pty Ltd and Google Earth.
[2]: Groundwater Level = Interpolated Surface Level – Groundwater Depth.
[3]: Seepage

It should be noted that local groundwater levels can be affected from many sources including climatic conditions, bore water usage, surrounding development, drainage systems etc. and therefore will vary over time.

4.3 Permeability

Seven in-situ permeability tests using either the constant head method or the falling head method were undertaken within the site. The constant head tests were undertaken in accordance with AS 1547-2000 Appendix 4.1F, while the falling head test values were estimated using Hvorslev's method (1951). Permeability values were also derived using the laboratory results in Section 5 and Hazen's formula, which applies for sand in a loose state. Results of the permeability analysis are summarised in Table 3 (next page).

Table 3: Summary of Permeability Analysis

Test Location	Depth (m)	Measured Permeability[1]		Derived Permeability (m/s) [2]	In situ Conditions of Tested Material
		(m/s)	(m/day)		
TP14	0.50	1.9×10^{-5}	1.6	-	Stiff to Very Stiff Clayey Sand
TP41	0.70	1.3×10^{-4}	11.2	-	Medium Dense Sand, trace of silt
TP52	0.50	1.3×10^{-4}	11.2	1.0×10^{-4}	Medium Dense to Dense Sand, trace of silt
TP63	0.50	1.3×10^{-5}	1.1	-	Very Stiff to Hard Clayey Sand
TP77	0.50	1.4×10^{-4}	12.0	1.7×10^{-4}	Medium Dense Sand, trace of silt
TP105	0.50	1.9×10^{-5}	1.6	-	Interface of sand filling and sand, with some clay
TP110	0.70	1.8×10^{-5}	1.5	-	Interface of sand filling and sand, with some clay

Notes: [1]: In-situ assessment.
[2]: Hazen's formula. Method mostly applicable for sandy soils.

5. Geotechnical Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of:

- The particle size distributions of 14 samples;
- The Atterberg limits and linear shrinkage of 8 samples;
- The shrink/swell index of nine samples.
- The organic content on five samples; and
- The modified maximum dry density (MMDD), optimum moisture content (OMC) and the California bearing ratio (CBR) values of four samples

The laboratory test results are summarised in Table 4 to Table 6.

Table 4: Results of Soil Identification Laboratory Testing

Test Location	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	LL (%)	PL (%)	PI (%)	LS (%)	Iss (%)	Material
TP2	1.1-1.3	-	-	-	-	-	-	-	3.2	Clayey Sand
TP14	0.3-0.5	52	<0.0135	0.16	72	19	53	13.5	-	Sandy Clay/Clayey Sand, with some gravel
TP31	0.6-0.8	-	-	-	-	-	-	-	2.6	Clayey Sand
TP37	0.2-0.3	44	<0.0135	0.21	34	16	18	8.0	-	Filling (Clayey Sand)
TP48	1.0-1.3	-	-	-	-	-	-	-	1.5	Clayey Sand
TP49	1.6-1.8	23	<0.0135	0.39	-	-	-	-	-	Filling (Clayey Sand)

Table 4 (continued): Results of Soil Identification Laboratory Testing

Test Location	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	LL (%)	PL (%)	PI (%)	LS (%)	Iss (%)	Material
TP51	1.1-1.4	19	<0.0135	0.60	29	20	9	5.5	0.1	Slightly Gravelly Slightly Clayey Sand
TP52	0.3-0.5	5	0.1	0.41	-	-	-	-	-	Sand, with some silt
TP54	2.3-2.4	31	<0.0135	0.48	65	18	47	15.0	-	Clayey Sand, with some gravel
TP63	0.3-0.5	19	<0.0135	0.45	32	14	18	5.5	-	Slightly Clayey Slightly Gravelly Sand
TP66	0.6-0.8	-	-	-	-	-	-	-	2.1	Clayey Sand
TP68	0.5-0.65	-	-	-	-	-	-	-	2.2	Clayey Sand
TP74	0.7-0.8	-	-	-	-	-	-	-	2.1	Clayey Sand
TP77	0.3-0.5	3	0.13	0.48	-	-	-	-	-	Sand, trace of silt
TP79	0.8-1.15	25	<0.0135	0.39	73	14	59	20.0	5.6	Slightly Gravelly Clayey Sand
TP87	0.5-0.6	20	<0.0135	0.30	-	-	-	-	-	Slightly Clayey Sand, trace of gravel
TP92	0.5-0.8	-	-	-	-	-	-	-	3.8	Clayey Sand
TP96	0.9-1.0	3	0.18	0.52	-	-	-	-	-	Filling (Sand with some gravel and a trace of clay)
TP103	0.6-0.7	5	0.16	0.51	-	-	-	-	-	Filling (Slightly Gravelly Sand, with some silt)
TP104	1.2-1.3	13	<0.0135	8.5	-	-	-	-	-	Slightly Clayey Sandy Gravel
TP106	0.5-0.6	61	<0.0135	0.07	-	-	-	-	-	Sandy Silt, with some gravel

Where:

- The % fines is the amount of particles smaller than 75 μm.
- A d_{10} of 0.17 mm means that 10% of the sample particles are finer than 0.17 mm.
- A d_{60} of 0.23 mm means that 60% of the sample particles are finer than 0.23 mm.
- I_{ss}: Shrink-Swell Index
- PL: plastic limit.
- LL: liquid limit.
- PI: plasticity Index.
- LS: linear shrinkage
- '-' means 'Not Tested'

Table 5: Results of Topsoil, Filling and Surface Sand Organic Content Laboratory Testing

Test Location	Depth (m)	Organic Content (%)	Material
TP37	0.2-0.3	4.9	Filling (Clayey Sand)
TP38	0.4-0.5	6.0	Filling (Clayey Sand)
TP49	1.6-1.8	19.3	Filling (Sand)
TP70	0-0.1	2.6	Topsoil
TP106	0.5-0.6	5.5	Sandy Silt, with some gravel

The CBR tests were undertaken at a target compaction level of 95% of modified maximum dry density. The samples were tested after soaking for four days with a confining surcharge of 4.5 kg, and the results are presented in Table 6 below.

Table 6: Results of Laboratory Testing for Pavement Design

Test Location	Depth (m)	MMDD (t/m^3)	CBR (%)	OMC (%)	Swell (%)	Material
TP14	0.3-0.5	1.816	1.5	15.2	5.0	Sandy Clay/Clayey Sand, with some gravel
TP63	0.3-0.5	2.070	4	9.1	4.5	Slightly Clayey Slightly Gravelly Sand
TP87	0.5-0.6	2.050	16	8.8	0	Slightly Clayey Sand, trace of gravel
TP106	0.5-0.6	1.786	13	18.2	0.5	Sandy Silt, with some gravel

Notes:
- MMDD: modified maximum dry density.
- CBR: California bearing ratio.
- OMC: optimum moisture content.

6. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
3. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
4. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
5. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.

7. Limitations

Douglas Partners has prepared this factual repor for this project at Coldwell Road, Kenwick in accordance with Douglas Partners proposals dated 18 December 2015 and 20 April 2016 and acceptance received from Mr Ben Lisle and Mr Brett Chivers of Linc Property Pty Ltd dated 1 December 2015, 20 April and 5 July 2016. The work was carried out under Douglas Partners Conditions of Engagement.

This factual report is provided for the exclusive use of Linc Property Pty Ltd for this project only and for the purposes as described in the factual report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this factual report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas Partners, does so entirely at its own risk and without recourse to Douglas Partners for any loss or damage. In preparing this factual report Douglas Partners has necessarily relied upon information provided by the client and/or their agents.

The results provided in the factual report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas Partners field testing has been completed.

This factual report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas Partners cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this factual report.

This factual report, or sections from this factual report, should not be used as part of a specification for a project, without review and agreement by Douglas Partners. This is because this factual report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

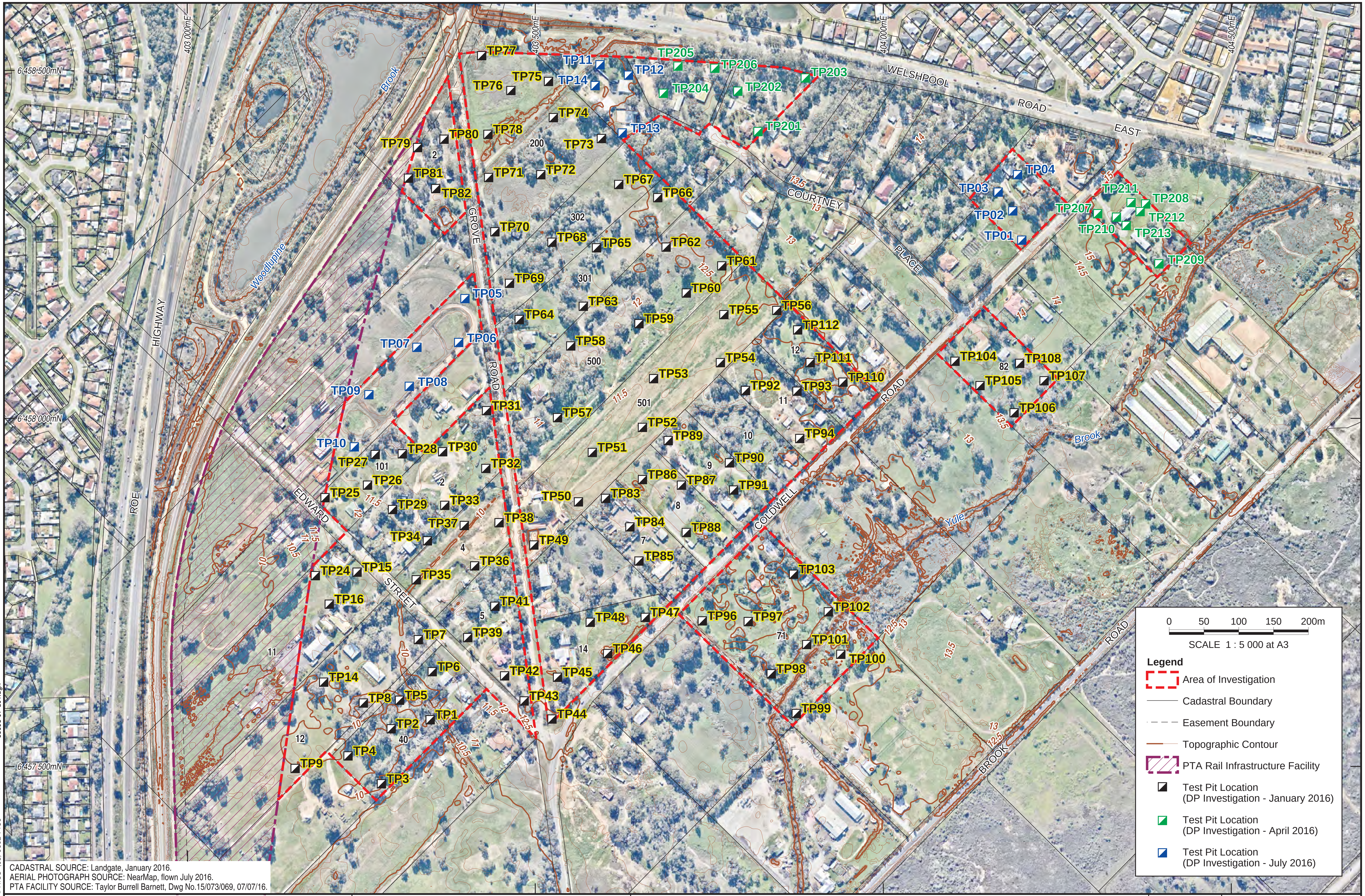
Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawing



88698-07-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Linc Property		
OFFICE: Perth	DRAWN BY: D. Reaveley	
SCALE: As shown	DATE: 28 Jul 2016	

TITLE: **Location of Tests**
Proposed Industrial Subdivision Development
Kenwick, WA

MGA

PROJECT No.:	88698.07
DRAWING No.:	1
REVISION:	A

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APPENDIX D

YULE BROOK LONG SECTIONS AND TAILWATER CONDITIONS

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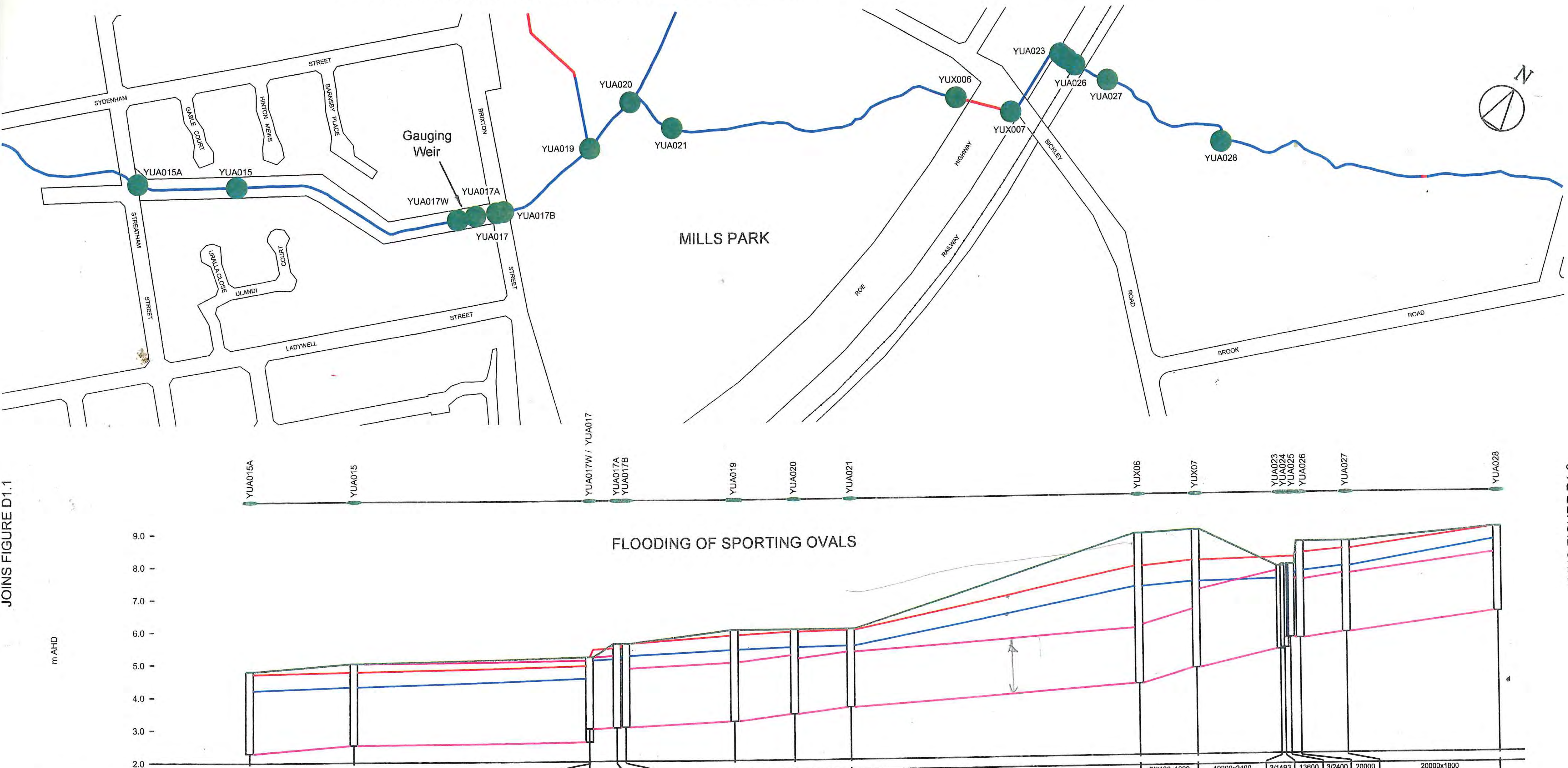
THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

JOINS FIGURE D1.1



JOINS FIGURE D1.3

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
1760	4.80	4.22	4.72	- / 2.30
1890	5.03	4.32	4.78	2.53 / 2.53
2183	5.20	4.55	4.93	2.60 / -
2184	5.20	5.10	5.43	- / 3.00
2218	5.60	5.13	5.47	3.03 / 3.03
2229	5.60	5.23	5.60	3.04 / 3.04
2364	6.00	5.40	5.84	3.20 / 3.20
2438	6.00	5.46	5.93	3.41 / 3.41
2508	6.00	5.48	5.97	3.60 / 3.60
2869	8.80	7.17	7.79	4.20 / 4.20
2940	8.90	7.31	7.95	4.66 / 4.66
3045	7.75	7.35	8.01	5.20 / 5.20
3050	7.79	7.48	8.02	5.24 / 5.24
3057	7.80	7.48	8.02	5.57 / 5.57
3069	8.50	7.60	8.15	5.53 / 5.53
3126	8.50	7.73	8.26	5.70 / 5.70
3315	8.90	8.50	8.89	6.30 / -

Chainage (m)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
1760–1890	15500x2500	22.67	26.92
1890–2183	15500x2500	22.67	26.92
2183–2184		-	-
2184–2218	14600 x2200	22.67	26.93
2218–2229	10000 x2000	22.67	26.93
2229–2364	11825x1800	22.66	26.97
2364–2438	11825x1800	22.72	27.25
2438–2508	11825x1700	15.43	16.90
2508–2869	8500x1700	15.45	16.92
2869–2940	.3/2400x1800	15.56	17.02
2940–3045	10200x2400	15.56	17.02
3045–3050	3/1493	21.77	26.67
3050–3057	13600 x2200	15.61	17.26
3057–3069	3/2400 x1800	15.63	17.46
3069–3126	20000 x1800	17.59	20.59
3126–3315	20000x1800	16.82	22.21

YULE BROOK MAIN DRAIN 2 OF 4
Hgls and Flows Ultimate System

LONGITUDINAL SECTION
Ultimate Development

Figure D1.2

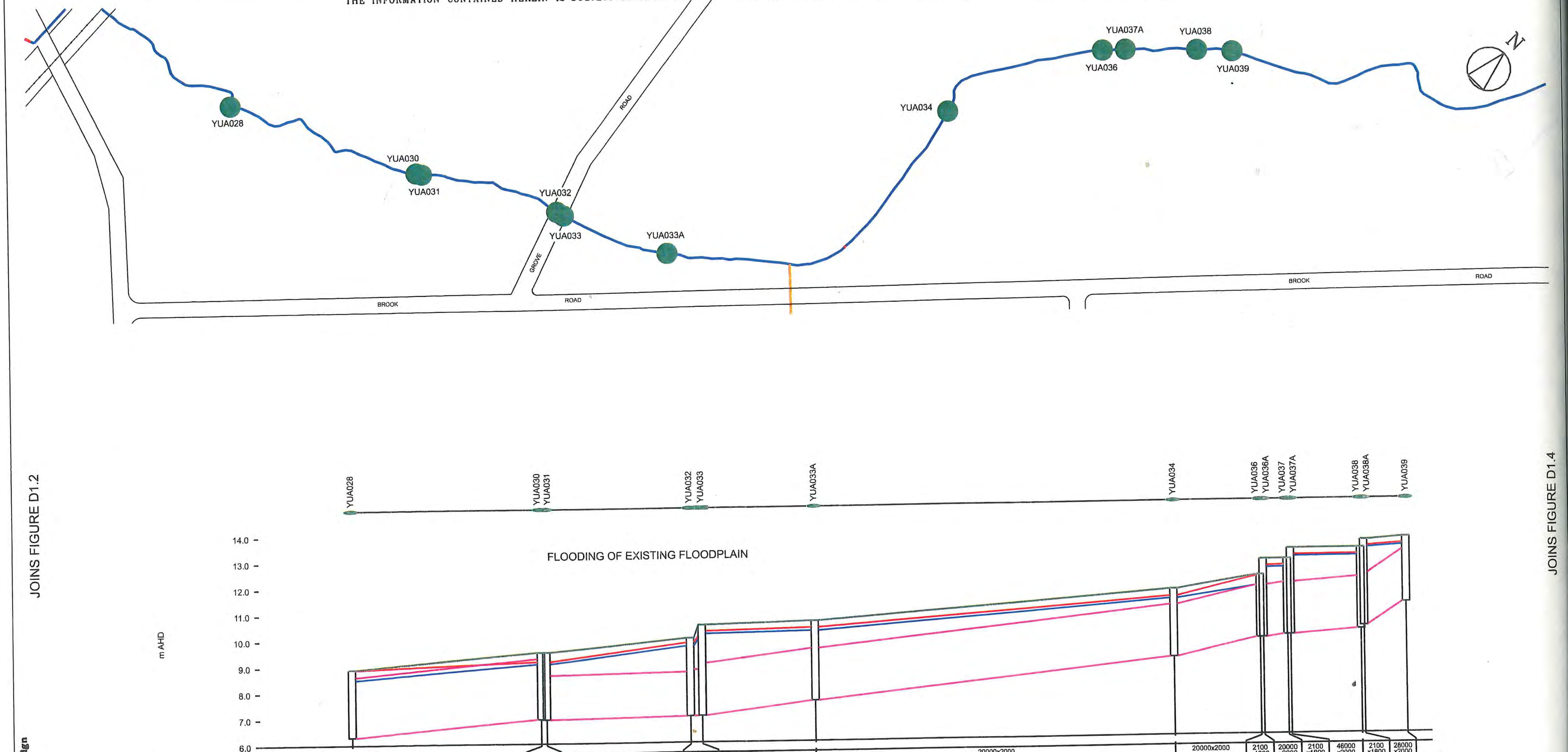
WATER CORPORATION

PROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

JOINS FIGURE D1.2

JOINS FIGURE D1.4



Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Size (mm) to next	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
3315	8.90	8.50	8.89	- / 6.30	20000x2000	15.80	25.00
3573	9.50	9.05	9.15	6.91 / 6.94	3/1340	19.29	27.01
3580	9.50	9.05	9.15	6.95 / 6.92	20000x1700	15.33	23.35
3765	10.00	9.70	9.82	7.01 / 7.01	2/1791	15.21	23.91
3774	10.50	10.16	10.26	7.02 / 7.02	20000x2000	21.19	28.95
3918	10.60	10.23	10.35	7.55 / 7.55	20000x2000	14.77	21.44
4380	11.60	11.24	11.33	9.00 / 9.00	20000x2000	15.37	18.94
4490	12.10	11.69	12.05	9.69 / 9.69	2100 x1800	16.25	23.05
4494	12.70	12.37	12.45	9.70 / 9.70	20000 x2000	17.97	20.14
4524	12.70	12.38	12.46	9.79 / 9.79	2100 x1800	17.32	21.55
4528	13.10	12.79	12.85	9.80 / 9.80	46000 x2000	20.50	23.47
4618	13.10	12.80	12.86	9.98 / 9.98	2100 x1800	19.97	23.91
4622	13.40	13.10	13.16	10.11 / 10.11	28000 x2000	13.15	20.37
4677	13.50	13.18	13.26	11.00 / -			

YULE BROOK MAIN DRAIN 3 OF 4

Hgls and Flows Ultimate System Ultimate Development

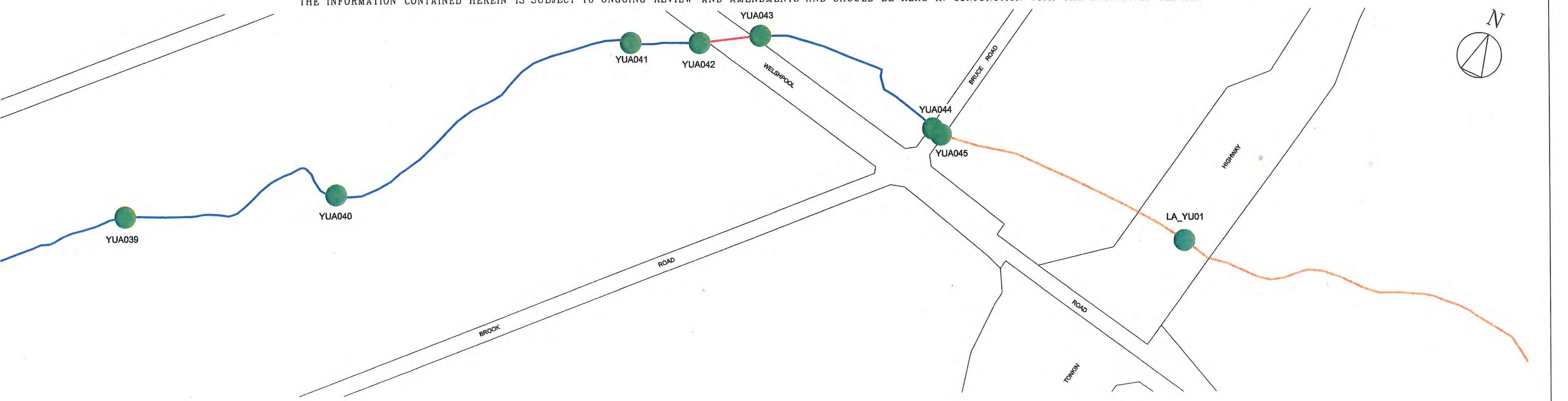
Figure D1.3

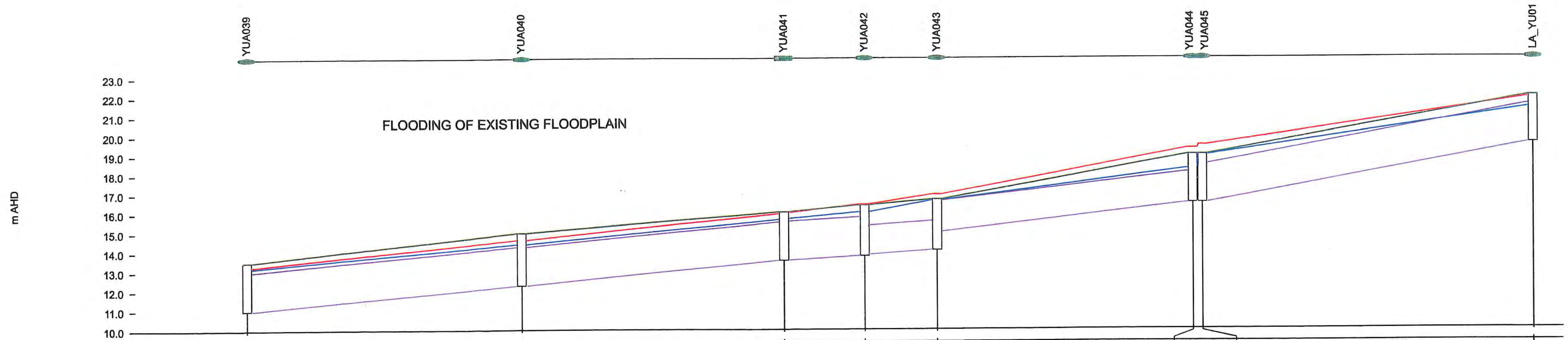
AUTHOR: FLETTNO DESIGN FILE: YuleBrk LSect.dgn

WATER CORPORATION

PROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.





Node	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
YUA039	4677	13.50	13.16	13.26	- / 11.00
YUA040	4965	15.00	14.43	14.64	12.28 / 12.28
YUA041	5240	16.06	15.69	15.96	13.56 / 13.58
YUA042	5325	16.40	16.04	16.44	13.78 / 13.85
YUA043	5401	16.70	16.64	16.95	14.08 / 15.02
YUA044	5671	18.99	18.27	19.32	16.50 / 16.50
YUA045	5681	18.99	18.96	19.47	16.50 / 16.50
LA_YU01	6027	22.00	21.40	21.90	19.57 / -

Reach	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
YUA039 – YUA040	20000x2000	16.11	19.43
YUA040 – YUA041	20000x2000	16.51	19.79
YUA041 – YUA042	20000x2000	17.21	20.43
YUA042 – YUA043	2/1800x1500 +1500	16.95	22.90
YUA043 – YUA044	22000x1600	16.95	20.71
YUA044 – YUA045	2/1800x1200 + 1200x1200	17.44	31.26 21.28?
YUA045 – LA_YU01	20000x2000	17.34	21.53

YULE BROOK MAIN DRAIN 4 OF 4

Hgls and Flows Ultimate System

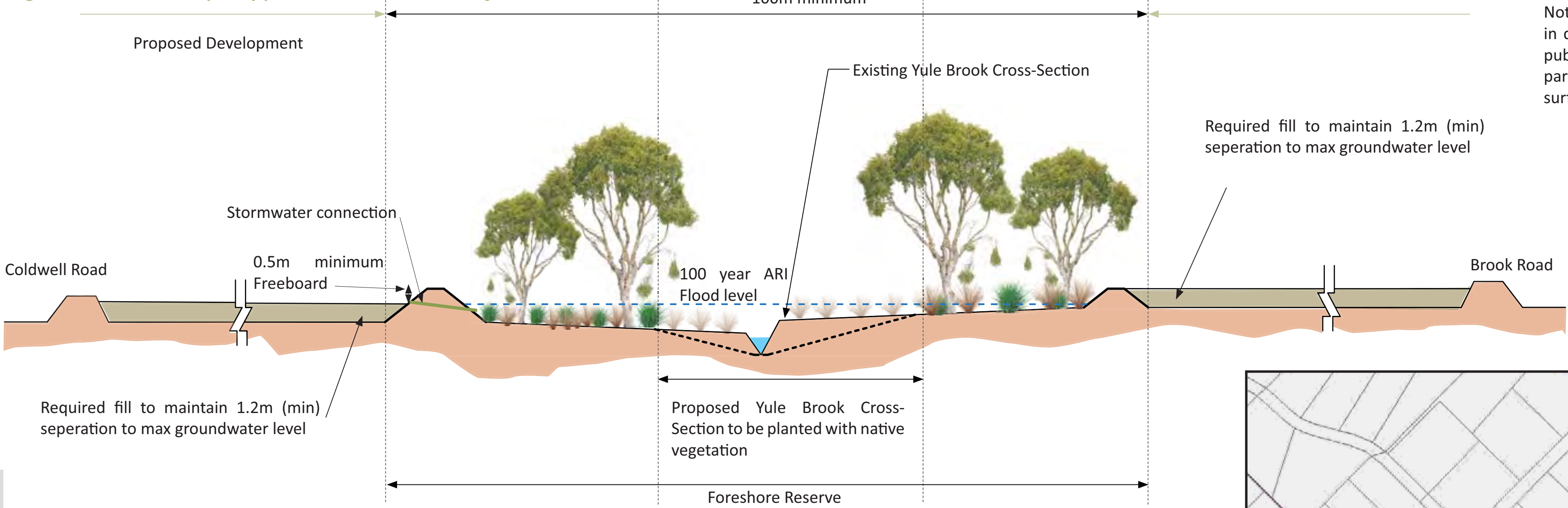
LONGITUDINAL SECTION Ultimate Development

Figure D1.4

WATER CORPORATION

ROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

Figure 18 - Concept Typical Cross Section for Yule Brook



Note: Detail Design of Levee required in detail design phase incorporating public safety and utility of future parkland and necessary changes in surface levels of existing roads.

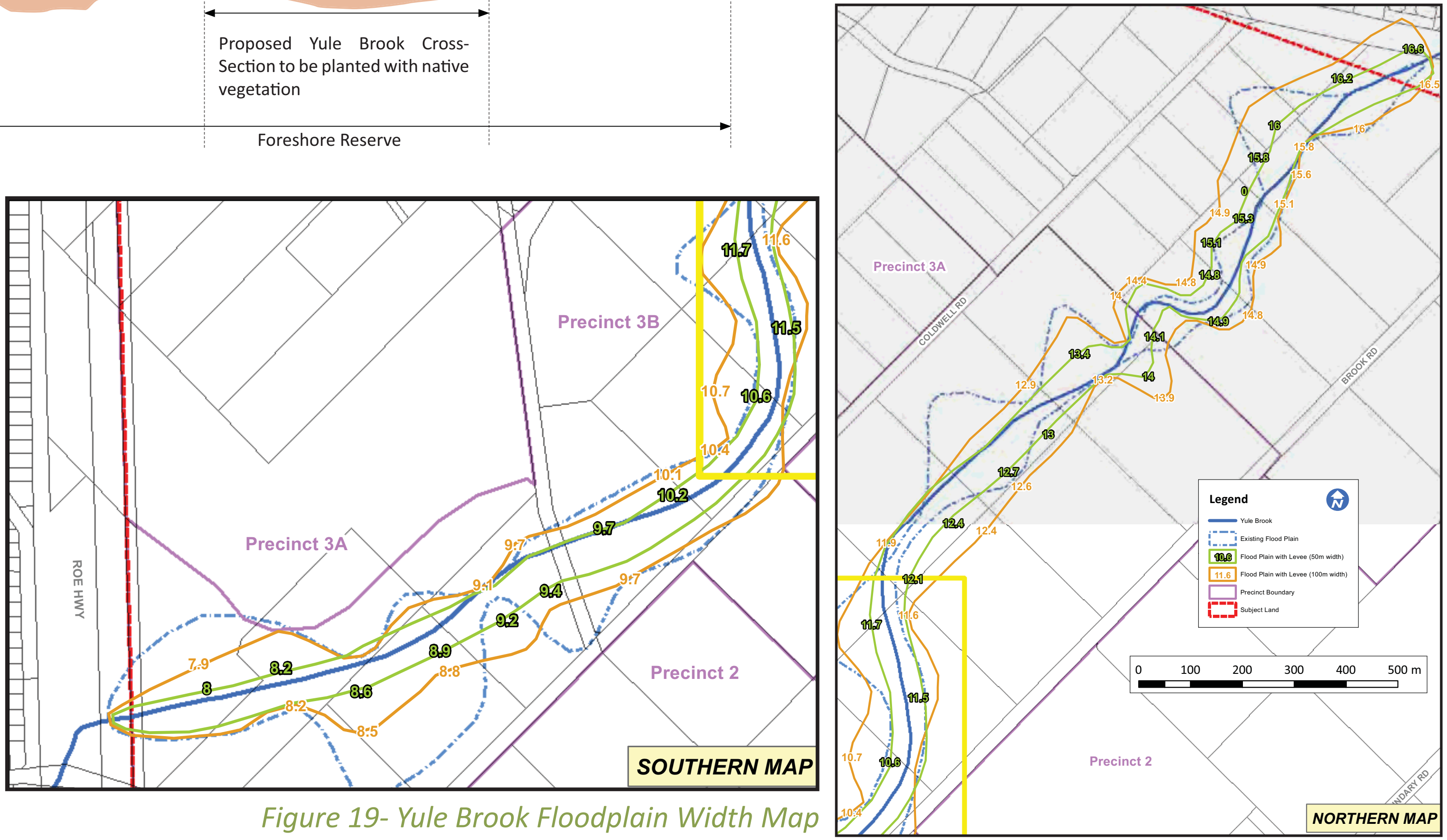


Figure 19- Yule Brook Floodplain Width Map

APPENDIX E

PRE-DEVELOPMENT MONITORING DATA

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Table 16: Surface Water Quality for the MKSEA: Field Parameters and Nutrients – 2010 Monitoring.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	°C		mS/cm	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Marine trigger		-	8.0-8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LT Irrigation trigger		-	6.0-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	24-Jun-10	11.5	7.36	319	6.8	-15.4	<5	117	10	9	0.6	0.26	<0.01	0.26	0.3	0.01	<0.01
M2	24-Jun-10	11.2	7.69	388	6.6	-35.5	<5	146	6	11	0.6	0.23	<0.01	0.23	0.4	0.02	<0.01
SW1	24-Jun-10	Insufficient or no flow															
SW2	24-Jun-10	Insufficient or no flow															
SW3	24-Jun-10	11.8	7.79	1534	5.1	-42.3	<5	610	8	59	1.2	0.01	<0.01	0.01	1.2	0.19	0.12
SW5	24-Jun-10	16.7	8.11	279	6.9	-61.2	<5	103	8	73	1.7	0.04	<0.01	0.04	1.7	0.1	0.02
SW6	24-Jun-10	Insufficient or no flow															
SW7	24-Jun-10	Insufficient or no flow															
M1	9-Jul-10	12.2	7.06	185	10.1	99.5	25	120	12	13	0.6	0.24	<0.01	0.24	0.4	0.05	<0.01
M2	9-Jul-10	12	7.13	199	6.9	119.0	16	129	23	16	0.7	0.22	<0.01	0.22	0.5	0.04	<0.01
SW1	9-Jul-10	13.9	7.02	429	7.7	102.9	10	270	15	52	1.9	0.42	<0.01	0.42	1.5	0.25	0.24
SW2	9-Jul-10	13.6	6.97	313	6.5	108.3	36	204	8	25	1.1	0.14	<0.01	0.14	1	0.13	0.04
SW3	9-Jul-10	12	7.01	477	8.6	132.0	5	310	12	53	1.5	0.22	<0.01	0.22	1.3	0.12	0.09
SW5	9-Jul-10	12.4	7	139	9.4	216.0	13	90	17	57	1.6	0.2	0.02	0.18	1.4	0.04	0.02
SW6	9-Jul-10	13	6.81	36	9.8	141.0	5	23	12	<5	0.4	0.13	0.02	0.11	0.3	0.07	0.02
SW7	9-Jul-10	Insufficient or no flow															
M1	13-Jul-10	11.5	7.43	460	6.9	-20.4	<5	181	2	22	1.1	0.83	<0.01	0.83	0.3	0.01	<0.01
M2	13-Jul-10	12.3	8.13	386	6.4	-62.8	11	145	3	32	1.3	0.73	<0.01	0.73	0.6	0.03	<0.01
SW1	13-Jul-10	13	7.57	950	3.8	-29.3	234	371	5	233	5	2.31	0.02	2.29	2.7	0.37	0.11
SW2	13-Jul-10	12.5	7.82	690	5.4	-43.0	<5	265	5	49	2.2	0.74	0.03	0.71	1.5	0.1	0.02
SW3	13-Jul-10	12.6	7.89	750	5.2	-47.6	20	290	<2	86	1.9	0.16	<0.01	0.16	1.7	0.18	0.1
SW5	13-Jul-10	14.6	7.64	301	7.3	-32.7	<5	111	<2	83	1.5	0.03	<0.01	0.03	1.5	0.53	<0.01
SW6	13-Jul-10	15.8	7.64	1279	0.7	-33.0	<5	500	3	186	2.4	1.54	0.02	1.52	0.9	0.07	0.02
SW7	13-Jul-10	13	7.79	630	2.6	-42.3	<5	239	<2	88	1.6	0.01	<0.01	0.01	1.6	0.1	<0.01
M1	12-Aug-10	12.8	6.86	330	6.8	-	11	123	<2	31	0.9	0.3	<0.01	0.3	0.6	0.04	<0.01
M2	12-Aug-10	12.5	7.69	284	6.1	-	10	106	<2	20	0.7	0.3	<0.01	0.3	0.4	0.03	<0.01
SW1	12-Aug-10	13.7	7.63	2400	4.9	-	10	811	<2	57	3.6	1.69	0.04	1.66	1.9	0.25	0.13
SW2	12-Aug-10	Insufficient or no flow															
SW3	12-Aug-10	14.3	7.32	871	5.6	-	<5	337	<2	73	2	0.22	0.01	0.21	1.8	0.13	0.03
SW5	12-Aug-10	15.3	8.33	325	6.6	-	5	121	<2	36	2.1	0.38	<0.01	0.38	1.7	0.11	0.02
SW6	12-Aug-10	14.5	7.88	159	3.4	-	7	57	<2	16	0.8	0.28	<0.01	0.28	0.5	0.06	0.02
SW7	12-Aug-10	Insufficient or no flow															
M1	1-Sep-10	14	8.32	460	6.7	-	<5	174	2	45	0.6	0.25	<0.01	0.25	0.4	<0.02	<0.01
M2	1-Sep-10	14	8.14	572	7.8	-	<5	217	<2	48	0.5	0.22	<0.01	0.22	0.3	<0.01	<0.01
SW1	1-Sep-10	16.1	8.04	3390	5.0	-	26	1390	6	115	3.3	1.36	0.04	1.32	1.9	0.2	0.1
SW2	1-Sep-10	17.4	8.2	700	4.0	-	44	270	17	83	2.1	0.01	<0.01	0.01	2.1	0.23	0.01
SW3	1-Sep-10	18.7	7.37	2815	2.5	-	6	1135	7	122	1.4	0.01	<0.01	0.01	1.4	0.14	0.15
SW5	1-Sep-10	21.5	9.34	371	11.6	-	16	1.39	11	102	3	0.26	0.07	0.2	2.7	<0.05	0.04
SW6	1-Sep-10	16.2	7.9	316	2.9	-	<5	117	7	77	0.9	0.04	<0.01	0.04	0.9	0.05	0.02
SW7	1-Sep-10	Insufficient or no flow															
M1	23-Sep-10	13.4	7.85	6180	6.3	-	10	2360	-	-	0.8	0.19	<0.01	0.19	0.6	0.02	<0.01
M2	23-Sep-10	13.4	7.33	8590	5.5	-	<5	334	-	-	0.4	0.04	<0.01	0.04	0.4	0.03	<0.01
SW1	23-Sep-10	17.7	7.43	4110	4.3	-	14	170	-	-	2.2	0.03	<0.01	0.03	2.2	0.14	0.03
SW2	23-Sep-10	Insufficient or no flow															
SW3	23-Sep-10	Insufficient or no flow															
SW5	23-Sep-10	Insufficient or no flow															
SW6	23-Sep-10	Insufficient or no flow															
SW7	23-Sep-10	Insufficient or no flow															
M1	14-Oct-10	17.9	8.1	956				374	-	-	0.8	0.038	0.024	0.014	0.76	0.02	<0.005
M2	14-Oct-10	16.9	7.35	1850				745	-	-	0.83	0.034	<0.005	0.034	0.8	0.02	<0.005
SW1	14-Oct-10	Insufficient or no flow															
SW2	14-Oct-10	Insufficient or no flow															
SW3	14-Oct-10	Insufficient or no flow															
SW5	14-Oct-10	Insufficient or no flow															
SW6	14-Oct-10	Insufficient or no flow															
SW7	14-Oct-10	Insufficient or no flow															

Table 15: Surface Water Quality results for the MKSEA: Field Parameters and Nutrients – 2009 monitoring.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	°C		mS/cm	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Marine trigger		-	8.0-8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LT Irrigation trigger		-	6.0-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	30-Jun-09	12.6	6.22	430	8.7	8.8	<1	280	7.0	<5	1.10	<0.760	<0.023	<0.74	0.32	0.02	<0.005
M2	30-Jun-09	12.8	6.41	450	8.5	-1.0	<1	290	<5	10.0	1.10	0.85	<0.028	<0.82	0.29	0.02	<0.005
SW1	30-Jun-09	16.2	6.68	1300	5.6	5.6	100	860	36.0	150.0	7.70	3.1	0.073	3	4.6	0.94	0.11
SW2	30-Jun-09	Insufficient or no flow															
SW3	30-Jun-09	12.8	6.45	1300	5.8	5.8	3	820	8.0	120.0	3.10	1.3	0.048	1.3	1.8	0.28	0.18
SW5	30-Jun-09	16.8	7.09	430	10.2	10.2	<1	280	8.0	570.0	2.60	1.2	0.032	1.1	1.4	0.04	<0.005
SW6	30-Jun-09	Insufficient or no flow															
SW7	30-Jun-09	Insufficient or no flow															
M1	11-Aug-09	14.8	6.58	410	8.6	-	2	158	53.0	6.0	0.88	0.52	0.008	<0.52	0.36	0.01	<0.005
M2	11-Aug-09	15	7.2	556	8.3	-	1	212	50.0	12.0	1.00	0.53	0.014	0.51957	0.48	<0.02	<0.005
SW1	11-Aug-09	16	7.18	1448	9.1	-	40	578	20.0	650.0	4.30	1.6	0.028	1.5813	2.7	0.35	0.19
SW2	11-Aug-09	Insufficient or no flow															
SW3	11-Aug-09	14.4	7.36	1900	6.7	-	22	770	20.0	450.0	3.60	0.22	0.019	0.2259	3.4	0.3	0.17
SW5	11-Aug-09	17.5	7.99	502	10.7	-	<1	192	57.0	350.0	1.60	0.04	0.007	0.04518	1.5	0.03	<0.005
SW6	11-Aug-09	16.4	7.3	1334	3.5	-	100	529	210.0	400.0	5.20	3.4	0.013	3.3885	1.9	0.17	0.025
SW7	11-Aug-09	Insufficient or no flow															
M1	18-Aug-09	-	7.2	240	-	-	66	150	<5	100.0	1.50	0.47	0.015225	0.4518	1	0.06	<0.005
M2	18-Aug-09	-	7	360	-	-	58	230	<5	300.0	1.80	0.58	0.01218	0.56475	1.2	0.08	0.005
SW1	18-Aug-09	-	7	420	-	-	19	270	<5	500.0	3.10	0.37	0.009135	0.36144	2.8	0.53	0.32
SW2	18-Aug-09	Insufficient or no flow															
SW3	18-Aug-09	-	7	560	-	-	60	360	<5	300.0	2.10	0.21	0.009135	0.20331	1.9	0.18	0.023
SW5	18-Aug-09	-	7	170	-	-	7	110	<5	400.0	1.90	0.037	0.00609	0.02259	1.8	0.05	0.005
SW6	18-Aug-09	-	7.3	440	-	-	27	280	7.0	300.0	3.30	0.9	0.015225	0.88101	2.4	0.63	0.51
SW7	18-Aug-09	-	7.3	290	-	-	19	180	<5	400.0	1.90	0.05	0.009135	0.04518	1.9	0.06	0.008
M1	11-Sep-09	15.8	7.98	399	8.0	-	8	150	<5	<5	0.71	0.56	<0.005	0.56475	0.15	0.01	<0.005
M2	11-Sep-09	16.6	7.83	601	7.8	-	14	230	<5	<5	1.10	0.46	0.005	0.4518	0.68	0.05	<0.005
SW1	11-Sep-09	16.1	7.7	1060	5.8	-	20	417	<5	100.0	3.20	0.25	0.006	0.24849	2.9	0.6	0.25
SW2	11-Sep-09	16	7.81	742	5.7		11	288	<5	48.0	2.40	0.62	0.033	0.58734	1.8	0.09	0.01
SW3	11-Sep-09	15	7.45	1050	7.2	-	30	417	<5	64.0	1.90	0.066	<0.005	0.06777	1.8	0.18	0.037
SW5	11-Sep-09	17.2	7.81	408	8.5	-	6	154	<5	60.0	1.60	0.008	<0.005	<0.1	1.6	0.04	<0.005
SW6	11-Sep-09	17	7.87	796	6.5	-	4	310	<5	36.0	2.30	0.77	<0.005	0.76806	1.6	0.27	0.15
SW7	11-Sep-09	17.2	7.67	662	5.7	-	7	254	<5	68.0	1.90	0.014	<0.005	<0.1	1.9	0.07	<0.005
M1	16-Sep-09	16.2	8	428	8.0		6	162	<5	52.0	1.10	-	<0.005	0.63252	1.1	0.01	<0.005
M2	16-Sep-09	16.4	7.86	555	8.0	-	9	213	<5	60.0	1.00	-	0.005	0.54216	1	0.02	<0.005
SW1	16-Sep-09	18.7	7.44	242	5.9	-	8	289	13.0	92.0	2.80	-	0.011	0.92619	2.8	0.3	0.14
SW2	16-Sep-09	17.5	7.51	674	6.2	-	6	258	<5	120.0	2.50	-	0.033	0.51957	2.5	0.1	0.015
SW3	16-Sep-09	20.1	7.9	1264	7.3	-	16	501	<5	340.0	2.20	-	0.006	0.11295	2.2	0.18	0.088
SW5	16-Sep-09	22.4	8.31	428	7.7	-	5	162	18.0	300.0	2.10	-	<0.005	0.006777	2.1	0.07	<0.005
SW6	16-Sep-09	16.8	7.81	1058	5.8	-	4	417	<5	240.0	4.00	-	0.007	2.430684	4	0.14	0.09
SW7	16-Sep-09	18.2	7.37	785	4.5	-	23	305	13.0	350.0	2.70	-	<0.005	0.033885	2.7	0.08	<0.005
M1	2-Nov-09	16.7	7.78	320	7.8	-8.0	<1	119	32.0	<5	0.63	0.36	<0.01	0.36144	0.27	0.5	<0.005
M2	2-Nov-09	19.2	7.75	572	9.0	-30.1	5	219	28.0	<5	0.64	0.27	<0.01	0.27108	0.37	0.5	<0.005
SW1	2-Nov-09	Insufficient or no flow															
SW2	2-Nov-09	Insufficient or no flow															
SW3	2-Nov-09	Insufficient or no flow															
SW5	2-Nov-09	Insufficient or no flow															
SW6	2-Nov-09	Insufficient or no flow															
SW7	2-Nov-09	Insufficient or no flow															
M1	19-Nov-09	17.7	7.45	246	7.4	-43.4	35		32.0	16.0	1.30	0.24	<0.005	0.24849	1.1	0.16	<0.005
M2	19-Nov-09	18	7.45	282	5.2	-44.6	35		49.0	100.0	1.20	1.2	0.008	1.17468	<0.05	0.05	<0.005
SW1	19-Nov-09	22.3	7.48	3640	4.9	-46.2	36		67.0	10000.0	3.20	0.54	0.089	0.4518	2.7	0.49	0.21
SW2	19-Nov-09	Insufficient or no flow															
SW3	19-Nov-09	26.2	7.83	3480	7.3	-64.2	35		64.0	10000.0	3.00	1.2	0.026	1.17468	1.9	0.1	0.016
SW4	19-Nov-09	-	-	-	-	-	14	-	59.0	300.0	2.30	0.51	0.007	0.49698	1.8	0.11	<0.005
SW5	19-Nov-09	28	7.88	422	5.9	-67.8	-	-	-	-	-	-	-	-	-	-	-
SW6	19-Nov-09	Insufficient or no flow															
SW7	19-Nov-09	Insufficient or no flow															

Table 9: Ground water Quality Results for the MKSEA: Field Parameters and Nutrients.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	°C		mS/cm	mg/L	mV	mg/L	ppk	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Domestic non-potable trigger values		-	-	-	-	-	-	-	-	-	-	-	30	500	-	-	-
LT Irrigation trigger values		-	6-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW01	9-Sep-09	18.4	7.37	4.810	0.0	-22.0	130	2.02	53.0	500.0	3.30	<0.005	<0.005	<0.01	3.3	0.27	<0.005
GW02	9-Sep-09	17.2	6.96	23.960	6.2	-3.4	10000	10.88	82.0	10000.0	3.10	<0.005	<0.005	<0.01	3.1	0.12	<0.005
GW03	9-Sep-09	15.9	7.11	0.525	1.1	-9.2	200	0.2	82.0	61.0	0.76	0.015	0.011	<0.01	0.75	0.07	<0.005
GW04	9-Sep-09	Insufficient sample for analysis															
GW05	9-Sep-09	16.4	7.23	0.653	0.6	-14.9	3300	0.251	7.0	580.0	3.80	0.015	<0.005	<0.01	3.8	0.07	<0.005
GW06	9-Sep-09	19.4	6.99	0.586	1.3	2.9	1600	0.225	7.0	1600.0	19.00	7.7	0.006	7.6806	12	0.21	<0.005
GW07	9-Sep-09	18.3	7.31	0.278	6.9	-17.1	4900	0.103	78.0	720.0	4.70	1.2	<0.005	1.19727	3.5	0.28	<0.005
GW08	10-Sep-09	18.3	7.3	0.240	0.0	-16.8	1700	0.88	64.0	190.0	2.30	0.38	0.018	0.36144	2	0.22	<0.005
GW09	9-Sep-09	17.2	7.02	0.523	1.0	0.6	-	0.2	-	-	-	-	-	-	-	-	-
GW11	9-Sep-09	18.3	6.73	0.220	6.9	7.8	2500	0.0796	74.0	190.0	3.20	0.12	<0.005	0.119727	3	0.97	0.078
GW12	9-Sep-09	15.5	7.39	8.830	0.5	-22.6	710	8.76	92.0	290.0	3.90	<0.005	<0.005	<0.01	3.9	0.99	0.68
GW01	25-Nov-09	21.9	7.84	3.750	0.2	-65.0	2900	0.91	-	-	3.30	-	<0.1	<0.01	3.2	0.15	<0.005
GW02	25-Nov-09	23.6	6.12	19.690	4.8	28.9	-	-	60.0	6400.0	2.00	-	<0.1	0.02259	1.9	<0.01	<0.005
GW03	25-Nov-09	20.6	7.25	2.258	1.6	-34.5	24000	0.158	50.0	4800.0	1.20	-	<0.1	0.04518	1.2	0.17	0.081
GW04	25-Nov-09	-	-	-	-	-	7000	0.202	-	-	-	-	-	-	-	-	-
GW05	25-Nov-09	22	7.79	0.421	4.2	-48.0	1300	0.093	42.0	9600.0	3.10	-	<0.1	0.04518	3	0.05	<0.005
GW06	25-Nov-09	20.1	6.88	0.533	0.3	9.5	-	0.0534	24.0	13000.0	4.20	-	<0.1	1.06173	3	0.25	<0.005
GW07	25-Nov-09	21.7	7.05	0.251	2.8	-17.9	-	-	39.0	8000.0	3.30	-	<0.1	1.42317	1.8	0.15	0.11
GW08	25-Nov-09	21.6	7.55	0.148	1.9	-36.4	3700	0.097	-	-	2.80	-	<0.1	0.24849	2.4	0.09	0.16
GW09	25-Nov-09	-	-	-	-	-	8800	12	-	-	-	-	-	-	-	-	-
GW11	25-Nov-09	21.3	6.91	0.263	0.9	-9.6	-	-	21.0	6400.0	2.30	-	<0.1	0.51957	1.7	0.48	0.11
GW12	25-Nov-09	19.9	7.68	26.6	0.2	-51.5	-	-	71.0	11000	2.70	-	<0.1	<0.01	2.6	1.4	<0.005
GW01	23-Mar-10	Insufficient sample for analysis															
GW02	23-Mar-10	Insufficient sample for analysis															
GW03	23-Mar-10	Insufficient sample for analysis															
GW04	23-Mar-10	Insufficient sample for analysis															
GW05	23-Mar-10	Insufficient sample for analysis															
GW06	23-Mar-10	23.2	6.02	0.578	0.0	30.1	-	0.22	120.0	120.0	-	-	-	-	-	-	<0.005
GW07	23-Mar-10	Insufficient sample for analysis															
GW08	23-Mar-10	Insufficient sample for analysis															
GW09	23-Mar-10	Insufficient sample for analysis															
GW11	23-Mar-10	Insufficient sample for analysis															
GW12	23-Mar-10	Insufficient sample for analysis															
GW01	24-Jun-10	17.9	7.81	4.22	0.1	-43.5	918.000	1.75	5	91	-	0.05	<0.01	0.05	2.2	0.17	0.02
GW02	24-Jun-10	Insufficient sample for analysis															
GW03	24-Jun-10	16.3	7.73	0.824	0.3	-38.8	<5	0.318	6	30	-	7.55	<0.01	7.55	9	0.05	<0.01
GW04	24-Jun-10	16.1	8.02	0.422	1.4	-53.5	-	0.198	-	-	-	0.06	0.02	0.03	1.9	0.26	0.07
GW05	24-Jun-10	15.5	7.27	0.783	4.8	-11.7	320.000	0.304	<2	93	-	0.58	<0.01	0.58	2.8	0.1	<0.01
GW06	24-Jun-10	19.6	6.81	0.638	0.0	26.2	1420.000	0.246	8	197	-	0.08	<0.01	0.08	2.6	0.3	<0.01
GW07	24-Jun-10	Insufficient sample for analysis															
GW08	24-Jun-10	Insufficient sample for analysis															
GW09	24-Jun-10	Insufficient sample for analysis															
GW11	24-Jun-10	Insufficient sample for analysis															
GW12	24-Jun-10	16.9	8.18	7.23	4.4	-62.0	-	3.05	-	-	-	0.54	<0.01	0.54	2.6	0.52	0.07
GW01	23-Sep-10	19.1	7.85	4.61	2.7	-	390	1.93	-	-	8.5	0.07	<0.01	0.07	8.4	1.08	<0.01
GW02	23-Sep-10	19.6	4.15	3.3	3.6	-	306	1.1	-	-	<1.0	0.02	<0.01	0.02	<1.0	0.95	<0.01
GW03	23-Sep-10	18.2	7.38	5.53	1.8	-	422	2.05	-	-	1.2	0.06	<0.01	0.06	1.1	0.08	<0.01
GW04	23-Sep-10	-	-	-	-	-	220	-	-	-	7.8	4.02	0.07	3.95	3.8	0.64	<0.01
GW05	23-Sep-10	18.2	7.16	4.9	4.3	-	30	1.86	-	-	6.2	4.5	<0.01	4.5	1.7	0.12	<0.01
GW06	23-Sep-10	20.3	6.29	10.52	3.0	-	-	4.09	-	-	-	-	-	-	-	-	-
GW07	23-Sep-10	Insufficient sample for analysis															
GW08	23-Sep-10	Insufficient sample for analysis															
GW09	23-Sep-10	-	-	-	-	-	-	-	-	-	4.1	0.04	<0.01	0.04	4.1	1.11	0.08
GW11	23-Sep-10	21.2	7.22	8.41	4.2	-	60	0.324	-	-	2.1	0.61	<0.01	0.61	1.5	0.26	0.05
GW12	23-Sep-10	16.7	7.24	2.076	3.2	-	-	0.933	-	-	-	-	-	-	-	-	-
GW01	15-Dec-10	29.8	7.87	40.6	5	-	-	14	-	-	8.9	<0.01	-	-	8.9	0.39	-
GW02	15-Dec-10	25.9	4.86	15.8	4.2	-	1060	7.3	-	-	2.1	0.02	<0.01	0.02	2.1	0.24	0.01
GW03	15-Dec-10	26	8.17	20.1	-	-	-	6.46	-	-	-	-	-	-	-	-	-
GW04	15-Dec-10																
GW05	15-Dec-10																
GW06	16-Dec-10	23.3	6.7	1.075	6.2	-	686	0.417	-	-	-	-	-	-	-	-	-
GW07	15-Dec-10	Insufficient sample for analysis															
GW08	15-Dec-10	Insufficient sample for analysis															
GW09	15-Dec-10	Insufficient sample for analysis															
GW11	15-Dec-10	Insufficient sample for analysis															
GW12	15-Dec-10	25	6.98	20.98	3.0	-	1480	9.8	-	-	8.4	0.08	0.02	0.05	8.3	1.5	0.09

Bore ID	Groundwater Levels, mAHD (mBGL)		
	14/06/16	**15/07/16**	**22/07/16**
MB01	#N/A	#N/A	11.98
	#N/A	#N/A	(3.01)
MB02	9.47	10.03	10.26
	(2.79)	(2.23)	(2)
MB03	9.19	9.79	9.97
	(2.71)	(2.1)	(1.92)
MB04	8.35	8.92	9.08
	(2.71)	(2.14)	(1.98)
MB05	7.39	8.17	8.44
	(4.07)	(3.29)	(3.02)
MB06	7.82	8.47	8.7
	(4.53)	(3.88)	(3.65)
MB07	6.42	6.93	7.13
	(2.63)	(2.12)	(1.92)
MB08	#N/A	#N/A	7.8
	#N/A	#N/A	(2.15)
MB09	#N/A	#N/A	13.22
	#N/A	#N/A	(0.92)
GW11	#N/A	9.26	9.36
	#N/A	(2.89)	(2.79)
GW1	12.4	12.32	12.59
	(0.39)	(0.47)	(0.2)

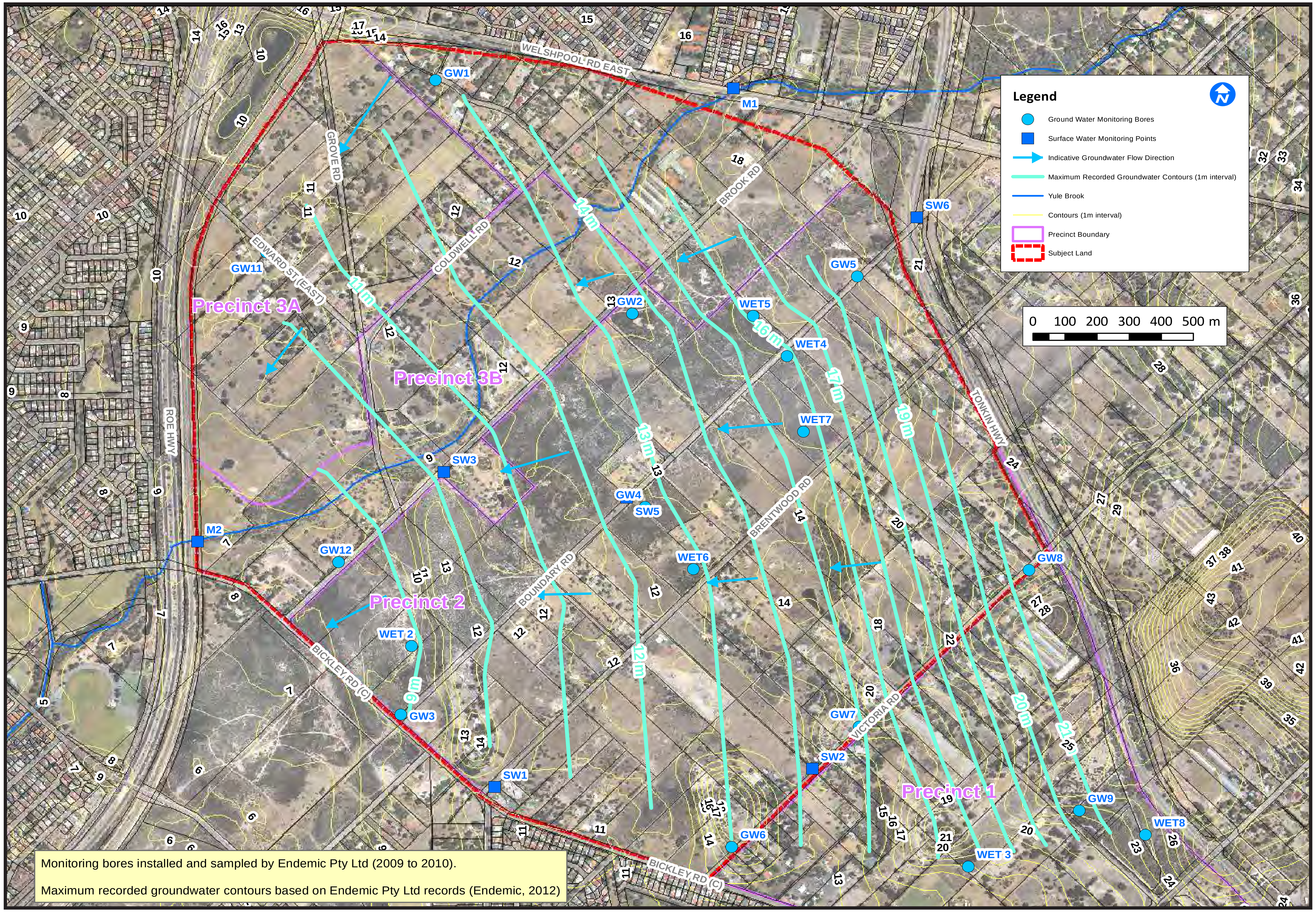

Figure 10 - Maximum Recorded Groundwater Contour Map

(Source: Endemic, 2012)

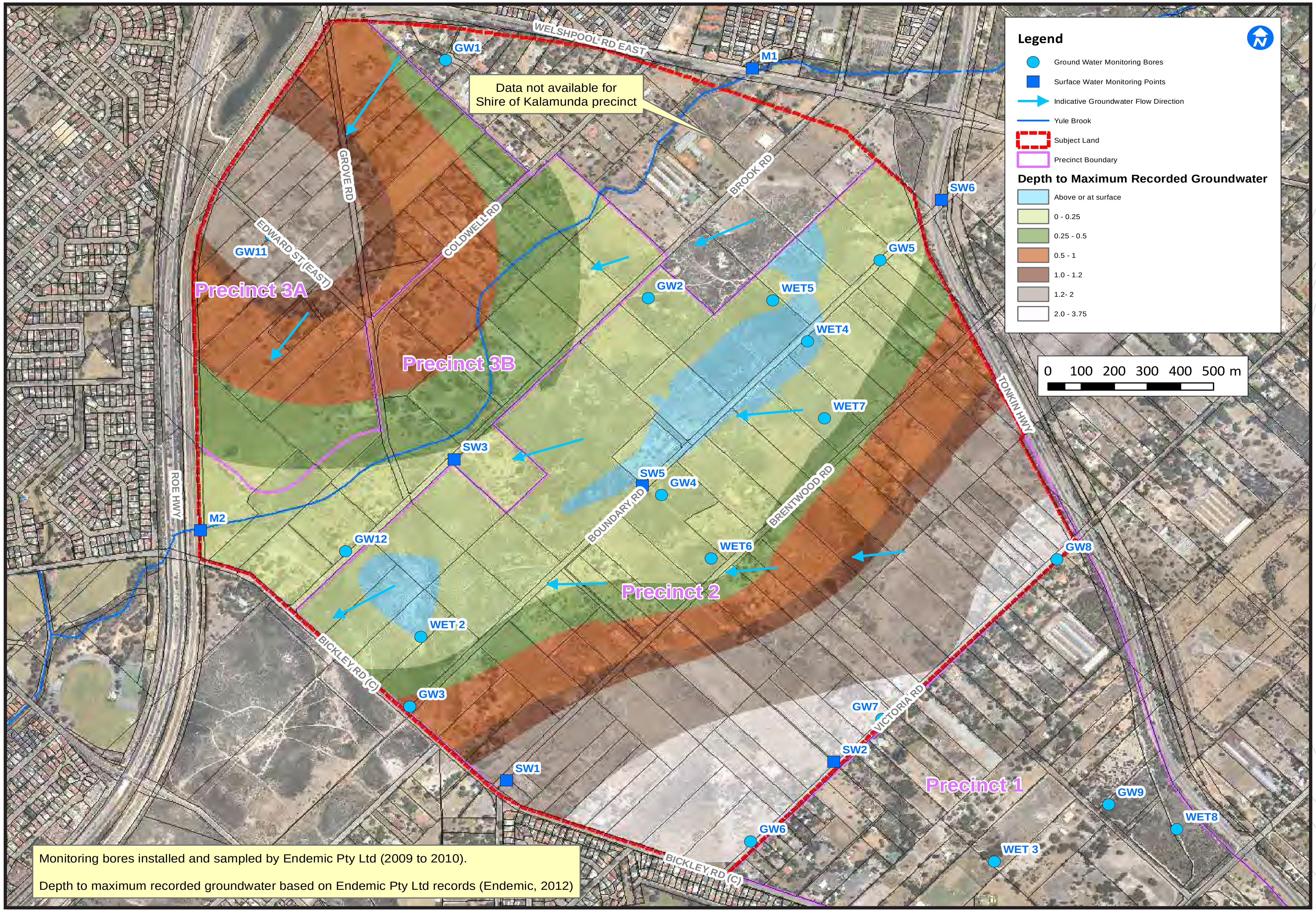

Figure 11- Depth to Maximum Recorded Groundwater Map

(Source: Endemic, 2012)

APPENDIX F

MODELLING ASSUMPTIONS REPORT

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MODELLING ASSUMPTIONS

MKSEA PRECINCT 3A

Project Number EP14-056

Prepared for Linc Property Pty Ltd
January 2017

Document Control

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Table of Contents

1 Modelling Assumptions

XPSWMM hydrological and hydraulic modelling software was used to calculate the surface water runoff volumes and peak flows for the Maddington Kenwick Strategic Employment Area (MKSEA) Local Water Management Strategy (LWMS).

A 2D pre-development model was constructed using a Digital Elevation Model (DEM) based on LiDAR and Water Corporation data. A 1D post-development surface runoff model was then dynamically coupled with a 2D model of the broader Yule Brook floodplain between Welshpool Road East and Roe Highway.

The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrologic model include:

- Runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment.
- Sub-catchment areas and slopes are determined from surveyed topographical data and earthworks plans.
- Infiltration assumptions and percentage imperviousness based on experience with model preparation for similar soil conditions.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSWMM. Assumptions associated with the 1D hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow path onsite) between nodes within a sub-catchment are given the length of 10 m and slope of 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a ‘storage’ node, a ‘dummy intermediate’ node or a conduit/link.
- Links between sub catchment storages act as conveyance channels (e.g. sheet flow within roads in 100 year Average Recurrence Interval (ARI) event). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- All channels are designed with a width of 5 m, roughness of 0.013 (Manning’s n) and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Lot detention areas (LDAs) and flood storage areas (FSAs) are modelled as nodal-reservoirs with no infiltration.
- Ponding conditions have been limited to 5% of total storage volume for LDAs.

The 1D hydraulic component of the post-development model is linked to the 2D hydraulic component of the model through nodes and natural channel sections. Interconnection allows the 2D surface runoff to enter and exit from the 1D components dynamically depending on the hydraulic head of the connected 2D cells and 1D elements.

1.1 Digital elevation model

In order to model the 2D surface runoff a DEM was created using survey data provided by the proponent for the area bounded by Roe Highway to the north and west, Welshpool Road to the east and Brook Road to south.

LiDAR data from the Department of Water (DoW) was used to extend coverage of the DEM to include additional area east of Welshpool Road. This allowed the 2D model boundary to extend across upstream catchments in order to assess breakout flows originating from Yule Brook at the Welshpool Road culvert and the associated flow paths along Welshpool Road.

The DEM was clipped along the northern side of Welshpool Road to represent a limestone wall at this location i.e. local runoff and breakout flow through Welshpool Road is allowed to flow westwards only.

The DEM was further updated based on aerial imagery at some of the locations where flown survey data seemed to be disturbed by heavy vegetation cover. Erosion of some of the natural channel sections near culverts was not picked up by the survey. Culvert invert data based on site survey and long sections provided by the Water Corporation were used to refine the DEM. Elevation shapes were used to rectify any irregularities (spikes) of the DEM along some of the road sections.

1.2 Grid size and time step

A 2D grid size of 5 m x 5 m was used to model both the pre-development and post-development environments. The selected size of the grid elements is adequate to represent the Yule Brook floodplain for the purpose of modelling runoff conveyance/breakout flows. 1D channels were used to detail the areas that cannot be covered by the selected grid size e.g. the toe of Yule Brook, which can be less than 5 m wide.

A 2D time step of 2.5 s was used to stabilize the model.

1.3 1D-2D connection

1D-2D connections were provided to link the 2D overland flow in and out of the natural channels and Yule Brook which were modelled as 1D components.

1.4 Rainfall on grid

Rainfall on grid was used to model the pre-development environment so that the runoff is hydraulically routed after allowing for infiltration and storage losses within the catchment.

2 Pre-development Model

A 1D-2D coupled pre-development model was created to assess the pre-development hydrology within the development site and the flood regime within Yule Brook.

The pre-development catchment area modelled as a 2D extent consists of 223.4 ha. The breakdown of catchment areas within the development site and external catchment are given in **Table 1**. Pre-development catchment boundaries contributing to the development site are shown in Figure 7 of the LWMS.

Table 1 Pre-development catchments

Sub-catchment	Area (ha)
Development site	90.3
External catchment	133.1
Total	223.4

An “initial loss - continual loss” infiltration model was adopted to represent the pre-development environment. Infiltration loss and surface roughness parameters were refined through a model calibration process. Pre-development land-use characteristics are summarised in **Table 2**. Higher Manning’s values were used to represent buildings to simulate the limited overland flow paths.

Table 2 Pre-development land-use characteristics

Land type	Initial loss (mm)	Continual loss (mm/hr)	Manning's n
Road Surface	0	0	0.014
Buildings	1	0.1	3
Clayey sand	9	1	0.05
Sand (S8 & S10)	12	2.5	0.08
Sandy silt	5	0.5	0.08

2.1 Yule Brook

The accuracy of the flown data along Yule Brook at some locations was disturbed by the heavy vegetation cover. Further, a grid size of 5 m x 5 m is not fine enough to detail the toe of Yule brook. Therefore Yule Brook was modelled as a 1D channel that connected to 2D floodplain to eliminate any DEM errors.

The 1D natural cross sections of the Brook were generated using the DEM. The 1D flow within Yule Brook was linked to a broader flood plain using 1D-2D connections and water level lines.

A Manning’s values between 0.025 - 0.035 were used for Yule Brook after the model calibration.

2.2 Culverts

Details of culverts that were included in the model are provided in the **Table 3**. These culverts were assigned Manning's values of 0.013. The entry and exist losses for culverts with different sizes and shapes were selected from the calibration process, and based on varying entry and exit conditions near the culverts. Culvert inlet types were selected based on aerial imagery.

Table 3 Modelled culverts

Culvert name	Culvert Details	Length (m)	DS Invert elevation (m AHD)	US Invert elevation (m AHD)	Source
Roe Hwy Culvert	3 x 2.4 x 1.8	71.0	4.20	4.66	Water Corporation
Cross Rd 1 Culvert	3 x 1.5	5.0	5.20	5.24	Water Corporation
Railway Culvert	3 x 2.4 x 1.8	12.0	5.57	5.53	Water Corporation
Cross Rd 2 Culvert	3 x 1.5	7.0	6.94	6.95	Water Corporation
Grove Rd Culvert	1 x 1.8 1 x 1.8	9.7	7.01 7.14	7.02 7.20	Survey
Cross Rd 3 Culvert	Plate 1.2 x 1.8	6.0	8.47	8.87	Aerial + DEM
Cross Rd 4 Culvert	Plate 1.2 x 1.8	4.0	9.60	9.70	Water Corporation
Cross Rd 5 Culvert	Plate 1.2 x 1.8	4.0	8.47	8.87	Water Corporation
Cross Rd 6 Culvert	Plate 1.2 x 1.8	4.0	9.98	10.11	Water Corporation
Cross Rd 7 Culvert	Plate 1.2 x 1.8	4.0	13.40	13.52	Aerial + DEM
Cross Rd 8 Culvert	Plate 1.2 x 1.8	4.0	14.00	14.29	Aerial + DEM
Welshpool Rd Culvert	2 x 1.8 x 1.5	76.0	13.85	14.08	Water Corporation
Lot 3.1 Culvert	2 x 0.6	6.0	9.51	9.72	Aerial + DEM
Lot 3.2 Culvert	2 x 0.6	6.0	10.08	9.90	Aerial + DEM

2.3 Pre-development upstream catchment inflows

Pre-development upstream catchment inflows to Yule Brook at the Welshpool Road culvert and southern catchments were provided by the Water Corporation. These inflows are shown in Figure 9 of the LWMS.

The inflows to Precinct 3A from Yule Brook breakout flows along Welshpool Road (three locations) were accounted for in the model as inflow hydrographs, based on breakout flow hydrographs and information provided by the Water Corporation.

3 Critical duration analysis

The critical duration for runoff from the local catchments within the site is different to the critical duration of the larger Yule Brook catchment.

A critical duration analysis was undertaken for the 10 year and 100 year ARI flows based on pre-development peak inflows from northern catchments to Yule Brook (provided by Water Corporation). This location was selected to define the critical duration of the local catchments within the site.

This analysis considered rainfall events from 1 hour to three days. The 10 year ARI event critical duration analysis for the local catchments is shown in **Plate 1** and the 100 year ARI event analysis is shown in **Plate 2**. The 10 year ARI event critical duration for the local catchments was determined to be 36 hours and the 100 year ARI critical duration was determined to be 24 hours.

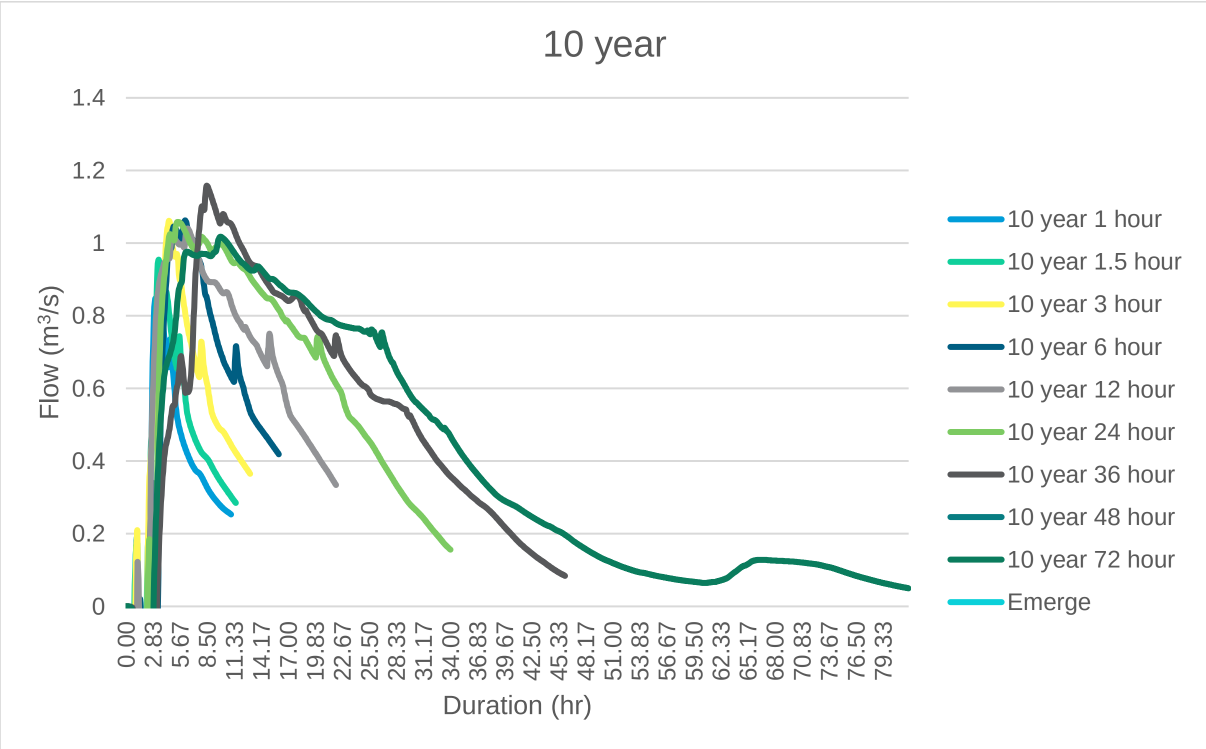

Plate 1 10 year ARI event critical duration analysis of local catchments

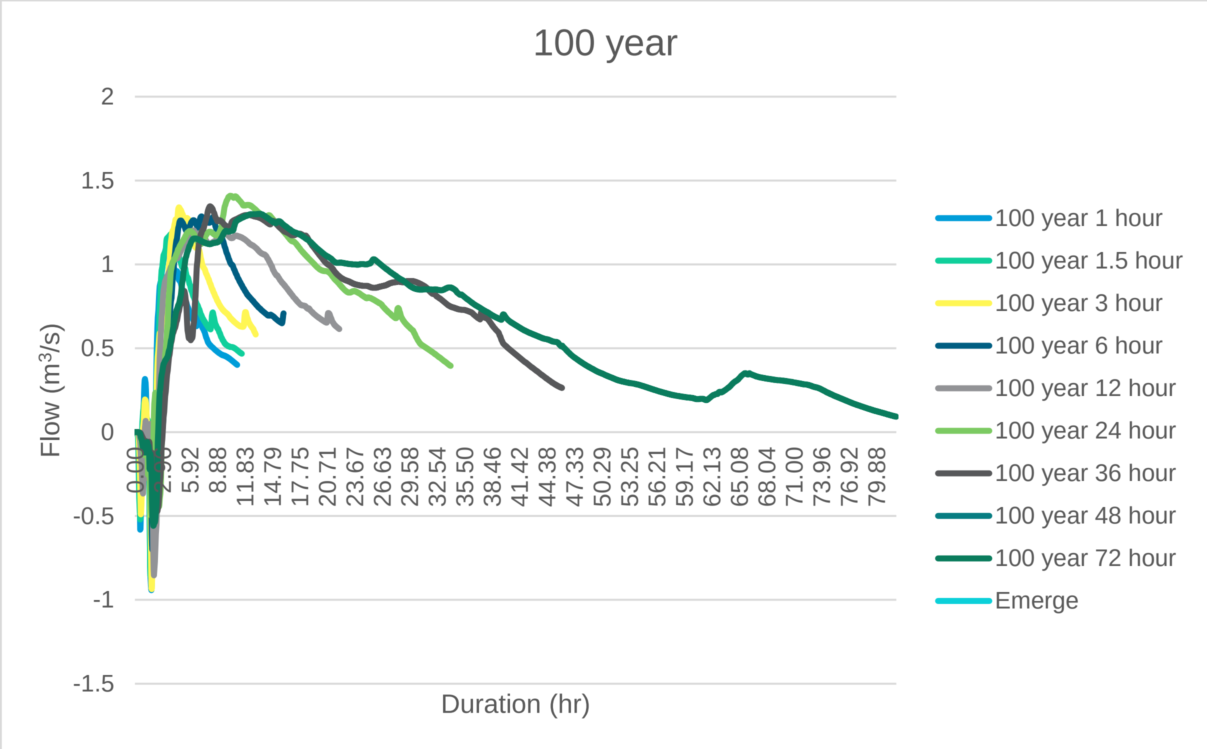

Plate 2 100 year ARI event critical duration analysis of local catchments

The peak flows at the culvert under Roe Highway was also considered when determining the critical duration event for the broader flood regime within the Yule Brook.

The 10 year ARI event critical duration analysis of the broader Yule Brook catchment is shown in **Plate 3** and the 100 year ARI event analysis is shown in **Plate 4**. The 10 year ARI event critical duration of the broader Yule Brook catchment was determined to be 48 hours and the 100 year ARI critical duration was determined to be 36 hours.

Ultimately, the 36 hour duration event was selected as the critical duration for both the 10 year and 100 year ARI events.

The critical duration that facilitates the maximum breakout flow through the Welshpool Road was the 100 year ARI 1 hour ARI event. Proposed channels along the Coldwell Road and through the development which convey this breakout flow were also tested for this rainfall scenario.

The results show that all the designed channels are capable of conveying the 100 year ARI 1 hour event worst case breakout flow.

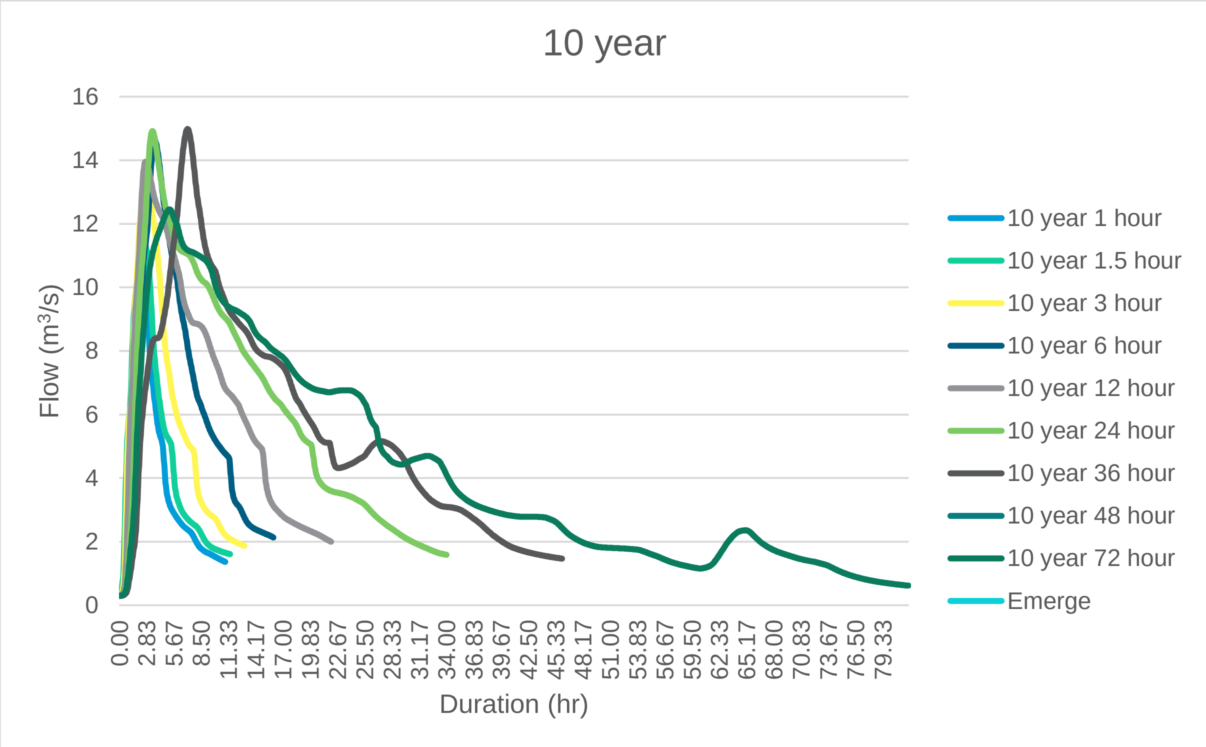

Plate 3 10 year ARI event critical duration analysis of broader Yule Brook catchment

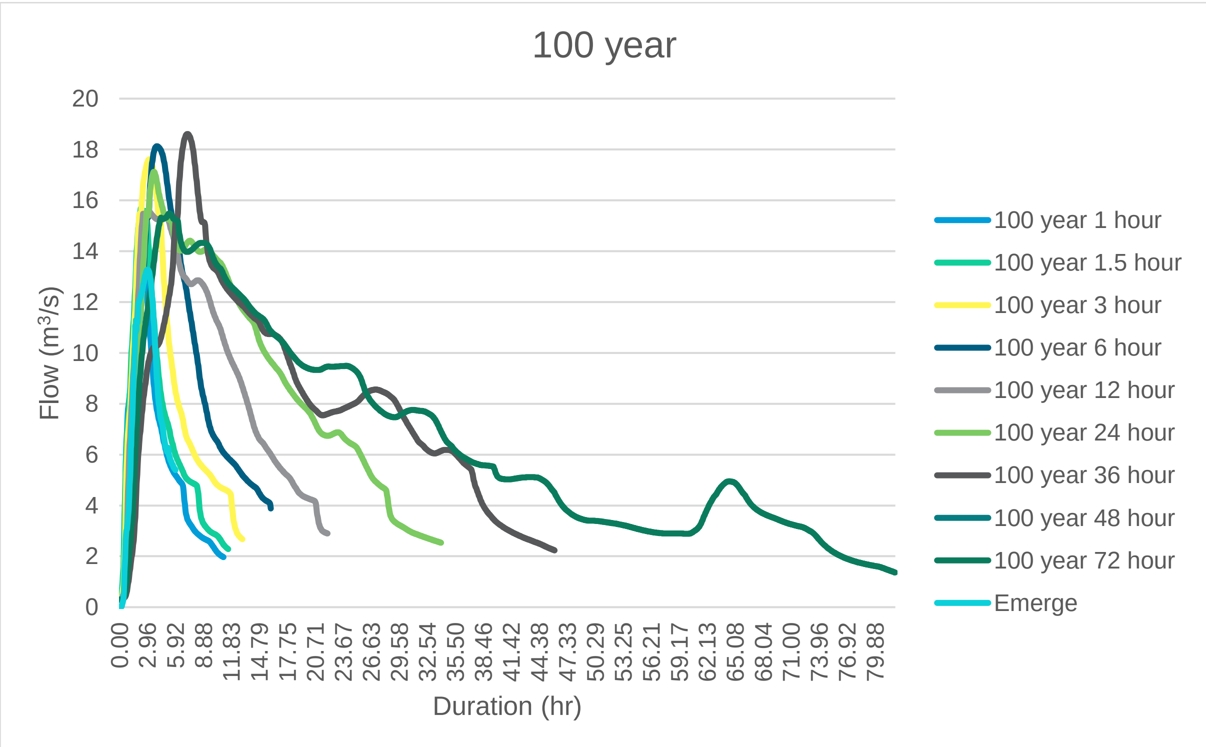

Plate 4 100 year ARI event critical duration analysis of broader Yule Brook catchment

4 Model Calibration

The pre-development model was calibrated by comparing peak flows at different locations along Yule Brook and the flood inundation results at properties along Welshpool Road that had previous flooding issues. The model was calibrated using the 10 year ARI 36 hour duration event and the 100 year ARI both long and short duration events of 36 hours and 1 hour.

The pre-development model was further calibrated to the Water Corporation model which has been verified using real-time data from major historical flood event events. The Water Corporation model itself has also been calibrated to flow data which exists further downstream of the site. The model was calibrated by varying the catchment land-use properties, roughness values within Yule Brook and culvert loss values.

The calibrated peak flows and Water Corporation peak flows are provided in **Table 4**.

Table 4 Peak flow comparisons between the calibrated model and Water Corporation data

Location	100 year 1 hour peak flow (m^3/s)		100 year 36 hour peak flow (m^3/s)		10 year 36 hour peak flow (m^3/s)	
	Water Corporation	Emerge	Water Corporation	Emerge	Water Corporation	Emerge
Inflow						
Yule Brook upstream	19.05	19.05	15.88	15.88	12.42	12.42
Southern catchments	2.35	2.35	2.55	2.55	2.42	2.42
Outflow						
Breakout flow through Welshpool Road	3.08	3.49	1.14	1.20	0.00	0.00
Culvert under Roe Hwy	14.48	13.31	18.64	18.64	14.99	14.35

The model calibration outflow hydrographs at the culvert under Roe Highway for the 100 year ARI 1 hour duration event is shown in **Plate 5**, the 10 year ARI 36 hour duration event is shown in **Plate 6** and the 100 year ARI 36 hour duration event shown in **Plate 7.**

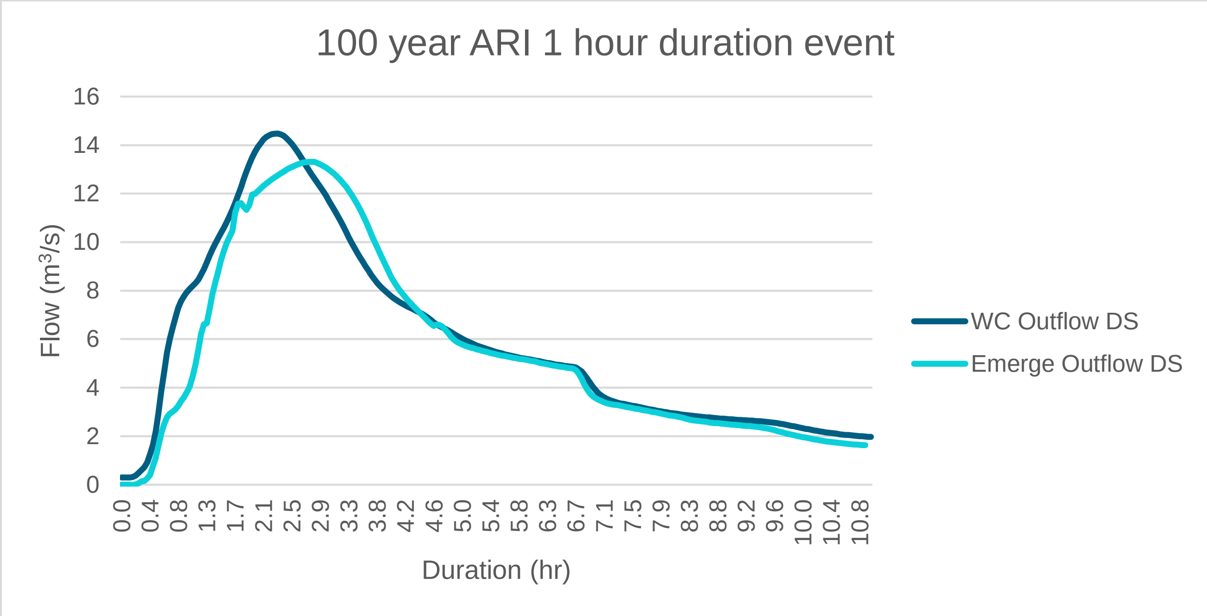

Plate 5 100 year ARI 1 hour duration event hydrograph comparison

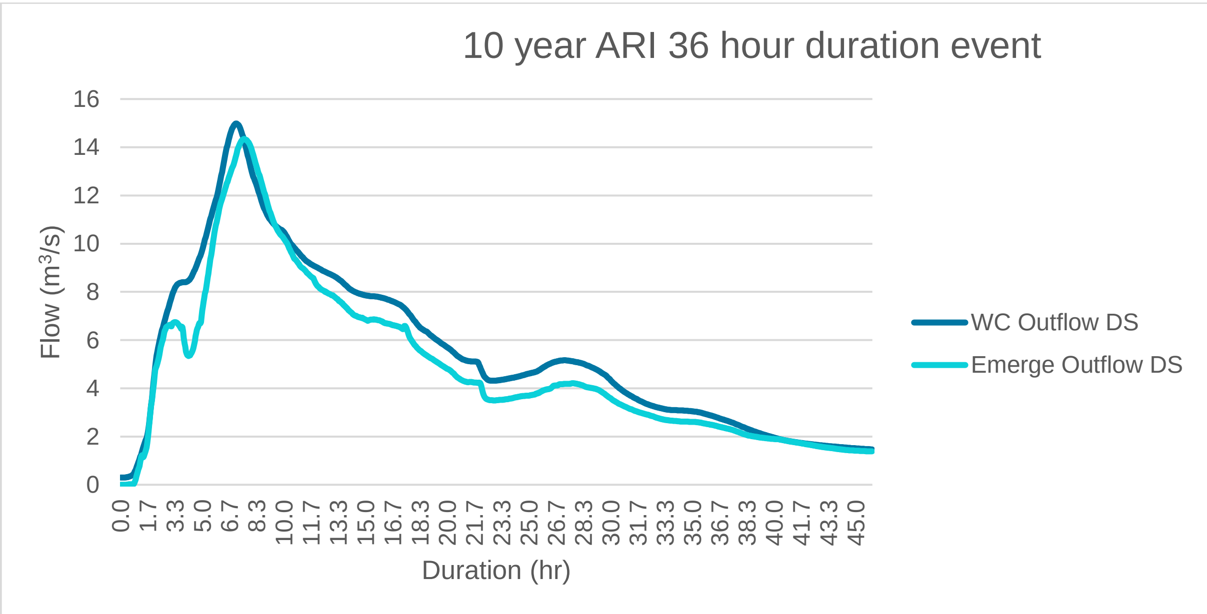

Plate 6 10 year ARI 36 hour duration event hydrograph comparison

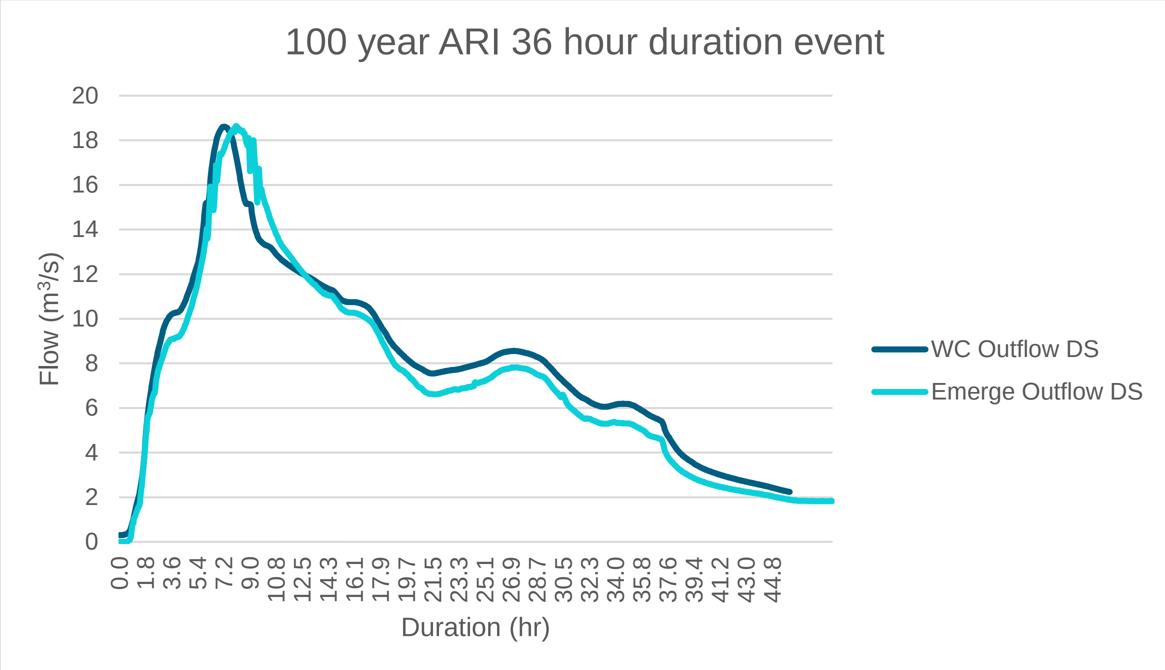

Plate 7 100 year ARI 36 hour duration event hydrograph comparison

Flow hydrograph regression at the culvert under Yule Brook for the 100 year ARI 36 hour duration event of the modelled results against the Water Corporation results are shown in **Plate 8**.

The R-squared (R^2) value for the 100 year ARI 36 hour duration flow regression chart is 0.973. Similarly, the R^2 for the 100 year ARI 1 hour event is 0.925 and 10 year 36 hour duration event is 0.971. The high R^2 value confirms a close fit between the Emerge and Water Corporation model results.

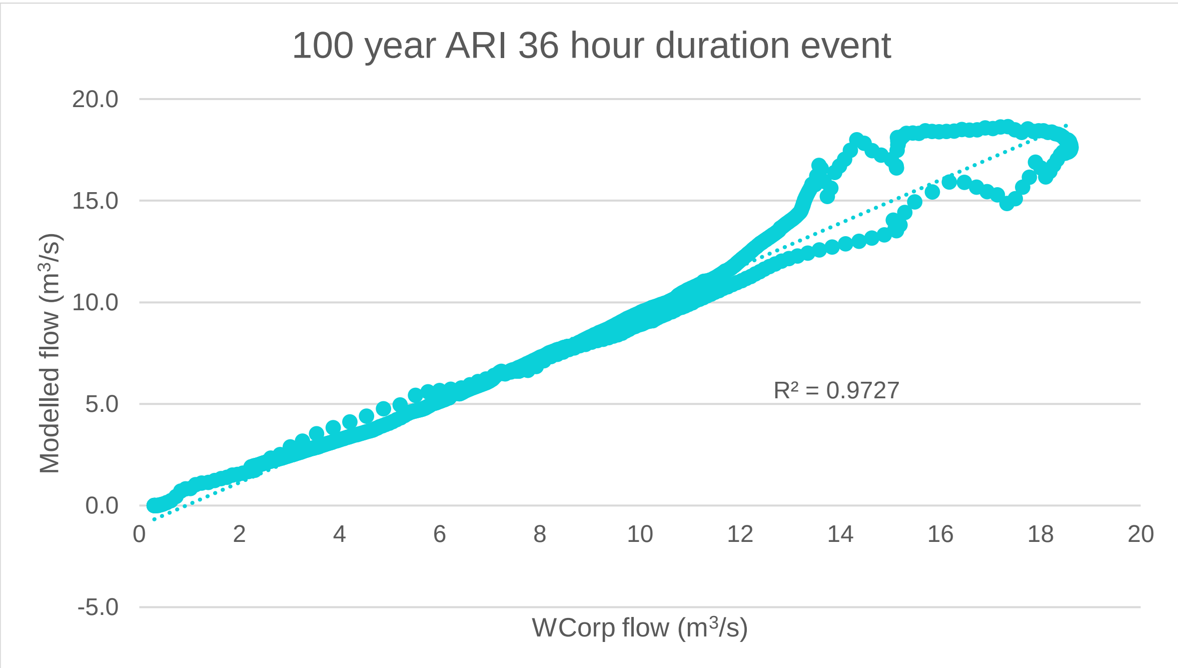

Plate 8 100 year ARI 36 hour duration event flow regression analysis

5 Post-development Model

The calibrated pre-development model was used to create the post-development model.

5.1 Post-development catchment hydrology

The post-development catchment areas were taken from the earthworks plan provided by the project team (Cossil & Webley 2016). Land types within the catchments were guided by the Local Structure Plan (LSP) (TBB 2016). Post-development catchment parameters are given in **Table 5** and are shown in Figure 7 of the LWMS.

Table 5 Post-development catchments

Sub-catchment	Area					
	Total area	Total road	Total lot	Impervious	Pervious	POS/ swales
Ct1	3.532	0.000	3.532	0.000	0.000	0.000
Ct10	8.260	0.000	5.760	0.000	0.000	2.500
Ct11	3.910	1.350	0.000	2.432	0.128	0.000
Ct12	9.317	2.280	0.000	6.685	0.352	0.000
Ct13	5.455	0.285	5.170	0.000	0.000	0.000
Ct18	9.401	1.425	7.976	0.000	0.000	0.000
Ct19	9.872	0.966	8.906	0.000	0.000	0.000
Ct2	6.523	1.082	5.441	0.000	0.000	0.000
Ct17	4.360	0.000	0.000	2.717	0.143	1.500
Ct3	5.284	0.656	4.629	0.000	0.000	0.000
Ct4	7.534	1.722	5.811	0.000	0.000	0.000
Ct6	5.682	1.294	4.388	0.000	0.000	0.000
Ct7	7.688	1.131	6.557	0.000	0.000	0.000
Ct8	4.541	0.420	4.121	0.000	0.000	0.000
Ct9	2.462	0.600	1.602	0.000	0.000	0.260
Ct15	0.662	0.000	0.000	0.000	0.000	0.662
Ct16	0.626	0.000	0.000	0.000	0.000	0.626
Ct Welshpool Rd	3.818	3.818	0.000	0.000	0.000	0.000
Total	100.888	17.030	65.854	11.834	0.623	5.548

An “initial loss - continual loss” infiltration model was adopted to represent the post-development environment, with loss values chosen based on project team experience with similar development areas in Perth. Post-development land-use characteristics are provided in **Table 6**.

Table 6 Post-development land-use characteristics

Land type	Initial loss (mm)	Continual loss (mm)	Manning's n
Road Surface	1	0.1	0.014
Road Verge	12.5	1	0.02
Roof	1	0.1	0.014
Lot IMP	1	0.1	0.014
Landscaped areas	20	2.5	0.02
POS	20	2	0.05

Catchment parameters and "initial loss – continual loss" rates used were predominantly based upon the following assumptions:

- Industrial lots have 50% roof area, 45% impervious area (e.g. pavement and hardstand) and 5% landscaped area out of total lot area.
- Lots owned by Perth Transport Authority (PTA) have 95% impervious area and 5% pervious area out of the total lot area. These lot proportions are based on the lot proportions of similar areas in Perth close to freight terminals.
- Road reserves within the site are 50% pervious verge and 50% impervious bitumen.
- There are no infiltration on roads, pavements and driveways. There are however some minor absorption storage losses, which is accounted for in the initial and continuing loss rates given in **Table 6**.
- Landscaped areas have high infiltration rates as it is likely that sand-based landscape mix or mulch will be used.
- Drainage reserves likely contain dense vegetation over a sand-based landscape mix. This will become compacted over time and reduces initial infiltration rates.
- The road verge area have similar infiltration characteristics to drainage reserves except that these also have an impervious fraction for vehicle crossings and footpaths. It is anticipated that the averaged initial loss and continual loss will be lower than the drainage reserve rates.
- Standard industrial lots will have their own detention of 350 m^3/ha. This storage detains the 100 year event runoff. Excess runoff from lot detention is routed to the downstream 100 year flood detention basin (FDB).
- The downstream 100 year ARI FDB detains excess runoff from road reserves and lots. Outflow is controlled by orifice at the bottom and a weir at the top to match 10 year and 100 year ARI event pre and post-development peak flows from the site.
- There is no infiltration from any detention basin or swales due to low permeability of underlying soils and proximity to groundwater.

5.2 Post-development upstream catchment inflows

The upstream inflows determined for use in the pre-development were used as an input to the post-development model (shown in the Figure 9 of the LWMS).

5.3 Conveyance swales

Conveyance swales are modelled as trapezoidal or V-shaped channels with 1.0 m depth, 12 m - 15 m width and 1:6 side slopes. Longitudinal grade is driven by the earthworks provided by the project team and minimum grades were 1:680. Flow conveyance swales are assumed to be vegetated to treat the first 15 mm of runoff from road reserves. These vegetated swales are represented by low grades and Manning's number of 0.035.

5.4 Model conclusions

The post-development model results detailed in the LWMS demonstrate that the proposed development, inclusive of detention storages detailed in the LWMS, shown in LWMS Figure 9 and summarised in **Table 7,** is able to meet the peak flow requirements of the Water Corporation for Yule Brook, and is able to match the pre-development peak flow regime to the wetland adjacent to Yule Brook.

Table 7 10 year ARI and 100 year ARI event detention volumes and design assumptions

Detention storage	100 Year ARI event		10 Year ARI event	
	TWL area (m^2)	Volume (m^3)	TWL area (m^2)	Volume (m^3)
Total lot detention		23,400		18,050
Swale 1		2,700		650
Swale 2		11,700		1,400
Swale 3		7,200		700
Swale 4		5,900		400
Total swale detention		27,500		3,150
Basin A – Linc acquisition area	13,400	14,200	11,900	7,000
Basin B – PTA Land	14,100	15,000	12,700	8,350
Basin C – Shire of Kalamunda portion of Precinct 3A	6,950	7,000	6,000	3,750
Basin D – Coldwell Road North	4,000	3,800	3,600	2,800
Total FDB storage	38,450	40,000	34,200	21,900
Total detention provided		90,900		43,100

It will be acceptable for the swale and basin configurations detailed in **Table 7** to be varied during the detailed design process, provided it can be demonstrated that the total design volume is achieved in some form.

APPENDIX G

EARTHWORKS PLAN AND ROAD CROSS-SECTION

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REV	DATE	DRN	CKD	APP	AMENDMENT
B	09.09.16	JAE			ISSUED FOR INFORMATION
A	25.08.16	JAE	-	-	ISSUED FOR INFORMATION

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APPROVED 09.09.16

DESIGNED JAE

SCALE 1:3000

PROJECT KENWICK INDUSTRIAL

TITLE PRELIMINARY DESIGN SURFACE OPTION 11

WAPC No.

DRAWING No. 6174-00-SK25

REVISION B

ORIGINAL SIZE A1

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APPENDIX 5
ENGINEERING REPORT

Cossill & Webley
CONSULTING ENGINEERS

ENGINEERING REPORT MADDINGTON-KENWICK STRATEGIC EMPLOYMENT AREA – PRECINCT 3A (incl KALAMUNDA WEDGE)

January 2017

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CONTENTS

1. Executive Summary

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Shire of Kalamunda Maddington-Kenwick Strategic Employment Area – Kalamunda Wedge Precinct 3A Local Planning Scheme amendment. The report also includes the corresponding Precinct 3A area within the City of Gosnells, recognising the rezoning and development of this broader area is similar in nature, has already been considered during planning within the City of Gosnells and will need to be coordinated across the Precincts. It summarises the results of a review of the civil engineering issues which will influence the form of the development and which are related to the future servicing of the rezoned land.

This report provides details for each major infrastructure type and a servicing strategy for implementation required for the development of Precinct 3A of the MKSEA. The level of detail is consistent with the requirements of a local structure plan and acknowledges further more detailed work will be required at the time of land development.

The engineering review has covered siteworks, roadworks, stormwater drainage, sewerage, water supply and utility services.

The investigation has found the land is capable of development in accordance with the proposed Local Structure Plan with logical progressive extension of infrastructure.

The ground conditions and past uses will not limit the proposed development.

The existing road access from the Welshpool Road/Coldwell Road intersection is proposed to be upgraded to a signalised intersection to provide road access for traffic predominately to and from the east. An additional access is proposed at the existing Hale Road/Welshpool Road signalised intersection. It is proposed this intersection will be upgraded to incorporate Right In, Left In and Left Out movements to/from MKSEA for predominately traffic to/from the west. The existing Grove Road will be realigned to connect to the Hale Road intersection. No direct access to Hale Road is proposed from Precinct 3A.

Sewer connection to the land is remote and not currently available, however, may be possible via construction of a wastewater pump station and extension of a pressure main under the freight railway and Roe Highway. Given the high cost associated with implementing this outcome, this is likely to require a commitment from Water Corporation as part of its Capital Infrastructure Works. In any event, waste water treatment could be achieved via connection to alternative treatment units (ATUs) on site.

Water supply will be provided via an extension of the existing DN200 main along Grove Road. Future upgrades of existing mains may be required to provide adequate services to the proposed industrial development.

Initial electrical supply can be provided by connection to the existing infrastructure along Edward Street and Coldwell Road. Future reinforcement of the power supply may be required.

Telecommunications and gas are available from existing services along Welshpool Road and Coldwell Road. The investigations and preparation of this report is largely based on preliminary advice from the various service authorities. The information is current as of April 2016.

2. Introduction

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Shire of Kalamunda Maddington-Kenwick Strategic Employment Area – Kalamunda Wedge Precinct 3A Local Planning Scheme amendment. It summarises the results of a review of the civil engineering issues which will influence the form of the development and which are related to the future servicing of the rezoned land.

The preparation of the Local Planning Scheme amendment and related planning processes has been carried out by a team of consultants, led by TBB planning consultants on behalf of Linc Property Pty Ltd.

The MKSEA Precinct 3A area (including the Kalamunda Wedge Precinct 3A area) is identified by the red boundary presented below in *Figure 1*.

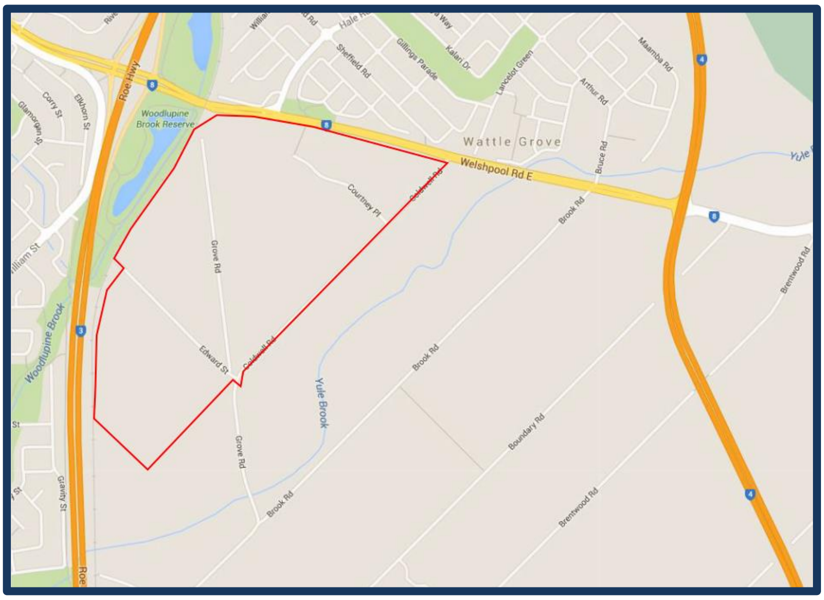

Figure 1 - Site Plan (Google Maps 2015)

3. SITE DESCRIPTION

The Site is approximately 95 hectares in area and is situated approximately 12.5 kilometres south east of the Perth city centre, within the City of Gosnells and Shire of Kalamunda.

3.1 Acid Sulphate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the South Metropolitan Region for potential for acid sulphates soils (ASS) indicates the Site is classified as having a low to moderate potential risk of ASS.

3.2 Geology and Landform

The Geological Survey of Western Australia Perth Metropolitan Region Soils Maps (Refer *Figure 3*) indicates that the Site is generally covered with sand overlaying sandy clay to clayey sand in the south and clayey sand in the north.

It is recommended that geotechnical investigations are completed prior to finalisation of subdivision designs to confirm the existing ground conditions, and provide recommendations on the earthworks and fill requirements, as well as inform drainage design.

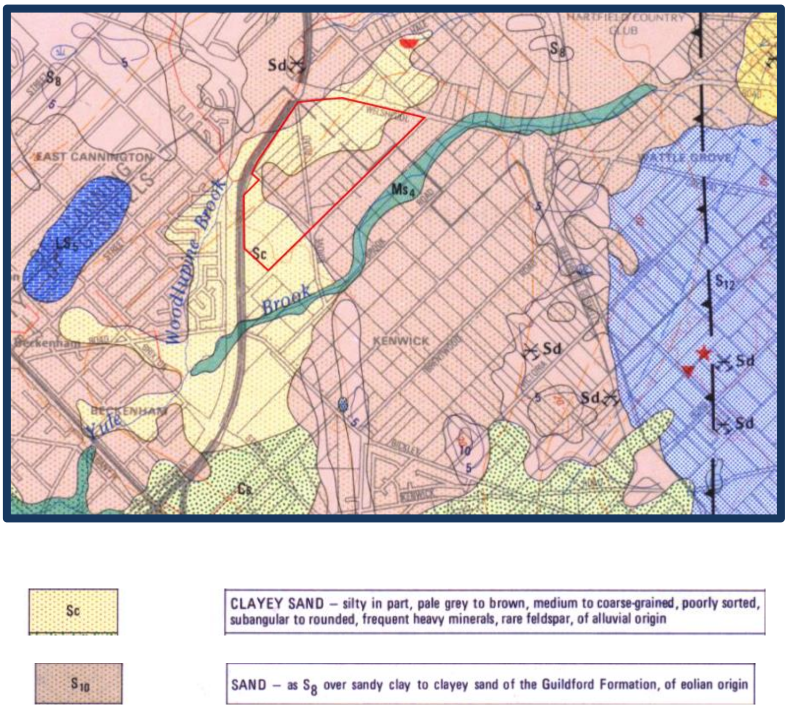

Figure2 - Geotechnical Information (Geological Survey of WA)

3.3 Groundwater

A desk top review of the Department of Water's Perth Groundwater Atlas indicates that the Historical Maximum Groundwater Levels are between RL9.0m to RL13.0m AHD across the Site, as presented in *Figure 3* below.

Given the natural ground levels are similar, it is anticipated that ground water levels will have a significant impact on earthworks design levels and the requirement for import fill to raise the ground levels. In addition, it is possible that dewatering may be required for some service installations.

It is recommended a detailed groundwater investigation is undertaken to confirm groundwater levels and a Dewatering Management Plan is prepared for the detailed development of the site.

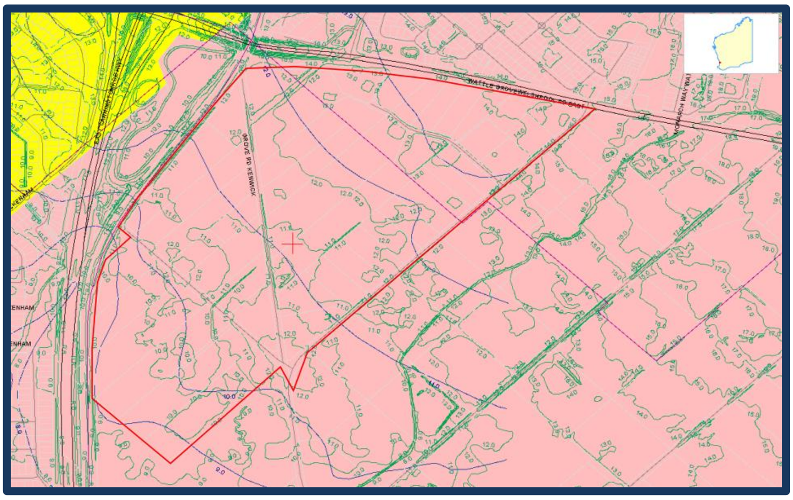

Figure 3– Groundwater Information (DoW Groundwater Atlas)

4. SITEWORKS & EARTHWORKS

The MKSEA is bounded by Coldwell Road to the south, Welshpool Road to the north and Roe Hwy to the west.

The Site is primarily cleared with some limited overstorey as presented in *Figure 4* below.

The Site is generally flat and low-lying, and ranges in elevation from RL12m AHD in the north east falling to an elevation of RL9m AHD in the south west.

Some localised clearing and earthworks will be required to create level lots. Fill will be imported to site to raise the site to provide adequate clearance to groundwater and allow for drainage of the Site. Refer to the LWMS for further detail.

Figure 4 – Aerial Photography (Google Earth 2016)

5. DRAINAGE STRATEGY

5.1 Existing Drainage Network

Existing surface runoff is via a network of open drains that discharge into Yule Brook at three separate locations.

Yule Brook ultimately discharges into the Canning River.

5.2 Integrated Urban Water Management

The Precinct 3A MKSEA Local Water Management Strategy (LWMS) has been prepared by Emerge Consultants as a separate document. This provides further clarification and advice as to how the desired outcomes of the District Water Management Strategy (DWMS) are achieved and provides a basis for ongoing development to ensure that appropriate allowances are made for total water management including the minimisation of scheme water use and the maximisation of recharge of stormwater runoff.

Stormwater drainage management is proposed by adopting a Water Sensitive Urban Design (WSUD) approach. Objectives of WSUD include:-

- Detention of stormwater rather than rapid conveyance;
- Use of vegetation for filtering purposes; and
- Water efficient landscaping.

For the MKSEA Precinct 3A LSP, the main WSUD practices which should be incorporated into the ongoing implementation of the site as follows:

5.3 Stormwater Collection and Management

The subject land is generally clayey sand with limited infiltration at source.

It is anticipated that runoff within future allotments for up to the 100 year ARI event will be detained on-site with a throttled connection to roadside swales. The swales will be vegetated and flat graded allowing for in-line treatment prior to the ultimate outfall.

Drainage from public roads will also be conveyed via vegetated roadside swales.

The LWMS details the stormwater drainage plan for the MKSEA Precinct 3A LSP. The plan shows the approximate location of the stormwater detention basin as well as the ultimate outfall locations to Yule Brook.

6. Roadworks

6.1 Traffic and Transportation

A Preliminary Transport Study of the overall MSKEA has been conducted by Cardno on behalf of the City of Gosnells.

The results of this include predicted traffic volumes for the MKSEA together with recommendations for major access points and internal road layouts.

In addition to the above initial report, a further Traffic Assessment study has been conducted by Cardno on the Precinct 3 area on behalf of Linc Property Pty Ltd.

This engineering review has taken account of the recommendations outlined in both Cardno reports and they will be incorporated into future detailed subdivision planning and design.

6.2 Regional Roads

Roe Highway and Welshpool Road are both Primary Regional Roads (Red Roads) under the Metropolitan Region Scheme. Both are dual carriageway (4 lane divided roads).

The intersection of Roe Highway and Welshpool Road is a grade separated interchange.

Road access to the Site is currently via Coldwell Road and Grove Road. It is intended that this intersection will be upgraded to a signalised T-intersection to cater for the increased traffic volumes.

The structure plan proposes an additional access (excluding Right Out and straight through movement to Hale Road) to MKSEA via the Hale/Welshpool Road intersection.

6.3 Existing and Future Internal Roads

Coldwell Road abuts the Site to the south, and Edward Street and Grove Road provide access through the Site.

The levels adjacent to the existing roads will be lifted as part of the overall earthworking of the site which will result in the requirement for the reconstruction of these roads to tie in with the finished levels. Re-alignments of both Grove Road and Edward Street are also proposed. Services to existing residents along Coldwell Road will be retained.

Road cross-sections will be designed to cater for utility services, on standard verge alignments, drainage requirements and pedestrian movements.

The engineering design of future industrial roads or the upgrade of existing roads will be carried out to comply with the requirements and standards of the City of Gosnells and Shire of Kalamunda (as relevant).

Typically, road reserves for industrial areas are required to be 20 metres wide and road pavements are 10 metres wide. Where it is proposed to incorporate roadside conveyance swales within the road reserve, a 30 metre wide reserve is proposed.

The future development is to cater for a Category 7 Restricted Access Vehicle (RAV 7). As such, future roads will be constructed to a RAV 7 standard and all existing roads upgraded to a RAV 7 standard, where required.

Details of proposed modifications to the existing internal roads are provided below.

6.4.1 Grove Road

It is proposed to re-align Grove Road from the north of the Coldwell Road intersection to connect to the future Hale Road/Welshpool Road intersection. The road reserve will also be lifted to accommodate the overall earthworking of the site with the width increased to 30m to allow for a 10m pavement and roadside swales.

6.4.2 Edward Street

It is proposed to close Edward Street to accommodate the future development layout and relocate it to the north to provide access to the Kenwick Rail Freight Facility. A portion of the Edward Street road reserve will be utilised for the widening of Grove Road.

6.4.3 Coldwell Road

It is proposed to reconstruct the section of Coldwell Road within the structure plan boundary to accommodate the overall earthworking of the site. This will also include the widening of Coldwell Road to 30m to allow for a 10m pavement and roadside swales. The reconstructed Coldwell Road will tie back into the existing pavement near Courtney Place. Coldwell Road will be the terminating leg at the Tee junction with Grove Road once Grove Road is connected to the Hale/Welshpool intersection

7 WASTEWATER

The Site is located within the Water Corporation's Wattle Grove district, for which long term scheme planning has recently been updated. This planning allows for the extension of the 750mm diameter Main Sewer from the west of Roe Hwy to the south of the site to collect sewer flows from the entire MKSEA area. This will then ultimately discharge into an existing sewer main downstream on Bickley Road. The 750mm dia sewer is a long term proposal.

An interim sewer arrangement may be possible for Precinct 3A. This would require the construction of a Type 40 WWPS which could discharge via a rising main into the existing Maida Vale Main Sewer (requiring crossing of the freight rail and Roe Highway corridors). Given the high cost associated with implementing this outcome, it is likely to require a commitment from Water Corporation as part of its Capital Infrastructure Works.

The location and nature of the Precinct 3A area and its appeal as a freight and logistics hub characterised by large warehouses suggests that waste water treatment could be achieved via connection to alternative treatment units (ATUs) on site.

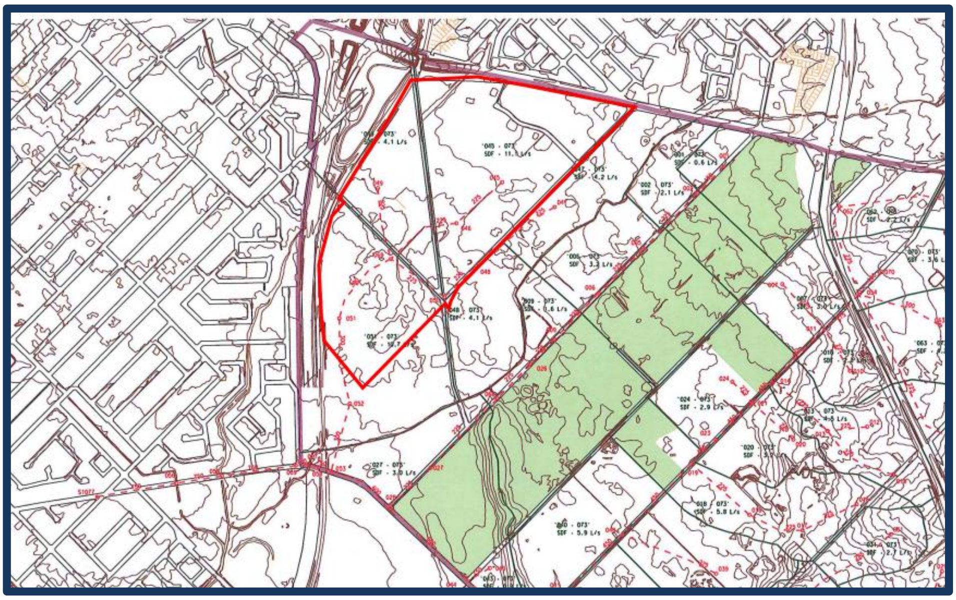

Figure 2 - Conceptual Long Term Wastewater Scheme Planning (Water Corporation, 2015)

8 WATER RETICULATION

There is existing water infrastructure surrounding the Site, including a 510mm main in Bickley Road to the south of the Site.

The Water Corporation has advised that the site can be serviced with water through the extension of an existing 200mm main from Grove Road which comes off the existing 510mm main in Bickley Road.

In addition to the above, the system will be reinforced via the connection to an existing 250mm main in Hale Road.

With the existing 200mm main along Grove Road, staging of the development would be best suited starting from the south west of the site near the Grove Road/Coldwell Road intersection.

The proposed industry types and water usages are not currently defined for the Site. A minimum main size of 150mm will be required to service an industrial development. As the existing mains within Grove Road, Edward Street, Coldwell Road and Courtney Place are 100mm, there will be a requirement to upgrade these mains to a minimum 150mm.

The water strategy for the Site is depicted in Appendix A.

Standard Water Corporation water headworks will apply to the development.

9 ELECTRICAL POWER SUPPLY

There is existing 22kV overhead power lines in Edward Street, Grove Road (south of Coldwell Road) and Coldwell Road (east of the structure plan area) that may be utilised to supply power to the Site. Initial investigations indicate that initially 5MVa can be provided from the existing 22kVa lines with additional capacity available on a staged approached.

Undergrounding of the internal power supply network along Coldwell Road and Edward Street will be required. In additional a series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements.

10 GAS SUPPLY

It is anticipated that the existing 225mm diameter high pressure gas main along Coldwell Road may require raising to coincide with the developed earthworks levels.

It is not intended to provide a gas supply to the development. However, future investigations into connecting to the Coldwell Road gas main may determine a supply is possible if it is deemed to be required.

11 TELECOMMUNICATIONS

The Site is within NBN Co's fixed line footprint, and hence can be serviced with optic fibre under their roll-out scheme for greenfield developments.

Under the Federal Government's new Telecommunications in New Developments Policy, developers are responsible for contributing to the cost of delivering the nbn™ network in new developments. This includes contributing to part of the costs of the build (civils and any backhaul required) as well as a per lot deployment change.

The current design practice for road reserves, pavement and verge provisions will make adequate allowance for services including broadband in accordance with the agreed Utilities Service Providers handbook. There will be some local land requirements for equipment sites, similar to current provisions which will be accommodated at detailed subdivision stage.

12 STAGING

Indicative staging of the MKSEA Precinct 3A area may commence along the realigned Grove Road and include the upgrade of Coldwell Street.

The provision of engineering infrastructure will need to be staged to suit the development demand, and a detailed program for this will need to be prepared as part of ongoing planning and design of the infrastructure.

Under the current policies contributions may be required to meet any pre-funding costs of the Water Corporation infrastructure.

13 CONCLUSION

The Maddington-Kenwick Strategic Employment Area Precinct 3A locality has planned strategies for power and water and wastewater treatment will be provided by ATUs if the works cannot be prefunded through the Water Corporation Capital Works program. Other public utility services are available or can be extended to service the proposed industrial area.

There are no engineering impediments to the development, and further detailed plans will be formalised with the relevant Service Authorities as the development progresses.

Appendix A

Drawings

REV	DATE	DRN	CKD	APP	AMENDMENT
B	09.09.16	JAE			ISSUED FOR INFORMATION
A	25.08.16	JAE	-	-	ISSUED FOR INFORMATION

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APPROVED 09.09.16

DESIGNED JAE

SCALE 1:3000

PROJECT KENWICK INDUSTRIAL

TITLE PRELIMINARY DESIGN SURFACE OPTION 11

WAPC No.

DRAWING No. 6174-00-SK25

REVISION B

A1 ORIGINAL SIZE

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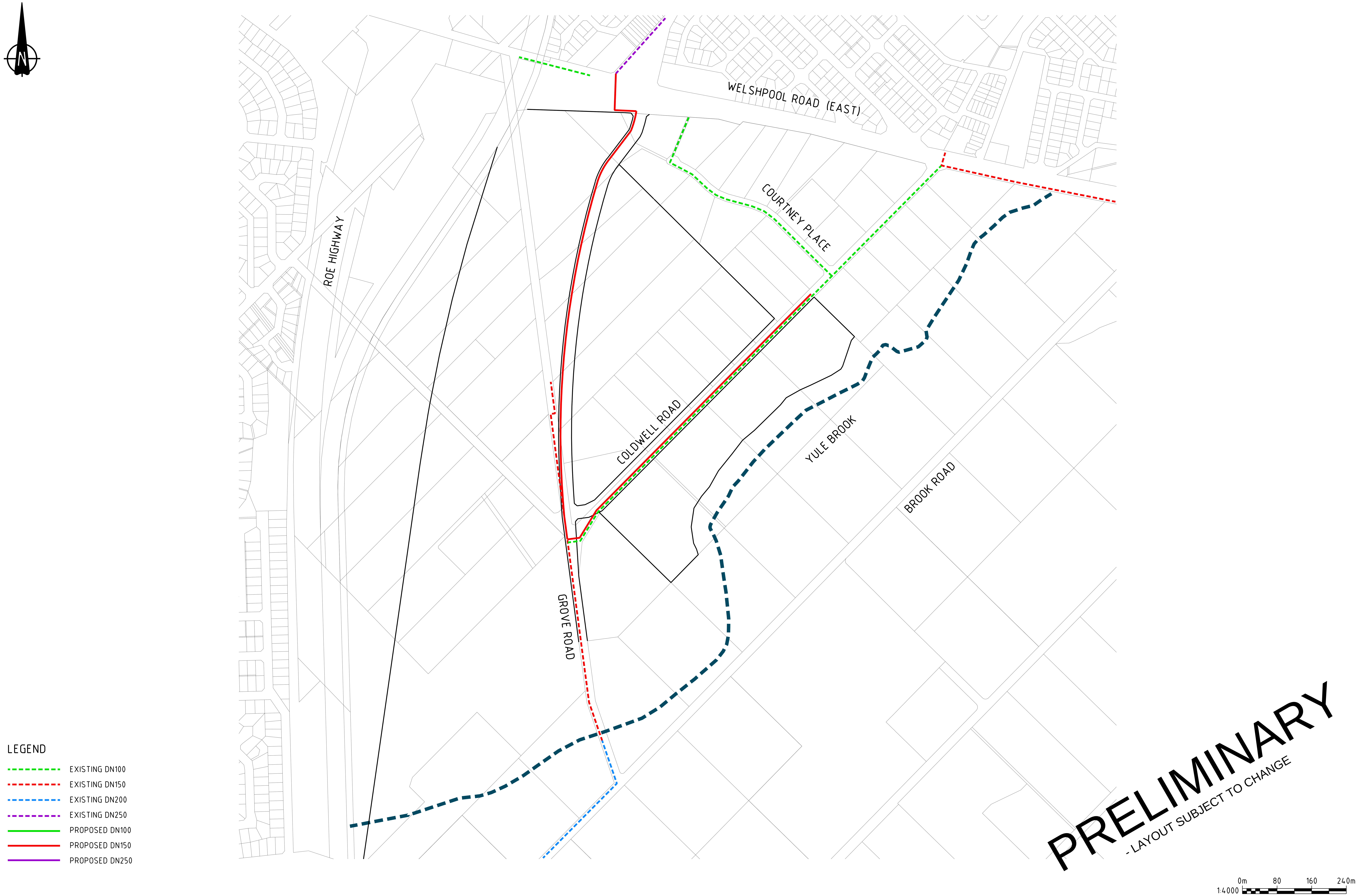

LEGEND

- EXISTING DN100
- EXISTING DN150
- EXISTING DN200
- EXISTING DN250
- PROPOSED DN100
- PROPOSED DN150
- PROPOSED DN250

REV	DATE	DRN	CKD	APP	AMENDMENT
C	04.05.16	JAE	LC	[signature]	ISSUED FOR COMMENT
B	18.04.16	PM	LC	N. BUTSON	LAYOUT REVISED
A	12.04.16	JAE	LC	A. THOMSON	ISSUED FOR COMMENT

This plan is not to be used for construction unless issued as revision 0 or higher

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CLIENT

APPROVED: AVRIL THOMSON

DESIGNED: JAE

SCALE: 1:4000

PROJECT: KENWICK INDUSTRIAL

TITLE: WATER SUPPLY STRATEGY

WAPC No.

DRAWING No.: 6174-00-SK16

REVISION: C

ORIGINAL SIZE: A1

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